IIIEE Theses 2014:XX

Business Models for Energy Efficiency Renovation in the Residential Sector

Learnings from Projects of Energy Service Companies in Sweden

Boris Kupchik

Supervisors

Bernadett Kiss

Kes McCormick

Thesis for the fulfilment of the
Master of Science in Environmental Sciences, Policy & Management
Lund, Sweden, June 2014

MESPOM Programme:

Lund University – University of Manchester - University of the Aegean – Central European University

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Erasmus Mundus Masters Course in
Environmental Sciences, Policy and Management

MESPOM

This thesis is submitted in fulfilment of the Master of Science degree awarded as a result of successful completion of the Erasmus Mundus Masters course in Environmental Sciences, Policy and Management (MESPOM) jointly operated by the University of the Aegean (Greece), Central European University (Hungary), Lund University (Sweden) and the University of Manchester (United Kingdom).

Supported by the European Commission's Erasmus Mundus Programme

Education and Culture

Erasmus Mundus

Published in 2011 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

ISSN 1401-9191

Acknowledgements

Foremost, I would like to express my sincere gratitude to my supervisor and mentor Prof. Kes McCormick for the continuous support and engagement through the learning process of my masters thesis, for his patience, motivation and immense knowledge.

Furthermore I would like to thank my advisor Dr. Bernadett Kiss for the useful comments, remarks and for introducing me to the topic as well as support along the way.

Also, I would like to thank IIIEE and Lund University for the wonderful atmosphere which helped me in my study. Besides IIIEE and Lund University I would like to thank CEU and University of the Aegean for aiming me at success and to attain better results and, of course, for unforgettable summer practice.

I appreciate the Erasmus Mundus Programme for the financial support of my education abroad, without which my presence here would not be possible.

My sincere thanks also goes to Mr. Bjoern Wistroem, Mr. Fredrik Aberg (Siemens), and Mr. Thomas Johnsson (E.ON), who have willingly shared their precious time during the process of interviewing for practical data and information about the implemented projects.

Moreover, I would like to thank Mr. Wolfram Moritz and Mr. Paul Kenny for their kind support and interesting presentations during the World Energy Days 2014 conference in Vienna.

Abstract

Energy savings and improvement in energy efficiency in residential areas have become very important tasks for citizens and businesses. However, most energy efficiency renovation projects, which are conducted by Energy Service Companies (ESCOs), are dedicated only to public buildings. Many publications are focused only on commercial and public buildings, while the residential sector is beyond the scope of their attention. Thus it is very important to find economically viable approaches to increase the effectiveness and quantity of ESCO residential energy efficiency renovation projects.

Different business models currently used in residential energy efficiency renovation projects were analyzed. Several of the most important models were chosen as the basis of this analysis, including Energy Performance Contracting (EPC) with shared and guaranteed savings, Chauffage, and Preferential loans. The PEST (Political, Economic, Social and Technological) framework was applied to analyze real life examples of ESCO residential energy efficiency renovation projects in Sweden. It was found that only one model is in use in the residential sector, which is EPC with guaranteed savings. The main investors of the renovation projects were found to be municipalities and tenants/landlords. While the main technological measures related to energy efficiency improvement were shown to be the improvement of ventilation systems, installation of monitoring and controlling devices, heat system renovation, and the improvement of the building insulation and building envelope.

The PEST framework is shown in this research to be a suitable approach to investigate ESCO residential energy efficiency renovations and the implementation of energy systems in renovation projects. The findings show the importance of long-term investments instead of short-term, and the need for other business models (not only EPC). In addition, it was found that campaigns and environmental education in connection with energy projects are essential not only in terms of output, but also in terms of interaction between actors by combining efforts of businesses, NGOs, municipal authorities and tenants.

Keywords: energy efficiency, residential building renovation, energy service company (ESCO), energy performance contracting (EPC), PEST analysis

Executive Summary

Energy savings and improvement in energy efficiency in residential areas have become very important tasks for citizens and for businesses, because 36% of overall consumed energy is caused by the residential building sector in Sweden. As a result, residential buildings are one of the main sources of greenhouse gases emissions, which in turn makes residential buildings one of the main triggers of climate change. However, most energy efficiency renovation projects are dedicated only to public buildings and many publications are focused only on commercial and public buildings. The residential sector is beyond the scope of their attention even though the number of residential buildings is 5 times higher than the number of public buildings (Swedish Construction Federation 2012). Moreover, 90% of the energy in the building sector is consumed by residential buildings. Thus in order to achieve the governmental goal of increasing Swedish energy efficiency 50% by 2050, it is very important to find economically viable approaches to increase the effectiveness and quantity of residential energy efficiency renovation projects.

The main research question is therefore as follows:

How could the involvement of energy service companies (ESCOs) help to improve energy efficiency of residential buildings in Sweden?

Sub questions were developed, which are:

- *What different business models are used by ESCOs in Sweden?*
- *How could current activities by ESCOs in the renovation sector of residential buildings be further improved?*

In order to answer these research questions a qualitative approach was chosen. Findings of the current thesis are based mostly on literature analysis and semi-structured interviews. First, a literature review of existing business models in the residential energy efficiency renovation market was done. It provided an understanding of what business models theoretically could be applicable to residential energy efficiency renovation. The next stage of the research was conducting the qualitative research of the Swedish ESCO energy efficiency renovation market. A PEST (Political, Economic, Social and Technological) analysis was chosen as the main instrument for such research. For the sake of conducted semi-structured interviews, a special questionnaire was developed on the basis of the PEST framework. The factors and aspects analyzed according to the PEST framework are listed below:

- Political: governmental and municipal policies in the energy efficiency renovation sector, environmental and energy regulations, state and municipal energy targets and goals.

- Technological: availability of different energy efficiency technologies, maintenance level of residential buildings, effectiveness of energy monitoring systems.

- Economic: energy savings, project costs, bank interest rates, financial funds for energy efficiency renovation purposes, payback period, organizational structure of ESCO companies.

- Social: level of awareness about energy efficiency-improving measures and energy efficiency renovation projects, level of tenant's energy friendly behavior, cultural and

social status of tenants and building owners, NGO's involvement in the energy efficiency renovation market.

Several of the most important business models were chosen as the basis for research and analysis. The following models are presented in this thesis: Energy Performance Contracting with shared and guaranteed savings, Chauffage, and Preferential loans. Based on the conducted research and findings of this thesis, the following conclusions were made about different business models. The EPC model with guaranteed savings does not demonstrate the same high energy savings in residential energy efficiency renovation projects in comparison with public energy efficiency renovation projects. It is related with the fact that EPC projects can be expensive and private customers are not able to pay a big sum of money at once. A shared savings model could be a solution, because financing will be provided by ESCO.

The Chauffage model gives the strongest incentive for ESCOs to implement energy efficiency renovation projects, because ESCO profits are in direct relation with operational costs. This means that the improvement in a building's energy efficiency will increase the amount of revenue an ESCO earns. Moreover, all financial costs for the renovation project are paid by ESCOs, which is beneficial for customers and tenants. Therefore, financial involvement of the customers is minimized, which makes this model especially suitable for the residential sector. The main disadvantage of the Chauffage model is a weak incentive for customers to behave in a more energy efficient manner, because their monthly energy payment does not depend on the amount of the consumed energy.

The preferential loans model allows ESCOs to attract additional financing for energy efficiency renovation projects. Such additional financing gives an opportunity for ESCOs to implement more energy efficient technologies and generate additional energy savings. However, there are also several disadvantages. First, because initially money is provided by the government, its involvement is obligatory during project implementation, which makes such a model non-flexible and costly. Furthermore, because banks are generally interested only in very big projects, it could be difficult to obtain financing support for individual residential projects.

Siemens and E.ON were chosen for the investigation of real life cases of residential ESCO energy efficiency renovation projects. Siemens is one the main ESCOs on the Swedish market whose core business is energy efficiency equipment production and installation. E.ON is one of the main ESCOs on the Swedish market whose core business is energy production. Moreover, representatives of the Skane Energy Agency and experts from the World Sustainable Energy Days 2014 conference were also interviewed, which helped to develop a better understanding of the topic and investigate from different perspectives.

During the research process, 21 real life cases of residential ESCO energy efficiency renovation projects were analyzed. The research shows that the average energy savings in Siemens strictly residential energy efficiency renovation projects is about 22%. The energy savings in E.ON energy efficiency renovation projects is around 45%, as E.ON renovated not only the residential buildings, but also on the energy supply side.

An applied PEST framework was found to be useful for evaluating residential ESCO energy efficiency renovation projects. Such an approach, together with a developed methodological framework, makes it possible to systematize data and to develop conclusions and recommendations (which are presented below) for each of the sectors. A PEST analysis is also recommended in future similar research projects because it provides rational results and will give an opportunity to track the changes in each of the sectors (political, economic, social or technological). Results of this thesis, which is based on Swedish energy efficiency renovation projects, could be extended and adapted to other countries in the European Union by considering their special characteristics of geographical location and cultural mentality.

Based on the PEST framework, the following political conclusions were drawn:

Sweden has a broad and well developed regulation regarding energy efficiency improvement. However, there are no legislative acts that would stimulate usage of private funds of the financial institutions and publication of the results of the residential ESCO energy efficiency renovation projects. Such a situation leads to a low number of implemented energy efficiency renovation projects in the Swedish residential sector, due to a lack of citizens' awareness about ESCO energy efficiency renovation projects and approaches, and lack of financial resources to pay for the project. Thus, even if ESCO residential energy efficiency renovation projects are conducted, customers often choose to decrease the payback period by using cheaper and less effective energy efficiency improving technologies. A significant improvement in the number and effectiveness of residential ESCO renovation projects could result from development of the legislative acts dedicated to the involvement of the financial institutions' funds for residential energy efficiency renovation purposes, and from legislative acts that aim to make projects' results and energy declarations publically accessible and available.

In addition, implemented PEST analysis indicates that the average payback period of an ESCO residential energy efficiency renovation project is 10 years. Therefore, an energy audit every 7 - 9 years (together with an existing mandatory energy evaluation after a significant energy renovation or 2 years after construction) would determine whether the building's energy system is performing as planned. The building's energy system could be adjusted for balance and to decrease energy consumption. Moreover, technologies could significantly change in 7 - 10 years. An audit would help to plan future steps for even deeper energy efficiency renovation. Therefore, development of legislation to require a building's energy audit every 7 - 9 years is recommended.

Based on the PEST framework, the following economic conclusions were drawn:

Energy efficiency renovation projects do not reach the best possible results in energy savings because of the lack of financial resources and implementation of only the EPC business model. Therefore, the use of additional business models (EPC with shared savings or Chauffage) is recommended. These models are able to divide a project's risks between different stakeholders and attract new investors. Moreover, the direct relation between the amount of invested financial resources and a project's energy savings was identified during a PEST analysis. Therefore, the following strategy needs to be emphasized to customers: further investment will lead to more energy savings; use long-term investments instead of short-term.

Based on the PEST framework, the following social conclusions were drawn:

During execution of the current thesis, it was found that tenants living in residential energy efficiency renovated buildings are not fully aware of the benefits that could be realized after implementation of such renovation projects. Awareness-raising campaigns and environmental education in connection with realized energy projects could stimulate further development of the energy service market and increase results of the implemented energy efficiency renovation projects. A special event to celebrate and present a finished residential energy efficiency renovation project is a good opportunity to invite residents of the nearest buildings (potential customers), representatives of the NGOs, and local authorities. Several of ESCOs objectives could be reached at the same time: educate tenants, improve maintenance of the building, present results of the project, find new clients, and improve ESCO's reputation.

Based on the PEST framework, the following technological conclusions were drawn:

Analysis of the case studies (by Siemens and E.ON) indicates that projects where both the supply side and demand side were renovated show more energy savings than ESCO energy efficiency renovation projects where only the demand side (residential buildings) was renovated. Therefore, it is recommended to renovate the supply side in addition to the demand side, if possible.

In addition, analysis showed that outside climate conditions are very important factors in achieving energy savings. Therefore, it is recommended to install not only energy monitoring systems in buildings, but also weather monitoring systems. Together, both systems would allow the current state of the energy system to be controlled in real-time with faster adjustments to weather changes. Moreover, the availability of data about energy consumption in relation to weather conditions would improve the quality of energy consumption predictions for future projects.

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Abbreviations

BPS - Building Performance and Sustainability

EE - Energy Efficiency

EIB - European Investment Bank

EU - European Union

EPC - Energy Performance Contracting

ESCO - Energy Service Company

NGO - Non-Governmental Organization

PFC - Performance Contracting

1 Introduction

Energy savings and improvement in energy efficiency in residential area become very important tasks for citizens and for business, because residential buildings are one of the main consumers of different forms of energy (electricity, heat and hot water). Growing energy consumption causes many serious environmental problems, such as global warming and climate change (IPCC 2007). There are many technological solutions, which goal is to improve energy efficiency in buildings. More and more modern buildings are constructed with zero or nearly zero energy consumption. However, old buildings, which were built decades ago still require a serious reconstruction, in order to reach modern low standards of energy consumption (Swedish Energy Agency 2009). Moreover, amount of buildings constructed in the 20th century is much larger than amount of modern energy efficient buildings (Statistics Sweden 2012). Building's replacement rate in European Union is only about 1% per year (MacDonald and Moore 2011), which makes energy efficiency renovation projects in the rest 99% of the buildings even a more important issue. Furthermore, taking into consideration the fact that even newly constructed buildings often do not meet planned low level of energy consumption energy efficient renovation becomes even more relevant; for example, in Sweden 80% of newly constructed buildings have a significant difference between projected and actual energy performance of the building (Wik et al. 2011).

Currently most of the renovation projects are focused only on public buildings (Copenhagen Economics 2012). It is related with the fact that financing of such projects is done by the government (Shafqat 2011). Energy efficiency improving programme or policy initiates the movement of funds from the governmental budget to the financial institutions, where they have to be spent for energy efficiency improving purposes. It is much easier for financial institutions to spent them on a big municipal projects, related with energy efficient renovation of public buildings, then to break these funds up for different numerous smaller renovation projects in residential sector, where often there are more than one building owner and results of the projects have a strong dependence on tenants' behavior (Nair et al. 2010). Due to this, energy service companies prefer to work with public energy renovation projects (WBCSD 2008). Therefore the number of energy efficiency renovation projects is significantly less than the number of similar projects in public sector.

Moreover, due to abundance of statistical and numeric data about results of public energy efficiency renovation projects (WBCSD 2008), many publications are dedicated only to commercial and public buildings, while residential sector is out of scope of their attention (Van Ha and Femenias 2009). Thus, the current thesis about residential energy efficiency renovation projects is relevant and it could be useful for deeper investigating and understanding of the residential buildings energy efficiency renovation market.

1.1 Problem Definition

It is well known that climate change and global warming are one of the main contemporary global problems. According to IPCC report (2007), average annual global temperature increased by 0.7 °C for the last century. Moreover, the average annual global temperature will continue to rise and in the end of the 21st century it will be higher by 1.8 - 4 °C than it was in 1990. Furthermore, the temperature rise will be even more significant in northern countries. Average annual temperature in Sweden will increase by 3 - 5 °C up to 2080s in comparison with temperature level of 1990s. There is a high probability that rise of average winter temperature in northern Sweden will reach even 7 °C. It means that the climate in Sweden will become warmer and wetter. Such changes in climate will increase the territory threatened by floods up to 6 million square meters (Swedish Commission on Climate and Vulnerability

2007). Sea level will rise approximately by 0.2 meter, which will threaten around 150 000 buildings. The risk of landslides also increases, what will threaten about 200 000 buildings in Sweden.

Intergovernmental Panel on Climate Change (IPCC 2013) claims that climate change is caused by anthropogenic greenhouse gases emission with 90% probability. Due to that greenhouse gases emission reduction is an important goal for climate change mitigation purposes. In order to avoid serious social and economic losses caused by climate change and global warming in the future efficient measures in greenhouse gases reduction should be conducted as soon as possible. It will allow to realize a better climate scenario and to decrease negative consequences of climate change on economy, humanity and environment (Flannery 2013). Greenhouse gases emission in Sweden in 2012 was about 58.3 million tons of carbon dioxide equivalent (Swedish Energy Agency (SEA) 2014). In order to mitigate climate change as much as possible, Swedish government introduced a goal to reduce greenhouse gases emission by 40% up to 2020 in comparison with 1990 (SEA 2014).

The main source of greenhouse gases emission is energy consumption (Pachauri and Reisinger 2007). According to Swedish Energy Agency (2012), 37% of overall energy consumption in Sweden is caused by the building sector. Swedish building sector consumed 156 TWh of energy in 2010 (SEA 2012), which caused about 21.6 million tons of carbon dioxide equivalent emission. Thus, in order to reach 2020 goals in declining the greenhouse gases emission, Sweden has to decrease energy consumption in buildings. Due to that, Swedish Ministry of Environment (2009) set up goals to decrease energy consumption in buildings by 20% up to 2020 and by 50% up to 2050 in comparison with energy consumption level in 1995.

There are about 4 million buildings in Sweden (Statistics Sweden 2012) and 86% of it are residential buildings. According to Swedish Energy Agency (2012) residential buildings consume about 90% of overall energy consumption of the building sector. More than 75% of the residential buildings are older than 30 years (Swedish Construction Federation 2012). For example, Figure 1-1-1 represents amount of square meters of built residential multi-dwelling buildings. The graph shows that the highest amount of apartments was built in the period from 1960 to 1970. It is related with the Million Programme, which goal was to build one million of new buildings in order to provide reasonably cheap accommodation for the population (Swedish Construction Federation 2012). Moreover, Figure 1-1-1 indicates that the main source of energy consumption in multi-dwelling buildings are district heating and electricity, which is also true for other types of residential buildings (Statistics Sweden 2012).

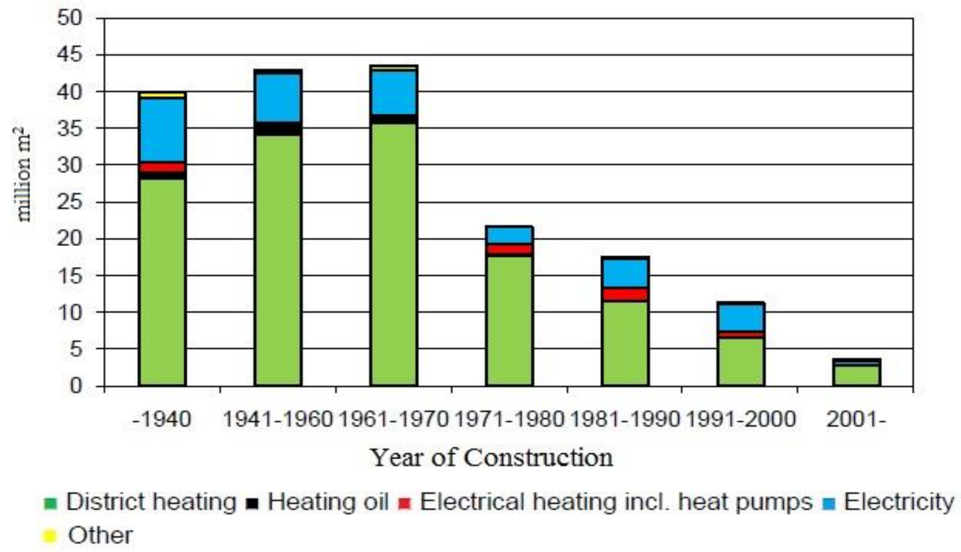

Figure 1-1-1 Energy Consumption Source and Square of Multi-Dwelling Buildings in Sweden

Source: Statistics Sweden 2012

According to National Board of Housing (2009), current results in energy consumption reduction in buildings is 3.7% in comparison with level of 1995. However, according to Building's Energy, Technical Status and Indoor Environment (BETSI) study (2011), energy consumption decreased by 9.7%. In any case, it is still not enough to fulfill 2020 target. According to Boverket's Building Regulations (2011) building's annual energy use should be equal or less than 120 kWh per m^2. Table 1-1-1 indicates that most of the buildings built in the 20th century has much higher energy consumption. Buildings built in the period between 1941 and 1960 consume 159 kWh per m^2 annually. Moreover, buildings built before 1940s and buildings built from 1961 to 1980 also have energy consumption level higher than 150 kWh per m^2 annually. Dwellings constructed after 2000 are the only one, which fulfill the Boverket's energy requirements. Thus, energy efficiency renovation projects in residential sector have to be conducted, in order to reach governmental energy and climate change mitigation goals.

Table 1-1-1 Average Annual Energy Consumption in Residential Buildings

Construction period	**Energy use, KWh/m^2**
Backwards - 1940	157
1941 - 1960	159
1961 - 1970	150
1971 - 1980	153
1981 - 1990	123
1991 - 2000	124
2001 - Onwards	115

Data Source: Swedish Energy Agency, 2009

Even though the number of residential buildings, as it was demonstrated above, is significantly larger than the number of public buildings, still energy efficiency renovation projects are mostly implemented in public sector (Copenhagen Economics 2012). This is related with the fact that big energy efficiency renovation projects in public sector are funded by the government or municipality, due to that these projects are less risky and therefore more profitable for Energy Service Companies (Shafqat 2011). However, such financing approach is not completely applicable for residential sector, because, due to high number of dwellings, amount of required financial resources is much larger and the process of dividing big budget sums into numerous residential energy efficient renovation projects is too complicated and not economically feasible (WBCSD 2008). This fact is also proven by Energy Efficiency Watch (2013), who claims that financial instruments for the energy efficiency renovation in Swedish residential buildings sector are not included into policy package. However, in order to reach 2020 and 2050 energy goals, implementation rate of residential energy efficiency renovation projects has to be increased significantly. Thus, insufficient amount of energy renovation projects conducted by ESCOs is an important contemporary problem in Sweden.

1.2 Research Question

The main research question is therefore as follows:

How could the involvement of energy service companies (ESCOs) help to improve energy efficiency renovation of residential buildings in Sweden?

In order to answer the main research question several sub questions were developed. For better understanding how ESCOs could improve energy efficiency renovation in buildings in Swedish residential sector, it is necessary to understand the whole process of ESCO's energy efficient renovation in residential sector. It is important to understand what economic, political, social and technical instruments are used by ESCOs and what is the current state of ESCO's energy efficiency residential renovation market in Sweden. After the overview of the current situation on Swedish ESCO's energy efficiency residential market, it will be possible to generate recommendations for further improvement and further stimulation of residential energy efficiency renovation projects. Thus, the sub questions of the thesis are:

- What different business models are used by ESCOs in Sweden?
- How could current activities by ESCOs in the renovation sector of residential buildings be further improved?

1.3 Limitations and Scope

First of all, this paper aims to investigate the whole concept of energy efficiency improving renovation in buildings conducted by energy service companies. Due to that the scope of Literature Analysis chapter is global. This thesis will try to identify what business models are used by energy service companies, how they are implemented, what advantages and disadvantages these models have.

Secondly, further chapters will be dedicated to Swedish experience of the energy efficiency renovation activities in residential sector. Thus this thesis will concentrate on ESCOs' participation in Swedish residential building market. So the first limitation is that most of the literature about current state of renovation sector in Sweden is in Swedish. Another limitation of this research is small size of the sampling group. Even though Siemens and E.ON represent significant part of Swedish ESCO market, answers of other companies could be different. Moreover, presence of ESCO's commercial classified information is also a limitation. Literature review and interviews will allow to create an overview of the current state of residential energy efficiency renovation market in Sweden and available business models, however, detailed financial information about costs and results of the implementation by ESCOs energy efficiency renovation projects is closed for the public access.

1.4 Audience

This thesis is aimed to energy service companies and possible to construction companies, who are interested in implementation of the energy efficiency improving projects in Swedish residential sector. The current thesis includes recommendations for further improvement of such projects and has a description of best available examples of the implemented projects in Sweden. Moreover, this thesis could also be interesting for municipal authorities and local NGOs, who are trying to improve energy efficiency in their living area and stimulate further realization of such energy efficiency improving projects. Finally, current thesis could be useful for private citizens, because the scope of the research is residential buildings, which means it has a direct relation with tenants' behavior and results of the conducted projects will have a significant impact on the citizens.

1.5 Disposition

Chapter 1 (Introduction) includes problem definition and list of research questions, formulated for solving this problem. The scope, audience and limitations of the current thesis are also discussed in this chapter.

Chapter 2 (Analytical Framework) describes what methodological instruments were used in the thesis. It also has a description of PEST (Political, Economic, Social and Technological aspects) framework and its applicability for the analysis in the current thesis and how all these instruments are going to be used for answering stated research questions.

Chapter 3 (Literature Analysis) includes an analysis of the literature dedicated to the business models, used by energy service companies for energy efficiency renovation projects implementation. It describes different business models and their core concepts. Description of every model is divided into 3 parts: classification, principle and scope, advantages and disadvantages. Classification part includes description of different types of the current model, if they exist. Principle and Scope part includes description of the core concept of the model and main stages of the renovation scheme, according to this model. Finally, advantages and disadvantages part includes main pros and cons for different stakeholders of the ESCO energy efficiency renovation market. Such stakeholders are tenants and customers, ESCOs and municipalities.

Chapter 4 (Findings) is dedicated to energy service companies impact on the residential renovation market in Sweden. It includes review of the energy service companies as a theoretical concept and has description of real life case studies, implemented by energy service companies in Sweden. The description of cases is divided into 4 parts according to the framework of PEST analysis (see methodology chapter): political, economic, social and technological. This chapter presents collected data from the interviews with ESCO companies, according to the developed framework.

Chapter 5 (Analysis and Discussion) includes analysis of findings from the literature review and case studies. This chapter is also divided into 4 parts (political, economic, social and technological) according to developed framework based on PEST analysis. Moreover, this chapter has a short overview of the made methodological choices. The chapter reflects on the quality of answered research questions and assess, conducted analysis and research.

Chapter 6 (Recommendations) has a list of recommendations for further improvement and development of the residential energy efficiency renovation sector in Sweden. This list is also divided into 4 parts, according to PEST framework, for better understanding by different stakeholders.

Chapter 7 (Conclusions) includes main conclusions from the conducted thesis research.

2 Analytical Framework and Research Methodology

2.1 Defining the PEST Framework

PEST framework is a marketing instrument of strategic planning, analysis and forecasting, which is mostly used by business sector and private companies (Carpenter *et al.* 2009). It develops a macroeconomic model for companies' external environment assessment (Collins 2014). Abbreviation PEST means Political, Economic, Social and Technological factors or aspects.

PEST framework is usually used to identify the current company's status and company's role in relationship with the external environment. Due to the fact that macro-environment includes numerous different factors, they are usually divided into 4 groups (Carpenter *et al.* 2009).

2.1.1 Political Aspects

Assessment of the political factors as a part of PEST analysis framework is motivated by the fact that state authorities regulate mechanism of money and resources distribution in the country. Main political aspects (Miller *et al.* 2011), which should be analyzed according to PEST framework, are:

- Current legislation on the market;
- Presence and role of the regulation and control authorities;
- State policy and state goals;
- State competition regulation and control;
- State financing, grants and initiatives;
- Taxes.

2.1.2 Economic Aspects

Economic aspects are important for assessment of company's business activity. Macroeconomic factors influence standard of living and population's purchasing capacity. Based on the received information from the PEST analysis it is possible to predict demand, price levels and profitability. Main economic aspects (Narayanan and Fahey 2010), which should be analyzed according to PEST framework, are:

- Economic situation and tendencies;
- Inflation rate;
- Investment climate;
- Energy prices;
- Seasonality and weather influence on the economic results.

2.1.3 Social Aspects

Social aspects are analyzed according to PEST framework, because often people's behavior and their social status have a direct impact on company's activity. Main social aspects (Abdi and Sharma 2007), which should be analyzed according to PEST framework, are:

- Demography;
- Client's behavioral models;

- Life style;
- Ethnic and religious factors.

2.1.4 Technological Aspects

It is important to analyze technological aspects, because there is a threat of losing market if company do not follow contemporary technological tendencies. Main technological aspects (Kotler 2013), which should be analyzed according to PEST framework, are:

- Development of competitive technologies;
- Production capacity;
- Specific technological solutions;
- Innovation potential;
- Intellectual property regulation.

2.2 Applying the PEST Framework

In the field of energy efficiency renovation PEST framework also might be applied, because all four sectors of PEST framework (political, economic, social and technological) are very important for the sake of better understanding of the market and its analysis. ESCO's business is built on the basis of contemporary legislation. Energy efficiency renovation projects are often initiated by the governmental goal to increase country's energy efficiency (Swedish Energy Agency 2014). Moreover, ESCO's activities are strictly regulated by the state laws and municipal regulations. Due to that analysis of the governmental and municipal policies in energy efficiency renovation sector as well as environmental and energy regulations (political aspects of the PEST framework) is crucial for answering the research questions.

Main goal of ESCOs as an economic entity is to generate profits and reach its economic goals. However, in order to answer mentioned research questions and understand how energy efficiency renovation is conducted in real life by ESCOs, current thesis will concentrate not on macroeconomic factors (which are identical for the whole state economy) or not on general company's income indicators. Thereupon economic aspects of the PEST framework will include specific results of energy efficiency renovation projects. Thus, amount of saved energy and investment costs could help to understand project's efficiency. Availability of financial funds for energy efficiency renovation purposes influences the implementation rate of the energy efficiency renovation projects in the country. Due to that, analysis of the economic aspects of the PEST framework is important for goals of the current thesis.

Scope of the current thesis is energy efficiency renovation projects implemented in residential sector, which means that ESCO energy efficiency renovation projects have a direct impact on life of the tenants and society. Moreover, people's behavior and different social and cultural habits could influence the energy consumption pattern and due to that change energy efficiency results of the conducted project. Thus, analysis of the social aspects is important for the sake of the current thesis.

Implementation of the energy efficiency renovation projects and achievement of the concrete energy saving results are done by installation and adjustment of different technological solutions. Different energy efficiency improving technologies have different impact on the final energy efficiency of the project. Thus analysis of the technological aspects is crucial for better understanding of ESCO energy efficiency renovation projects' implementation and answering the mentioned research questions.

Taking everything into account, the PEST framework could be applied for the analysis of the ESCO energy efficiency renovation market. However, due to the fact that the current thesis pays attention only to ESCO energy efficiency renovation projects and not to all activities of ESCO companies, aspects of the PEST framework will be presented in the different order. At first political aspects will be analyzed as a basis for energy efficiency renovation projects. After that technological aspects will be described, because it is important to understand what exactly was done and what technological solutions were implemented. After that economic aspects will be analyzed in order to identify efficiency and results of the conducted ESCO energy efficiency renovation projects. The final stage of the PEST analysis will be analysis of the social aspects on the ESCO energy efficiency renovation projects. Thus, because of the specific research questions of the current thesis and special characteristics of the energy efficiency renovation market (mentioned above), following factors were chosen as a part of 4 sectors of the PEST framework:

- Political: governmental and municipal policies in the energy efficiency renovation sector, environmental and energy regulations, state and municipal energy targets and goals.

- Technological: availability of different energy efficiency technologies, maintenance level of residential buildings, effectiveness of energy monitoring systems.

- Economic: energy savings, project costs, bank interest rates, financial funds for energy efficiency renovation purposes, payback period, organizational structure of ESCO companies.

- Social: level of awareness about energy efficiency improving measures and energy efficiency renovation projects, level of tenant's energy friendly behavior, cultural and social status of tenants and building owners, NGO's involvement in the energy efficiency renovation market.

The compilation of the research questions, which PEST analysis aims answer in this thesis is presented in Table 2-2-1. In order to answer main research questions (how the involvement of ESCOs could help to improve energy efficiency renovation of residential buildings in Sweden?), it is required to understand what is the current state of the ESCO energy efficiency renovation market, what are the energy and cost effectiveness of such projects and how different factors influence this effectiveness.

Table 2-2-1 Compilation of the Questions, which PEST Analysis Aims to Answer

<table>
<tr><th>Questions</th><th>Methodological Instrument</th></tr>
<tr><td>How do Swedish state energy targets influence the residential ESCO energy efficiency renovation market?</td><td rowspan="2">Analysis of the political aspects based on PEST framework</td></tr>
<tr><td>What are the legal barriers and incentives for ESCO energy efficiency renovation projects?</td></tr>
<tr><td>What technologies are used in Swedish ESCO energy efficiency renovation projects?</td><td rowspan="2">Analysis of the technological aspects based on PEST framework</td></tr>
<tr><td>How do implication of different technologies influence effectiveness of Swedish ESCO energy efficiency renovation projects?</td></tr>
<tr><td>How cost effective are conducted ESCO energy efficiency renovation projects?</td><td rowspan="2">Analysis of the economic aspects based on PEST framework</td></tr>
<tr><td>What energy savings are generated by ESCO energy efficiency renovation projects</td></tr>
<tr><td>How do social aspects influence the energy consumption?</td><td>Analysis of the social aspects based on PEST framework</td></tr>
</table>

2.3 Methodology and Approach

In order to answer the mentioned research questions a qualitative approach was chosen. According to Savin-Baden (2013), qualitative research aims to understand the subject of the research. Its goal is to explore general scheme and state of the researched area. Creswell (2008) claims that qualitative research is less formalized and logic of the conducted analysis is inductive, which means that conclusions about general concepts are made on the basis of investigated individual cases. Taking into account stated above research questions and goal of the current thesis, qualitative research is appropriate for the current thesis.

Findings of the current thesis are based mostly on literature analysis and semi-structured interviews. Compilation of the research subjects and used methodological instruments is presented in Table 2-3-1. First, a literature review of the existing business models in the residential energy efficiency renovation market was done. It provided an understanding of what business models theoretically could be applicable to residential energy efficiency renovation. It gave an overview of main advantages and disadvantages of such models for different market players.

Table 2-3-1. Compilation of the Research Subjects and Used Methodological Instruments

Research Subject	Methodological instruments
Business models for ESCO energy efficiency renovation in residential sector	Literature review; Communicating with experts on Swedish energy market; Communicating with experts and specialists during Sustainable Energy Days in Vienna
Current state of the residential ESCO energy efficiency renovation market in Sweden	Literature review; Semi-structured interviews with representatives of Swedish ESCOs
Possible further improvements and recommendations	Qualitative analysis based on the PEST framework

The next stage of the research is conducting the qualitative research of the Swedish ESCO energy efficiency renovation market. A PEST analysis (Political, Economic, Social and Technological analysis) was chosen as the main instrument for such research. Pest framework was described in the section above.

Special questionnaire was developed for the sake of the current thesis (See Appendix A). Questions in that questionnaire are divided in 4 groups (political, economic, social and technological) in order to simplify process of further PEST analysis. This questionnaire was used during semi-structured interviews with representatives of Swedish ESCO companies. In order to understand the situation on Swedish ESCO renovation market in residential sector, two companies were chosen for the interview: Siemens and E.ON. Such choice of companies is explained by the fact that Siemens is one of the main actors on the Swedish energy efficiency renovation market, whose core business is manufacturing and selling energy efficiency improving equipment. On another hand E.ON is one of the main energy producers, whose core business is selling kilowatt hours of electricity and district heat. Due to that on the basis of the conducted interviews useful data was received, which allows to compare approaches used in residential energy efficiency renovation by those two types of ESCO companies.

3 Literature Analysis

There is a broad wise amount of different scientific, theoretical and practical publications related with energy saving topic. A lot of papers, reports and articles are dedicated to improving energy efficiency in different kinds of industries, but there is a significant lack of literature devoted to estimation of energy efficiency renovation of residential buildings. In this thesis the main efforts were aimed on finding and on analysis of those publications, which were devoted to different types of business models, used by energy service companies for energy efficiency renovation projects implementation. It was found that in general there are such basic business models as Energy Performance Contracting (with sub models – Shared Savings and Guaranteed Savings), Chauffage and Preferential loans. Detailed description for each model was done. For better understanding each abstract of literature analysis describes principle and scope, advantages and disadvantages of every business model including core concept of the specific model and main stages of the renovation scheme, according to this model. The main pros and cons are stated for different stakeholders (tenants and customers, ESCOs and municipalities) of the ESCO energy efficiency renovation market.

3.1 Energy Performance Contracting

There are several business models which goal is to stimulate energy efficiency development in building sector. One of them is *Energy Performance Contracting (EPC)*. EPC was first introduced in USA in 1992 as a Federal solution for attracting private capital for financing energy efficient projects (EPACT 1992). Different terms exist in literature, which have the same meaning. Energy Policy Act of 1992 calls this model "Energy Savings Performance Contracts". Association for the Conservation of Energy (2013) in its report uses term "Energy service companies performance contracting", which apparently consist of two parts: *Energy service companies (ESCO)* and performance contracting. ESCO is a company, which provides a full package of energy services, for example, energy system design, implementation, optimization, maintaining and financing, planning and realization of energy efficient projects, etc. (Bleyl-Androschin and Ungerbock 2009). ESCO as a concept will be described in the next chapter of the current thesis.

EPC is a special type of business model (see Figure 3-1-1), when energy efficiency measures are implemented, which allows to decrease energy costs for the building owner and generate profits for ESCO from the energy savings (Bleyl 2008). Such EPC project (complex of energy efficient measures) is financed by the customer or by the ESCO depending on a type of EPC model (see Classification section). Energy savings are determined by comparison of the energy consumption after the realization of EPC project with the basis level of energy consumption and energy costs, which were set in advance (Bleyl 2008).

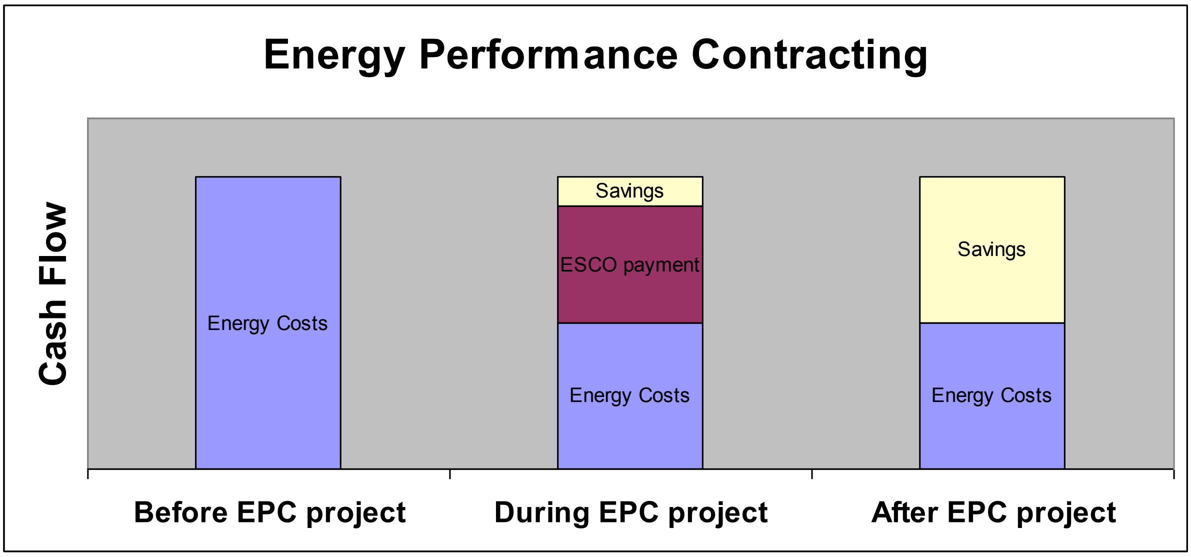

Figure 3-1-1 Energy Performance Contracting Model
Data source: Kumar 2002.

3.1.1 Classification

All EPC projects are associated with 2 types of risks: performance risks and financial risks (SEAI 2012). *Performance risk* is a risk that completed EPC project will not reach its predetermined energy savings level (SEAI 2012). Hansen (2006) claims that because of the fact that ESCO is responsible for the whole realization process of the EPC project (construction, installation of the energy efficient equipment, etc.), ESCO will have to pay a compensation fee to the customer, if the building will not comply with the energy requirements recorded in the EPC contract. *Financial risk* is a risk related with the probability that investments in the project will not return (SEAI 2012). Moreover, if investments do not return then it will be impossible to repay the possible loans.

Most of the authors define 2 basic types of EPC: guaranteed savings and shared savings (Bleyl 2008; Hansen 2006; Johnson Controls 2010). According to Singh (2010), Chauffage is the third type of the EPC model. However, Chauffage will be described separately from EPC model in the current thesis.

Shared Savings

ESCO finances the whole EPC project in this type of business model (IEA 2011). It means that ESCO has to pay for everything related with the project (planning, designing and development, procurement of the equipment and materials, salary of the workers, construction, optimization and installation of the energy efficiency improving measures, etc.). As a result of the EPC project energy cost savings are divided between ESCO and the customer according to a split, recorded in the energy performance contract. Wargert (2011) claims that shared savings are often followed with savings guarantee. The size of the savings guarantee is chosen in order to cover the desired amount of profit for ESCO and for the customer and to insure the return of the investments. Thus, if savings guarantee is used during the EPC project then ESCO will have to reach planned level of savings. Otherwise ESCO will have to compensate the difference (Wargert 2011).

Hansen (2006) states that shared savings model suits more for the developing markets, where customers do not have significant financial resources and they can not afford to pay for the energy efficiency improving project by themselves. Moreover, according to Hansen (2006), level of the awareness about EPC contracts and energy efficiency improvement technologies could be also very low on those markets. Therefore shared savings model, when ESCOs initiate the EPC projects, take all the risks and pay for everything, could be a very appropriate solution for the energy problems of developing countries. Moreover, shared savings model allows customers to receive benefits immediately after the EPC project is done, while ESCOs will have to payback the investments or return the loans to the financial institutions. Due to the fact that ESCOs need some additional time after the end of the EPC project in order to start generate the profit, shared savings contracts are usually longer than guaranteed savings contracts (Vine 2005).

According to Wargert (2011), the main disadvantage of the shared savings model is that ESCO takes both types of risks on itself: financial and performance risks. Therefore ESCO will try to avoid risky decisions as much as possible and the company will not implement the best technologies from the energy efficiency point of view, but will choose the most financially attractive ones. Due to that desired energy efficiency improvement might be not reached. However, Smith (2008) claims that because of the high risk pressure on ESCOs, only very financially stable companies are able to realize EPC projects, which in turn allows to realize large projects, which include several buildings at once or even several groups of buildings. Thereby according to Smith (2008) shared savings give an opportunity to increase scale of energy efficiency construction and renovation. On another hand as it stated by Joint Research Center of European Commission (JRC EPC 2011), such situation creates a barrier for small ESCOs to enter the market and limits the competition.

Guaranteed Savings

Customer pays for the realization of the EPC project. Moreover, ESCO's profit is also included in the customer's payment (IEA 2011). Therefore customer takes the financial risk, while ESCO takes the performance risk. Thus, ESCO is responsible for the results of the energy efficiency project and energy savings. EPC contract usually includes a guaranteed level of energy savings, which have to be reached as a result of the EPC project implementation (See Figure 3-1-1-2-1). Figure 3-1-1-2-1 shows that customer finances the whole project including ESCO's profit and if savings exceed the guaranteed level then profit will be divided between the customer and ESCO, according to predefined agreement. If ESCO fails to reach the guaranteed level then customer will get financial compensation. Such approach allows to decrease risks for the customer (ADISR 2010).

One of the main advantages of guaranteed savings model is the fact that, ESCO can choose smaller projects and be more flexible, regarding the options of the energy efficiency improving measures, because ESCO does not have so large financial obligations (ADISR 2010). Due to this ESCO is able to choose more expensive (more financially risky) EPC projects with higher energy saving potential.

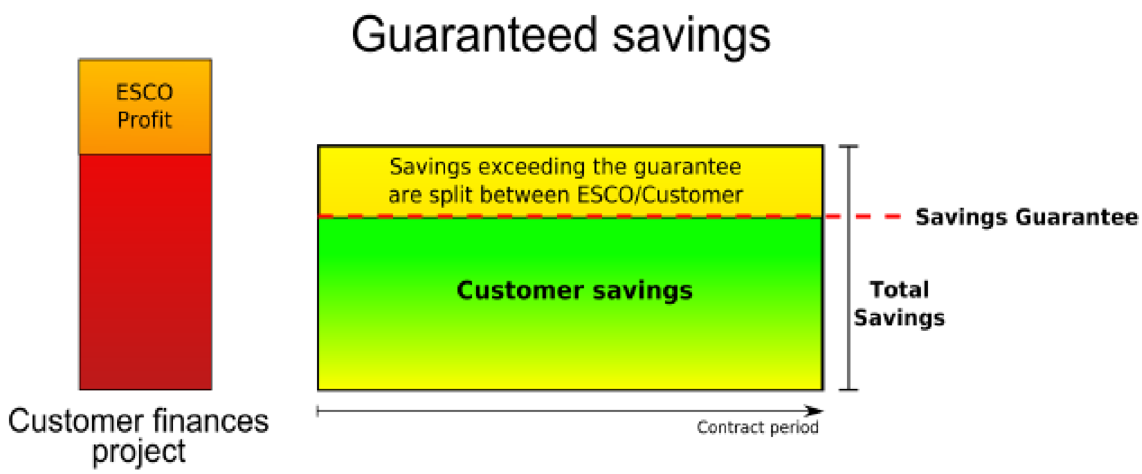

Figure 3-1-1-2-1 Guaranteed savings

Source: Wargert 2011

According to Hansen (2006), guaranteed savings model is more appropriate for the developed countries, where customers are able to afford expensive projects. Moreover, level of awareness is also a crucial factor for the guaranteed savings model, because customers should understand the potential of the energy efficient technologies well enough in order to be ready to invest their own money into the EPC project. Banks and financial institutions are also should be well developed for providing loans for the energy efficiency construction and renovation projects (Smith 2008).

3.1.2 Principle and Scope

EPC model is divided into 4 stages (See Figure 3-1-2-1). Everything starts with the preliminary analysis, when the first estimation of the energy system and energy consumption in the building is done. Goal of this stage is to find out what is the current state of the energy balance and what are the areas for improvement. The possibility of using the other energy sources is also investigated during this stage. In order to understand the energy situation in the building better and to be sure that there will not be any inconveniencies for the tenants caused by the project, several interviews with customers are carried out. The result of this stage is a project report-1 or a preliminary report (Huse 2010).

Figure 3-1-2-1 Stages of the EPC project in Siemens

Data Source: Siemens 2014

When preliminary report is done, customers and ESCO negotiate about what measures should be implemented and as a result of it a letter of intent is written (Zaitsau 2013). Customers often ask to decrease payback period to 4 - 5 years (Aberg 2014 pers. comm.), what results in smaller rate of energy efficiency technologies implementation and lower energy savings. Such approach is often called "low hanging fruits picking", because customers are usually interested only in the most cheap and easiest technologies from the implementation perspective. Later this letter of intent is used as a basis for the EPC contract.

The second stage is related with the detailed analysis (Audin 2004). Detailed energy audit is conducted on this stage. Technical installation and building's envelope are examined in order to be sure that they fit for the proposed measures in the letter of intent. The result of the second stage is project report-2 or detailed study. This report includes prices from the subcontractors and all the costs for the energy efficiency improving measure, which customer would like to implement.

The third stage is the implementation of the EPC project (Huse 2010). This stage is conducted on the basis of EPC contract, where complete list of the planned activities, subcontractors and prices is included. Several project meetings are organized during this stage in order to be sure that objectives of the project will be reached and check if works are done according to the schedule. Environment and quality managers are appointed on this stage.

The last stage is a guarantee stage (ICF International 2012). Equipment adjustment and building's energy systems optimization are conducted on this stage. Another important activity, which is executed on the last stage, is training and education. Customers, tenants and people responsible for the operation of the equipment will have several seminars, where they will learn how to maintain and further improve their energy consumption.

3.1.3 Advantages and Disadvantages

Customers

First of all, customers get their buildings renovated, which allows them to decrease their energy related costs. That's the main advantage for tenants and customers. Moreover, in case of shared savings customers do not pay for the energy efficiency renovation project, but receives benefits from it. However, in that case customers do not receive any guarantee that energy savings will be generated. Furthermore, customers are not sure about the certain amount of energy savings, which will be generated. Due to that customer's expectations might be not satisfied.

Guaranteed savings model gives an opportunity to customers to ensure that the money spent on EPC project will lead to significant improvements. The growing amount of implemented EPC projects shows that these projects actually reach its goals and awareness about it also increases. Such positive trend could create an opportunity for developing EPC projects with a longer-term duration, longer payback time and higher price, but with much higher energy savings level. However, EPC model in the renovation sector of residential buildings is not so well developed in comparison with public and commercial buildings. It is related with the fact that EPC project could be rather expensive and private customers are not able to pay a big sum of money at once. Due to that shared savings model could be a solution, because financing will be provided by ESCO.

ESCOs

All EPC projects are profitable for ESCOs. In case of shared savings, when ESCO is responsible for the whole energy efficiency renovation process, amount of generated energy savings and profits, depends on ESCO and its decision. Thus, ESCO has an opportunity to plan his economic activities, according to results of different EPC projects. In case of guaranteed savings, ESCO has obligations to customers, but then ESCO's profit is also guaranteed, because it is included in the customer's payment.

EPC contracting is a complex process, due to that developing a big amount of individual projects for private customers could be slowed down. On another hand it might create a specific market niche for recently created ESCOs, which do not have big financial resources for implementing huge projects for public and municipal buildings. But their small size and higher flexibility in comparison with older market participants (Schneider Electric, YIT and Siemens) could be used in providing individual EPC projects as a competitive advantage.

Municipalities

Advantages of using EPC business model in public buildings sector are quite obvious. Its implementation allows to reach significant results in energy savings with the private funds usage. Moreover, it is much easier for municipality to take some loans with a better (lower) interest rate than for a private company or a citizen. These factors explain why EPC model in Sweden is mostly used only in renovation projects of public and municipal buildings.

3.2 Chauffage

Chauffage is one of the oldest business models associated with energy services (Fawkes 2007). This model appeared in France, but then got commonly known all over the world. Chauffage is a French term, which literally means "heating" (Energy Terminology 1986), however there are other variants of terminology, which is used in literature to describe the same financial model. For example, comfort contracting (JRC 2014), function contracting (Anwar and Capehart 2007) or energy service contracting (HSA 2012). However, for the purposes of this thesis Chauffage will be used as a main term.

3.2.1 Classification

Chauffage is a business model, which core concept is that ESCO is fully responsible for providing an energy function. By energy function most of the authors mean an energy related assets, for example, certain lightning level, room temperature, air quality or even motive power in case of commercial or industrial buildings (Fawkes 2007). According to Chauffage model, ESCO is responsible not for providing energy savings as it is for EPC model, but for providing an energy function on a lower price than it was before contracting. For example, ESCO could be responsible for keeping a constant temperature in the room throughout the year and a customer will pay for it less on the monthly basis than the customer was paying for heating before signing a Chauffage contract. ESCOs are very often responsible for the whole cycle of energy management, including fuel purchasing, energy production, distribution, service and maintenance of the equipment. Due to this, Joint Research Center (2014) calls Chauffage an "extreme form of energy management outsourcing". Chauffage model cannot be divided into different types, due to that Chauffage will be described here as single concept.

3.2.2 Principle and Scope

Chauffage model starts with an energy audit. ESCO identifies current energy consumption level and the price, which customer pays for the consumed energy. Based on the collected data ESCO proposes a new price for a function per square meter. According to Anwar and Capehart (2007), the price proposed by ESCO is usually 5-10% lower than it was before contracting (see Figure 2-2-2-1). However, Studebaker (2012) claims that the difference in price before and after Chauffage contracting could vary from 10% to 30%. Due to this, it is more beneficial for a customer to sign a Chauffage contract than to continue paying in a classic way. For example, if customer was paying 100 Euros for heating, then after signing a Chauffage contract the new price will be 90 Euros for keeping inner temperature at level of 23°C (or any other predetermined by Chauffage contract temperature). Another classic example of Chauffage services is providing lighting at a certain amount of lumens.

In case of Chauffage contracting a customer do not need to be concerned about any factors, which could influence energy consumption or energy price. The price of the energy function, which customer pays to ESCO, will always be the same, even if winter is very cold and heat demand rises or summer is too hot and air conditioners require more energy than usually or there are some disturbances on the energy market, which lead to changes in fuel prices. All these factors could influence operational costs of providing an energy function, which mean ESCO's profit will also fluctuate (see Figure 3-2-2-1), because ESCO is responsible and pays for everything related with providing an energy function to a customer.

However, ESCO does not have to conduct the whole energy supply chain by itself. Any of the stages of the energy supply chain (fuel purchasing, energy production, energy distribution, equipment maintaining and operation control) could be outsourced. Although ESCO will still be responsible for outsourced stages towards the customer. If something goes wrong on the outsourced stages, ESCO will have to compensate probable losses to the customer. The most common way of Chauffage model implementation is when fuel consumption and energy production are outsourced, but ESCO installs technical equipment on site (in the building), conducts operational control of it and monitors the current state of energy function (temperature in the room, illumination level, etc.) in order to adjust and maintain the equipment when needed. Technical equipment could include ventilation systems, water and heat pipes, water heaters, air conditioning systems, thermo controllers, windows, wall insulation, monitoring systems, etc.

The typical payment structure from the customers perspective is presented on the Figure 3-2-2-1. Customer's payment is decreased after Chauffage contract is signed, but now it consists of operation costs coverage and ESCO's profit.

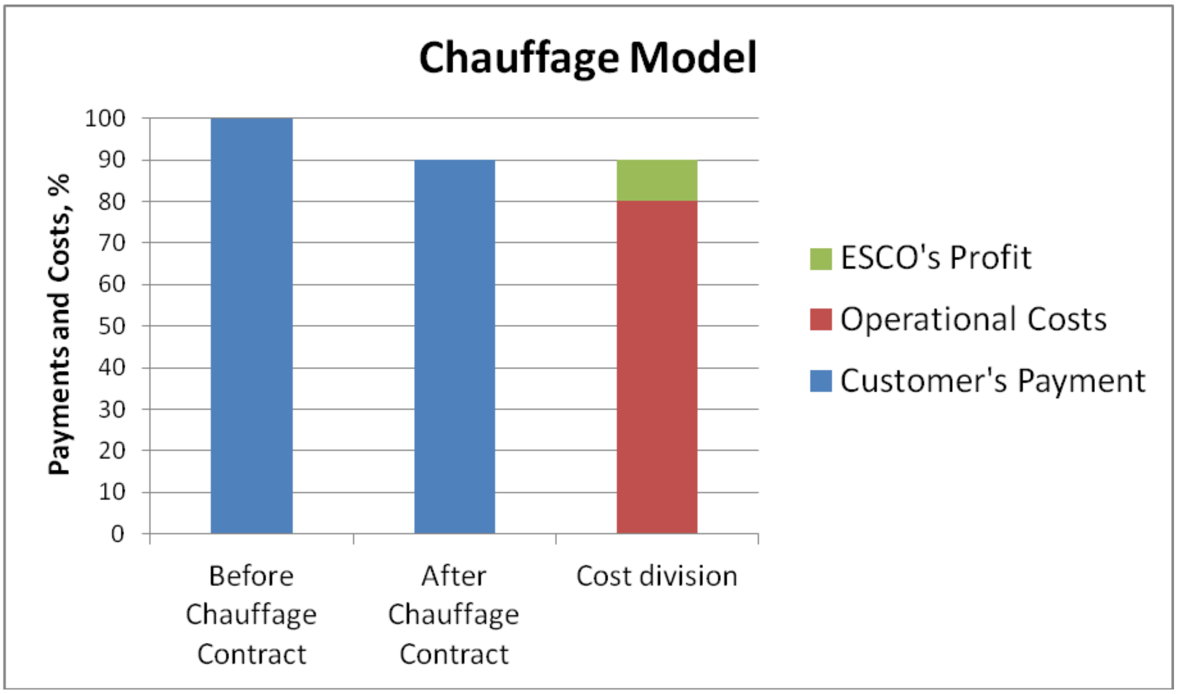

Figure 3-2-2-1 Chauffage Model

Data Source: Studebaker 2012

Due to the high price of installations, Chauffage contracts are usually rather long 20-30 years (Hansen 2011). Such long duration of the Chauffage contract allows ESCO to compensate costs of the initial technical equipment and adjust all the installations for the more effective work. The need of adjustment is usually related with the behavioral aspect of the energy consumption and technical features of working of new equipment. Monitoring system helps to overcome both these aspects and decrease operational costs as much as possible. Moreover, such long duration of the Energy contract allows to compensate all the fluctuations in energy and fuel prices related with market instability or weather conditions. However, Fawkes (2007) claims that in case when new technical installations or significant changes in the supply side are not required, the duration of the Chauffage contract could be shortened to 3-5 years.

As it follows from the Figure 3-2-2-1 and description of the Chauffage model above, the less operational costs are, the higher profits will be received by ESCO. Moreover, due to the fact that a customer pays not for amount of consumed energy, but for an energy function per square meter, ESCO's income will be the same, even if energy consumption drops down. All these factors create a very strong motivation for ESCO companies to implement and finance energy renovation projects.

Typical Chauffage renovation scheme could be divided into several stages (see Figure 3-2-2-2). On the initial stage Chauffage contract is signed, according to it, ESCO will pay for all operational costs. ESCO's profit is calculated as the difference between predetermined price for an energy function and operational costs. During this stage energy audit is conducted and potential for the energy consumption reduction is defined.

On the next stage energy renovation project is implemented. Chauffage energy renovation projects are usually financed only by ESCOs. It allows to ESCOs not show their operational costs to the customers, which provides an opportunity to set higher prices for the energy functions. On another hand it makes Chauffage more suitable for the residential sector, because average citizens do not usually have big amounts of money for the whole renovation project. Moreover, it is easier to implement such projects in comparison with other business models, because deep involvement of the customer is not required, due to the fact that major portion of the renovations are related to the technical and supply side of the energy cycle. Therefore such renovations are mostly "hidden" from the customer's perspective. If the energy renovation project is rather big and an ESCO is not able to finance it all by itself, ESCO might use other financial models in order to attract additional financing, for example, preferential loans, credits and risk sharing.

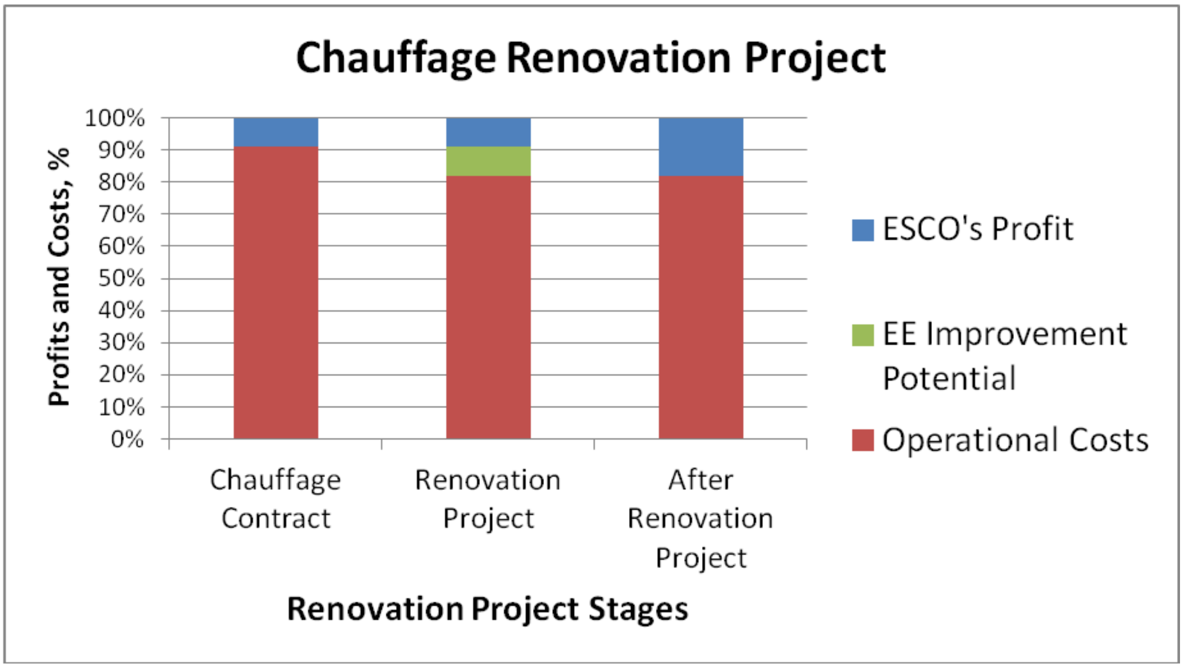

Figure 3-2-2-2 Chauffage Renovation Scheme

Data Source: Anwar and Capehart 2007

The last stage of the Chauffage renovation scheme is realized after the renovation project (see Figure 3-2-2-2). On this stage adjustment of the new technical equipment is done. Another important aspect of the energy efficiency improving process on this stage is education of the tenants. ESCOs organize special seminars for tenants in order to teach them how to use new equipment rationally and further decrease their energy consumption.

3.2.3 Advantages and Disadvantages

Customers

All financial costs for the renovation project are paid by ESCOs, which is beneficial for customers and tenants. Due to that financial involvement of the customers is minimized, which makes this model especially suitable for the residential sector, where financial resources of the customers are limited.

The main disadvantage of the Chauffage model is weak incentive for customers to behave in a more energy efficient manner, because their monthly energy payment does not depend on the amount of the consumed energy. However, this problem could be solved by the educational program or a seminar conducted by ESCOs or any other parties interested in the energy demand reduction in residential sector (for example, municipalities or NGOs).

ESCOs

One the main advantages of the Chauffage model is the strongest incentive for ESCOs to implement energy renovation projects, because ESCO's profits are in direct relation with operational costs. Which means their improvement in building's energy efficiency will increase the amount of revenue an ESCO earns.

It also simplifies the renovation project, because less cooperation between ESCO and customers is required. There is no need to determine an energy baseline as it was for the EPC model, because all payments are made for a unit of an energy function according to the contract.

Another important positive aspect of the Chauffage model was discussed on the World Sustainable Energy Days 2014 conference in Austria. Mr. Moritz (2014) during his presentation on this conference called Chauffage "energy model of the future". During our personal communication Mr. Moritz (2014) stated that energy market is shifting from the centralized to the decentralized state. Moreover, a new role of the ESCO companies appears - to sell energy functions. The combination of these 2 factors: decentralization and usage of energy functions, allows ESCO companies to replace conservative energy production and distribution unities by a modern ones during energy efficiency renovation projects. For example, typical heating systems could be replaced by steam heating or compressed air heaters. Therefore, Chauffage model supports innovation of the energy efficient technologies and helps to increase their implementation rate in the public and residential buildings sectors.

Municipalities

Chauffage model is beneficial for municipalities in case of non-residential buildings, because it simplifies the payment process for electricity or heating. If there is a building, where no one lives (for example, office or shop) and there are certain hours when this energy function is required, then the monthly payment significantly decreases due to more efficient approach of providing this energy function. However, Chauffage model does not have any specific advantages or disadvantages for municipalities.

3.3 Preferential Loans

Preferential loans model is a business model for financing energy efficiency improving projects (Kats et al. 2011). Different terms could be met in literature, which has the same meaning, for example, dedicated credit lines (IEA 2011) or soft loans (ACE 2013).

Preferential loans model is used rarely as an individual business model, but it could be applied as supplementary financing scheme. It is useful especially for big and expensive projects. It is a rather beneficial model for ESCOs, because it gives an opportunity to them to implement more expensive projects with higher energy saving potential and higher profits. ESCOs do not always borrow money by themselves. Sometimes municipalities or individual customers could borrow money from the financial institutions and forward it to ESCOs as a payment for energy efficiency renovation project implementation.

3.3.1 Classification

The core idea of this business model is that financial institutions (usually banks or credit organizations) lend money for energy efficiency improving purposes to energy service companies or construction companies on a lower rate of interest than ordinary consumer credits (ACE 2013). Preferential loans model cannot be divided into different types, due to that it will be described in the thesis as single concept.

3.3.2 Principle and Scope

On the first stage of Preferential loans model financial institutions receive funds from the public partner (municipality or national government). Due to that banks are able to decrease their interest rate. There is usually some governmental energy efficiency programme or a regulation, which initiates this movement of finances from state authorities to financial institutions. Due to that, on the second stage banks can pass these funds further to ESCO companies or customers, which in turn will pay by this money to ESCOs (see Figure 3-3-1). Loan agreement is signed on this stage between the financial institution and the borrower. All the details about party's obligations are described in this agreement, including the interest rate and the payback period. The last stage is the implementation stage of the energy efficiency renovation project. ESCO implements all energy efficiency improving measures according to the signed contract. Another important aspect, which is realized on the last stage is that the payback process starts on this stage. Money generated by the received energy savings will be returned to the financial institutions according to the loan agreement (ACE 2013).

Figure 3-3-1 Funds Movement in Preferential Loans Model

Data Source: Kats et al. 2011

Yeh (2013) claims that preferential loans business model is more suitable for immature markets, where there is a serious lack of financial resources for energy efficiency improving projects. Moreover, financial institutions of the immature markets do not completely understand the necessity and problems of the energy efficiency renovation projects, due to this banks require a slight push from the government in order to start investing in such projects. However, Kats (2011) suggests that preferential loans model could be still very useful even on mature markets like Swedish, because it allows to increase available funds for energy efficiency improvement and to collect investments for implementation of very big and expensive projects cannot be financed by only one market player.

There are several banks in Europe, which use preferential loans model. One of them is European Investment Bank (EIB). The amount of money which EIB lent for the energy efficiency renovation projects has been decreasing in the last three years. It is related with the global financial crisis, however the amount of invested in the energy efficiency projects is still rather significant: 2.4 billion EUR in 2010, 1.2 billion EUR in 2011 and 0.8 billion on 2012 (Six 2014). Six (2014) emphasizes that current business model could be applied only to big projects or group of projects, due to this preferential loans model could not be used for individual residential projects. However, it perfectly suits big energy efficiency renovation projects of the whole residential districts or even municipalities.

Six (2014) defines the minimum limit of required investments into the energy efficiency renovation project as 100 million EUR. Otherwise banks are not interested in investing into the project, because financial and time costs for finding and assessing several small projects become much higher than for one big energy efficiency improving project. However, Six (2014) states that the financial stream (see Figure 2-3-1) could be prolonged by adding additional smaller banks. Thus, a big national bank, which received funds from the government will divide it into several smaller sums and provide it to local or regional banks, which in turn will invest it into small or medium-scale renovation projects.

According to Bullier and Milin (2013), projects, which are aiming to receive financing through preferential loans business model, should fulfill several requirements:

- planned amount of energy savings should satisfy bank's energy efficiency requirements;
- be financially viable;
- be technically achievable;
- have a feasible payback period;
- at least 25% of the project must be financed by the customer or ESCO itself.

3.3.3 Advantages and Disadvantages

Customers

Preferential loans is rarely used by individual customers for private residential energy efficiency renovation projects, because banks or other financial institutions are not interested in financing many small energy efficiency renovation projects. For financial institutions such projects are not cost effective. Moreover, in order to get funds, customers have to provide documents, which give a guarantee for financial institutions about customer's ability to pay and insure that borrowed money will be returned. All of these factors make Preferential loans an expensive and complicated model from the customers perspective.

ESCOs

Preferential loans model allows ESCOS to attract additional financing for energy efficiency renovation projects. Such additional financing gives an opportunity for ESCOs to implement more energy efficient technologies, generate additional energy savings. Thus, residential energy efficiency renovation projects become more profitable. Moreover, the current model allows to stimulate participation of the financial market members in energy efficiency improving activities, which attracts attention to the renovation sector and brings new customers to ESCO companies.

However, there are also several disadvantages. First of all, because initially money is provided by government, its involvement is obligatory in the process of project's implementation, which makes such model non-flexible and costly. Furthermore, due to the fact that banks are interested only in very big projects, it could create troubles in getting financing support for individual residential projects. Finally, application of Preferential loans model makes the whole renovation project more costly, because money must be returned to the financial institution with a specific interest rate.

Municipalities

Preferential loans model is a rather useful model for municipalities, because banks and other financial institutions willingly work with municipalities, due to the fact that if the project will not be successful and will not reach its energy goals then all costs will be covered by municipal or governmental budget. On another hand municipal energy efficiency renovation projects are usually initiated by some state energy policy or goal. In that case municipalities are able to attract large funds for big projects with high energy saving potential and full fill the energy goal in the shortest period of time.

4 Energy Service Companies

This chapter will include description of the ESCO concept and real life examples of the conducted residential ESCO energy efficiency renovation projects in Sweden. According to the developed methodological framework, PEST analysis will be applied. Due to this findings from the research will be divided into 4 sectors: political, technological, economic and social.

4.1 ESCO Concept

There are different definitions for the Energy service company (ESCO) or Energy Savings Company in different literature sources (NAESCO 2009, JRC 2014, EUBAC 2013). However, for the sake of the current thesis the broad definition will be used: ESCO is a commercial or non-profit organization, which provides energy services (Hopper et al. 2005). In turn energy service is any kind of service related with energy and energy systems, which leads to improvement of energy efficiency and reduction of energy consumption (Goldman et al. 2002). Thus, ESCO is a company, which core business is related with design, financing, implementation, risk management and control of the energy projects, renovation of the energy systems, maintaining of the energy equipment, energy supply and distribution and energy audit. There is also another term, which could be met in literature (Ma 2013) - Energy Management Company (EMC or EMCO), but it has absolutely the same meaning as ESCO. Thus, for the sake of this thesis generally accepted abbreviation ESCO will be used.

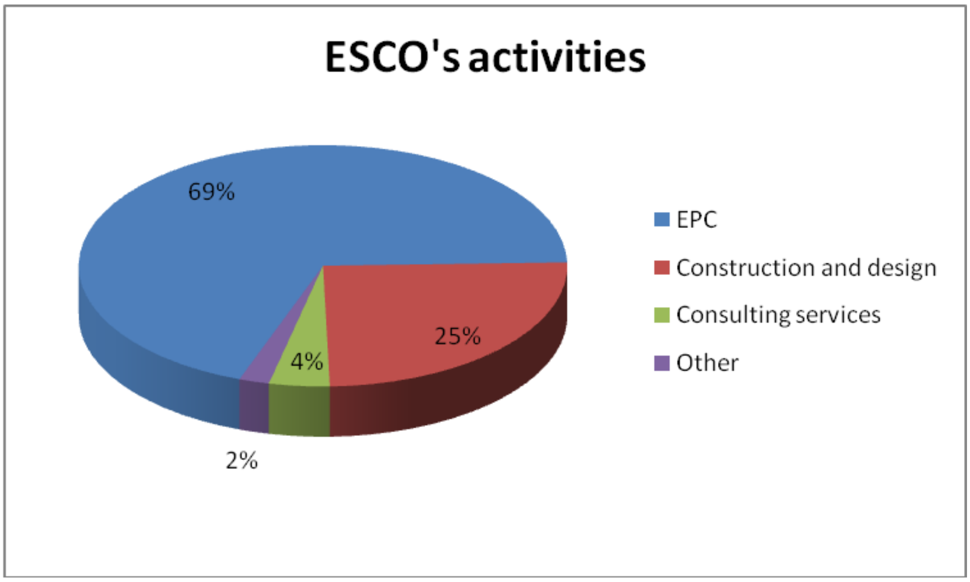

Figure 4-1-1 ESCO's activities

Data Source: Hopper et al. 2007

According to Hopper (2007), most of the activities conducted by ESCOs are related with energy performance contracting - about 69%, after that goes construction and design activities (see Figure 4-1-1). Thus, EPC is a very important part of ESCO's business and the amount of profit, which ESCO is going to earn, depends on effectiveness of EPC projects. Bertoldi and Rezessy (2005) stated that the main difference between ESCO and other types of business companies is that ESCO provides an energy savings guarantee and could participate in the project's financing. Such approach makes ESCO more like an energy partner to the customer. Due to this JRC (2014) marks out 3 main characteristics of the energy service companies:

- ESCOs gives a guarantee to decrease energy consumption and generate energy savings or at least keep energy consumption on the same level;

- ESCO's profit has a direct relation with amount of energy savings;

- ESCO could invest its own money into energy efficiency improving projects or help to find additional finance sources for the customer by providing an energy savings guarantee.

The first appearance of ESCOs is related with the energy crisis in 1970s (Vine 2005), when price for energy significantly increased and the need in energy savings occurred. With the development of technologies the need in building renovation and equipment replacement started to grow. Projects conducted by ESCOs became much more complicated and diversified (EUBAC 2013). The most recent definition of ESCO is provided in the European Union directive 2006/32/EC, which regulates current energy service market in EU. "Energy service company (ESCO): a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria".

Most of the ESCOs could be divided into two types (Dressen 2011). The first type of ESCOs works on the supply side of the energy system. Such companies produce energy and distribute it to the customers. Thus, supply ESCOs are making money from the selling energy units (kWh) to the customers. Due to that reduction of the energy consumption will cause a decrease in the company's profits. The second type of ESCOs is concentrated on the demand side of the energy system. Companies of the second type generate their profits from the energy savings, which means that the more efficient is the energy efficiency improving project, the more profit will the company make.

4.2 Siemens Case

Siemens is an international company, which works in different sectors of economy, for example, electrical engineering, manufacturing of electronic, energy and power equipment, transport and lightning technologies. Siemens is presented in 190 countries (Siemens Global Website 2014), including Sweden. Siemens in Sweden is mainly concentrated on the energy sector, healthcare sector, industry sector and infrastructure sector. One of the core Siemens's business activities in Sweden are production and distribution of the energy efficient technologies. Siemens provides different kinds of services, which ultimate goal are to decrease customer's energy consumption. Due to that Siemens is an undoubted example of the ESCO companies.

Siemens differentiate such terms as Energy Performance Contracting (EPC) and Performance Contracting (PFC). By EPC Siemens means only consulting service, which helps customer to procure the energy project and make smart decisions about customer's energy system. By PFC Siemens mean a business model, when ESCO signs a contract with a customer, guarantees certain amount of energy savings, implements an energy efficiency project and receives profit from the generated energy savings (see Figure 4-2-1.). Thus as it was shown in the second chapter of this thesis, what Siemens calls PFC in most of the literature is called Energy Performance Contracting. In order not to create misunderstanding for the goals of this thesis terminology generally accepted in the literature will be used. Therefore the business model, which is executed by Siemens, is EPC and consulting services will be treated separately in this thesis.

Siemens is one of the biggest members of the Swedish buildings energy renovation market. Currently Siemens handle approximately 6 million m^2 of renovated buildings, which results in about 100 million SEK (11 million Euros) generated by the saved energy. Siemens's renovation projects in the residential sector could be divided in 2 groups: projects, where renovation only of the residential buildings is done and big projects, which include renovation in the residential sector. For the sake of this thesis both these types will be described in the following sections.

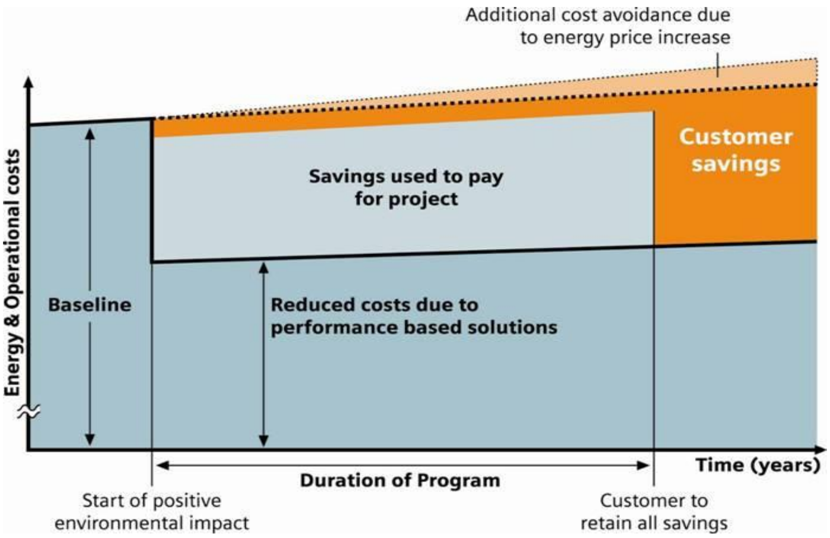

Figure 4-2-1 Performance Contracting (PFC)
Source: Siemens 2014

4.2.1 Political Aspects

Due to the fact that Siemens uses typical EPC model for their residential energy efficiency renovation projects, than it is appropriate to describe how EPC model developed and by what legislative acts it is supported. Such description will be in this chapter, even though it is applicable not only for Siemens's projects, but for all EPC projects.

Legislation

European Union Directive 2010/31/EU on the energy performance of buildings emphasis the importance of improving energy efficiency in buildings. The Directive (2010) states that the energy performance of buildings has to be measured and verified. This Directive created a basis for the future EPC implementation and development in member states of European Union, because member states developed their own legislative acts on measuring building's energy performance. After building's energy performance was measured, a necessity of energy efficient renovation became obvious.

Energy Efficiency Directive (2012/27/EU) was issued in 2012. According to Energy Efficiency Directive (2012), EPC is "a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings". Moreover, EU member state has to make an energy efficient renovation of the public buildings and organize and institutional framework for financing energy efficient projects (EU Directive 2012/27/EU). In addition to that a new Energy Performance Contracting Campaign (EPCC) is under development and negotiation right now (European Commission Website 2014). The Goal of the campaign is to increase awareness in member states about availability of EPC models and to stimulate its implementation. Seminars and training sessions are going to be organized on national and local levels throughout European Union member states in 2014 (European Commission Website 2014).

EPC in Sweden

EPC model development in Sweden could be divided into 2 phases. The first EPC contracts implementation started in late 70s/early 80s. At that time EPC was a Swedish government's response on oil crisis and growing share of nuclear power in the country's energy mix. However, EPC programme did not bring expected results and trust of the society in such measures was significantly damaged (Lindgren and Nilsson 2010). As a result EPC concept disappeared for the next 20 years. The second phase of the EPC development in Sweden started about 2000 (see Table 4-2-1-2-1). Since then Swedish energy market grown up, it became more stable and economically successful. Energy price rose significantly. Moreover, environmental issues became more important for society and awareness of people about energy efficiency and sustainability concepts also increased. All these factors created a base for the EPC model implementation in Sweden (Wik and Evander 2013).

There are several ESCO companies working on the Swedish energy market. Here is the list of the main market members: Schneider Electric, E.ON and Siemens (Wargert 2011). Competition between ESCOs is increasing. New market participants appear and decrease the market share of the biggest three companies (Wik and Evander 2013). The most wide spread EPC model in Sweden is guaranteed savings (Lindgren and Nilsson 2009). Such choice allows Swedish ESCOs to decrease their risks and sign longer term contracts. It is a rather popular scheme for the energy efficiency improving renovation of the existing buildings (Karlsson

2013), however, many construction companies choose to use their own financial resources with a lower rate of implemented energy savings (Togero 2013).

Table 4-2-1-2-1 Implemented EPC projects in public sector in Sweden

Year	Number of EPC projects	Projects' area,m^2
2001	2	75 000
2002	4	491 000
2003	4	219 000
2004	9	962 000
2005	11	893 000
2006	12	2 115 000
2007	7	2 478 000
2008	13	4 175 000
2009	12	2 148 000
2010	2	229 000
2011	7	1 575 000

Data source: Swedish Energy Agency 2011

EPC model have a big potential for the future development in the Swedish building sector. Swedish Energy Agency (2011) claims that the benefit from the realization of the EPC projects is 4 TWh of saved electricity. For comparison annual energy consumption in Swedish residential sector was 147 TWh in 2011 (Swedish Energy Agency 2012). According to Schneider Electric (2010), average amount of saved energy by ESCOs is about 20-25%.

ESCOs in Sweden

First European Union Directive, which aimed to improve energy efficiency in buildings, was issued in 2002 (EU Directive 2002/91/EC). According to that directive, EU member states have to develop their own action plans on the energy efficiency improvement in buildings and provide energy declarations of the newly constructed buildings. In order to comply with this directive and reach EU goals of 20% energy efficiency improvement up to 2020, Swedish national Energy Performance in Buildings regulation was implemented in 2006 (SS 627750:2003), but initially only public buildings larger than 1000 m^2 had to declare their energy performance. The situation changed in 2009, when Sweden expanded scope of the regulation and since then all buildings, which are sold, constructed or significantly *renovated* have to provide an energy performance declaration. Thus, ESCOs, which are implementing big energy efficiency renovation projects, have to submit the energy performance declaration. Such declaration includes information about energy consumption level in the building, results of inspection of the building's ventilation system and an energy baseline for comparison of current level of energy performance with the same indicator from previous years. Energy performance declaration could be prepared only by organizations, which are certified by Swedish government.

Moreover, special technical requirements were set for buildings, which energy declaration is going to be submitted. For example, there maximum limits for roof's and wall's thermal insulation in Wt/m^2 per °C.

Next revision of the law happened in 2011. According to it, energy performance of the newly constructed buildings larger than 100 m^2 has to be evaluated. According to Wik (2013), 80% of evaluated buildings do not comply with the initial energy requirements. However, there are no obligations in the law for ESCOs to renovate the buildings with high energy consumption.

Swedish policy on municipal level is presented by Second Energy Action Plan (ER2010:32). According to it, 10.8 million EUR per year are provided to municipalities for energy efficiency improvement purposes Swedish Energy Agency. Municipalities spent this money via tender, where local authorities identify the best energy efficiency renovation project. Some of such projects will be presented further.

ESCO companies also have some individual regulations and standards (Siemens 2014, E.ON 2014), however, these regulations are not available, because they are classified.

4.2.2 Technological Aspects

As it has been already mentioned, Siemens implements energy efficiency renovation projects, which could be divided into 2 types: renovation of the whole municipalities (public, commercial and residential buildings) and renovation of only residential buildings. All projects conducted by Siemens and related with energy efficiency improvement in residential buildings and specific technologies, which were used in that projects, will be described in this section.

Strictly Residential Projects

Totally data about 16 energy efficiency renovation projects conducted by Siemens in the Swedish residential sector was collected. Compilation of the strictly residential projects is presented in the Table 4-2-2-1. This table includes only that technological solutions, which were used in more than two residential energy efficiency renovation projects. For the whole description of the projects (full list of technological solutions, year when the contract was signed, number of renovated apartments, etc.) see Appendix B.

Table 4-2-2-1 List of residential projects conducted by Siemens in Sweden

№	**Project Reference**	**Location**	**Area, m²**	New building automation system	Energy system adjustment for the operation efficiency	Adjustment of the radiators' temperature	Water saving measures	Adjustment of the heating system	New air handling units with heat recovery and demand control	Ventilation control system

					improve ment					
1	AB Hultfreds Bostäder	Hultsfred	16 930	YES	YES					
2	AB Svenljunga bostäder	Svenljung avägen	21 893	YES	YES	YES	YES			
3	Brf Riddarspor ren	Norrtälje gatan	11 000	YES	YES	YES		YES	YES	
4	Brf Väduren	Haninge, Stockhol m	69 000	YES	YES		YES			YES
5	Bågen 233 Brf	Stockhol m	37 160		YES			YES	YES	YES
6	Hallbo	Hallsberg	134 000	YES	YES					YES
7	HSB Hallsberg	Hallsberg	13 400	YES	YES		YES			YES
8	Norabostä der AB	Nora	15 548	YES	YES			YES		YES
9	Norabostä der AB, Gyttorp	Nora	10 913	YES	YES			YES		YES
10	Nordostpas sagen 3659	Göteborg	22 000	YES	YES				YES	YES
11	Nordostpas sagen Brf	Göteborg	19 000	YES	YES				YES	
12	Sandvikenh us 2	Sandvike n	33 789	YES	YES		YES			YES
13	Sandvikenh us AB	Sandvike n	44 000	YES	YES		YES		YES	YES
14	Simrisham ns Bostäder AB	Simrisha mn	44 000	YES	YES	YES			YES	YES
15	Sunne Bostads AB	Sunne	34 000	YES	YES				YES	
16	Vårgårda bostäder	Vårgårda	25 470	YES	YES		YES			YES

Data source: Aberg 2014 (personal communication)

Municipality Renovation Projects Conducted by Siemens in Sweden

Several residential renovation projects were described in the previous section. However, the most common type of building's energy renovation in Sweden is renovation initiated by local municipalities. Swedish State Government set a target to reduce energy consumption per heated unit in residential and commercial buildings sector by 20% up to 2020 and by 50% up to 2050 in comparison with energy consumption level in 1995 (Swedish Energy Agency 2014). In order to achieve this ambitious goal many Swedish municipalities made a decision to implement complex renovation projects for the whole cities. Such projects usually cover different public buildings such as schools, hospitals, sport facilities, etc., but residential buildings are also included in the renovation plans.

Local authorities make a tender for the best energy efficiency renovation project and sign a contract with the winner. Totally data about four municipality energy efficiency renovation projects conducted by Siemens in Sweden was collected. Compilation of the municipality renovation projects is presented in the Table 4-2-2-2. This table includes only that technological solutions, which were used at least in two municipality renovation projects. For the whole description of the projects (full list of technological solutions, year when the contract was signed, list and amount of renovated buildings, legal contract relationship description) see Appendix C.

Table 4-2-2-2 List of municipality renovation projects conducted by Siemens in Sweden

Project Reference	**Area, m²**	New building automati on system	Energy system adjustment for the operation efficiency improvement	Ventilation control system	Oil usage minimi zation	Roof insulation	Direct electric heating replacement by the water-based heating
Vellinge Municipality	120 000	YES	YES				
Karlstad Municipality	330 000			YES	YES	YES	YES
Landskrona Municipality	160 000	YES	YES	YES	YES		
Umea Municipality	425 000		YES	YES			YES

Data source: Aberg 2014 (personal communication)

4.2.3 Economic Aspects

Siemens has a special department in its organizational structure, which task is to deal with energy services. The department is called Building Performance & Sustainability (BPS). This department includes sales personnel and energy engineers, who works with clients and prepare documentation for the projects. Both customer and Siemens could be an initiator of the project, but it usually depends on the project type. If it is a small renovation project for a single residential house than commonly the client is the one who comes to the sales manager and asks energy engineers to calculate potential benefits and energy savings amount from the implementation of the project. However, if it is a big project for a buildings association or even for a whole municipality than sales personnel could be an initiator of the project. When contract is signed, the project will be implemented by technicians and subcontractors. Head of the energy efficiency project is a project manager, who is responsible for the whole execution process of the project. Such developed structure of the BPS department shows that energy efficiency projects are important for the company and Siemens pays significant attention to it.

Regarding energy efficiency improvement in residential buildings, Siemens provides a list of the energy services, which consists of monitoring and control of the energy system and energy usage in the building, energy audit, adjustment and optimization of the energy system, maintenance and renovation of the current energy equipment and, of course, installation and replacement of the new energy supply equipment. Apparently, different energy services require different amount of investments and have different payback period. The relation between payback period and potential energy savings of the different energy services is presented in Figure 4-2-3-1. Thereby renovation projects have the highest energy savings potential up to 45%, but the payback period is also rather long. According to information received from Siemens, average payback time of the energy efficiency renovation projects in residential sector in Sweden is 6-7 years, which is a rather good indicator, because average payback period for such types of energy efficiency renovation projects is about 10 years (Swedish Energy Agency 2012).

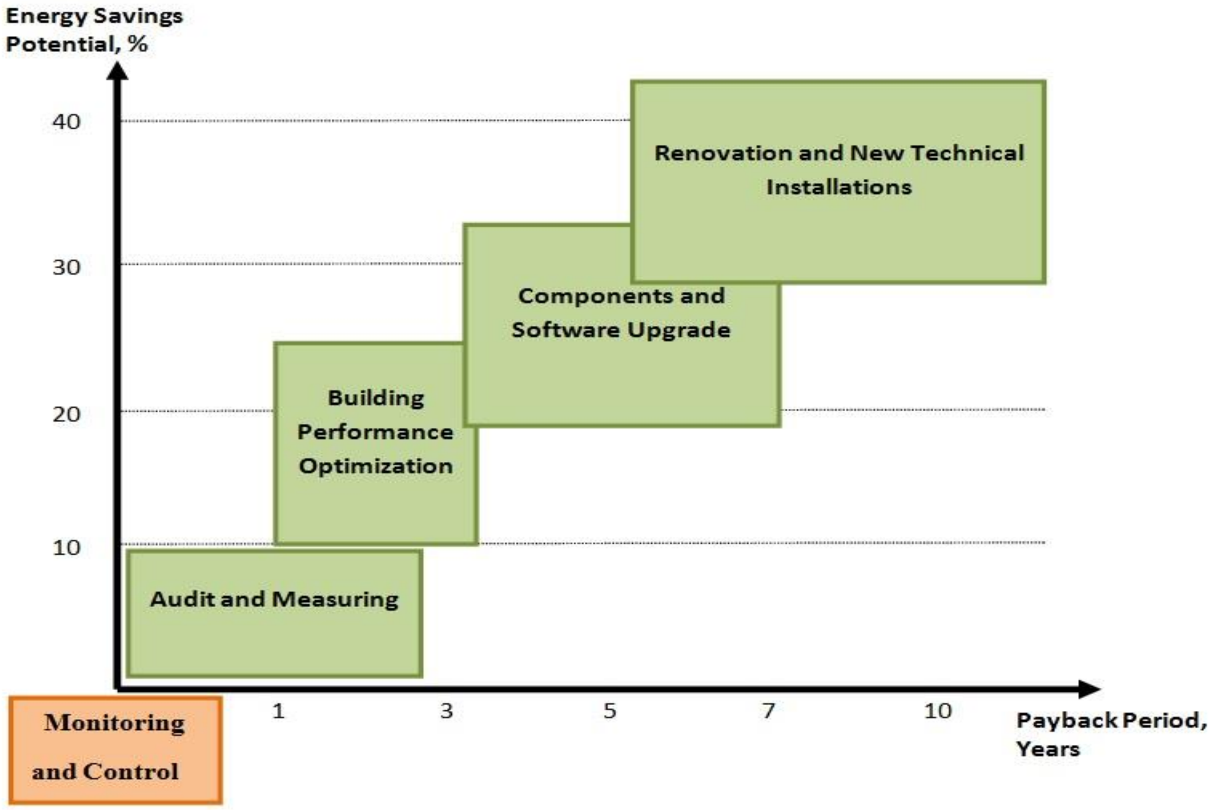

Figure 4-2-3-1 Energy Services Potential and Payback Period

Source: Siemens 2014

Collected data about results of the implemented by Siemens energy efficiency renovation projects in residential sector are presented in Table 4-2-3-1. However, a significant part of information is not available due to the fact that it is a classified information.

Table 4-2-3-1 Siemens's results of the residential energy efficiency renovation projects

№	Project Reference	Energy savings, %	Energy Savings, EUR	Investment costs, EUR	Payback period, year
Residential Projects					
1	AB Hultfreds Bostäder	48	N/A	N/A	N/A
2	AB Svenljunga bostäder	14	N/A	N/A	N/A
3	Brf Riddarsporren	36	N/A	N/A	N/A
4	Brf Väduren	21	N/A	N/A	N/A
5	Bågen 233 Brf	N/A	79 000	600 000	N/A

6	Hallbo	19	N/A	N/A	N/A
7	HSB Hallsberg	26	N/A	N/A	N/A
8	Norabostäder AB	21	N/A	N/A	N/A
9	Norabostäder AB, Gyttorp	23	N/A	N/A	N/A
10	Nordostpassagen 3659	25	N/A	N/A	N/A
11	Nordostpassagen Brf	31	N/A	N/A	N/A
12	Sandvikenhus 2	15	N/A	N/A	N/A
13	Sandvikenhus AB	15	N/A	N/A	N/A
14	Simrishamns Bostäder AB	25	N/A	N/A	N/A
15	Sunne Bostads AB	20	N/A	N/A	N/A
16	Vårgårda bostäder	18	N/A	N/A	N/A
Municipality Projects					
1	Vellinge Municipality	26	N/A	N/A	N/A
2	Karlstad Municipality	N/A	850 000	8 500 000	10
3	Landskrona Municipality	N/A	700 000	6 300 000	9
4	Umea Municipality	N/A	1 120 000	13 700 000	11,8

4.2.4 Social Aspects

Siemens does not implement any activities related with the social sphere on a regular basis. However, some of the projects conducted by Siemens in residential sector (for example, projects in Karlstad Municipality, Sunne Bostads AB and Norabostader Ab) had training courses and seminars for tenants and maintaining staff. Sometimes it is related with the replacement of the old energy equipment as it was for Sunne Bostads AB project. Thus, Siemens needs to train operator to use new equipment. Sometimes such seminars are financed by municipality and aim to change tenant's behavior to more sustainable and energy friendly, as it was for Karlstad Municipality.

4.3 E.ON Case

E.ON is an international electric and utility service provider. Its core business is energy providing. Thus main profit source for the company is selling kilowatt hours of electricity and district heat. E.ON in Sweden decided to broaden their business portfolio about 6 months ago and to develop a new product (Johnsson 2014 pers. comm.). E.ON decided to became an "energy partner" for the customers. By energy partners E.ON means to create relationships between the company and a customer, which would stimulate improvement in the energy efficient consumption. The company is well aware that such approach will lead to reduction of the profit due to lower energy demand; however this lack of profit will be compensated by the growing sales of the energy services. Thus, E.ON is going to replace part of their core business related with energy sales by the new product basket with energy services.

4.3.1 Political Aspects

Due to the fact that E.ON has just started implementing residential energy efficiency renovation projects, there is no unique cooperation between E.ON and local authorities. However, of course E.ON operates in the same political field as Siemens and obey to the same Swedish regulations, which were described in the previous chapter. Thus, there is no need to repeat.

4.3.2 Technological Aspects

One of the energy services in the planned new product basket is energy efficient renovation project of the residential buildings. In order to test and prepare energy renovation projects for a bulk sale, E.ON identified several areas in Sweden for a pilot project implementation. Thus E.ON has only two pilot projects in the residential energy renovation sector. One of them is called Retrofit. This project includes renovation of the several buildings in Lindangen district of Malmo City. The renovation project consists of approximately 400 apartments.

The landlord was one of the initiators of the project. His goal is to decrease energy consumption as a way of increasing value of the building. The crucial aspect for the landlord is to cover project's cost without rising the rent. Goal of the company is to reach 50% level of energy savings. However, E.ON chose not a typical scope for the project. Retrofit's scope includes not only the buildings itself, but also production and distribution sites (see Figure 4-3-1-1). Mr. Johnsson (2014 pers. comm.) claims that the limit for energy savings, which could be reached by energy efficiency renovation project in a residential building, is about 25%. This number is also proved by Siemens (2014) and Schneider (2010). In order to achieve 50% of energy savings in residential building the whole supply net should be also renovated and adjusted.

According to E.ON's approach, improvement in the efficiency of the supply side will lead to the further reduction of the energy consumption on the demand side. For example, absence of peaks in the distribution line will lead to a better and more efficient work of equipment in the building. Thus, E.ON's goal is to reach 50% overall reduction in energy consumption in the whole net by implementing a renovation project with 25% of energy savings.

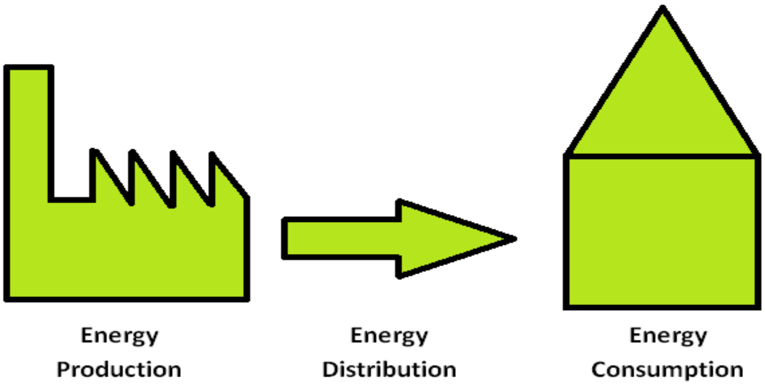

Figure 4-3-1-1. Scope of the E.ON's energy efficiency renovation project

Data Source: E.ON 2014

The project could be divided into 2 parts. The first one is renovation of the energy supply side. The first part is already finished and it was done by E.ON itself. The second part is renovation of the buildings, which is currently under implementation. The second part is conducted by subcontractor - Schneider Electric. This stage includes implementation of the energy efficiency improving measures in several groups of energy related issues:

- insulation;
- ventilation;
- windows;
- hot water;
- electricity;
- heating system.

Each of these groups consists of several actions that should be done in order to reach the goal of the project. For example, renovation of the heating system includes adjustment of the heating system and thermo controllers examination, optimization of the pressure level in the radiators, replacement of all thermostats in all 400 apartments, etc.

4.3.3 Economic Aspects

Taking into account the fact that this project is still not finished, it is hard to estimate its results. The planned payback period of the project is 7 years. According to Swedish Energy Agency (2014) average energy consumption for the similar residential buildings in Sweden is 180 kWh/m^2/year, which means a tenant pays for energy about 34 EUR per m^2 per year.

Tenants' energy costs before project implementation were about 950 000 EUR per year. The goal of the project was to decrease this amount below 525 000 EUR per year, which is about 19 EUR per m^2 per year and as E.ON claims (2014 pers. comm.) this energy goal is obviously reached. Thus, energy savings are about 45% in comparison with the initial level of energy consumption.

4.3.4 Social Aspects

However, sometimes even a successful implementation of the renovation project in the residential building does not lead to a significant drop in building's energy consumption. E.ON (2014) explains that by the poor level of building's maintenance. Mr. Johnsson (2014) claims that the maintenance of the equipment in the building is underdeveloped in Sweden. Very often there is a situation when some of the tenants are feeling themselves cold or hot and they change the settings of the heating equipment in the building, which leads to the misbalance of the whole building's energy system and rise of the building's energy consumption. Customers are not educated enough to conduct maintaining by themselves and there is no professionals responsible for the building's operation after the end of project.

In order to solve the problem with poor level of maintenance E.ON is going to develop a new energy service - equipment maintaining. Currently Retrofit project is still in the implementation stage, but it is planned that the maintenance will be conducted by the company during the year after the end of the implementation stage. During this year E.ON will organize several education seminars for the tenants. Moreover, E.ON is planning to use maintenance as a new energy service. Customers will be able to sign a contract and pay some amount of money on a monthly basis; in turn E.ON will provide constant monitoring of the building's energy system and adjust it if needed.

One of the main barriers, which E.ON faced during the implementation of the project, is to persuade tenants to behave in a way, which is more beneficial from the energy efficiency perspective. This problem is related with the fact that tenants are very diverse groups of people. Tenants have different social, economic status; very often tenants are from different countries and have different cultures. All these factors make a dialogue between the company and tenants a rather complicated task. Currently company is looking for the best incentive models, which will help to stimulate energy friendly behavior. One of the ideas, which is going to be implemented, is to install water meters in every single flat. Amount of water consumption will be more obvious, what, according to the plan, will lead to a rational use of water.

5 Analysis & Discussion

This chapter will include analysis of the collected data from the literature review and from the conducted interviews with ESCO companies. PEST analysis will be used as the main methodological instrument, due to that this section will be divided into 4 parts: political, technological, economic and social. Main advantages and disadvantages will be identified for each sector.

5.1 Political Aspects

As it follows from the last revision of Swedish National Energy Performance Regulation (see policy aspects section in the previous chapter), energy performance declaration must be prepared by organizations, which are certified by Swedish Government. It allows to standardize the assessment process and increase objectivity and reliability of the results. Such approach allows ESCOs to show their energy saving results to public and create positive reputation. It is very important, because as it was mentioned many ESCO energy efficiency renovation projects are allocated by tenders. In that case positive reputation could help company to win such tender and get a contract.

Moreover availability of declarations with information about energy consumption level in buildings and inspection results could help ESCOs to make a decision about entering new market. ESCOs could compare their results with results of the competitors and adjust their business development strategies based on that information.

Special technical obligations, which are set for projects with submitted energy declarations, are important for ESCOs and customers, because it ensures that the building will be energy efficient. Furthermore it gives an opportunity to ESCOs to compare results of the energy efficiency renovation project with the etalon and to identify how competitive is their energy performance on the market. Furthermore, Research and Development processes in the field of energy efficiency technologies as well as constant revision of the energy policies and regulations (for example, decreasing amount of allowed energy consumption as it is demonstrated above with energy declarations) are also beneficial for ESCOs, because it creates potential demand. Constant toughening of the energy performance limits insures that ESCOs will have to implement new projects with higher energy savings results and there will be a market for ESCOs' products and services. Moreover, in case of Chauffage model application, exceeding the governmental requirements for energy performance, will allow ESCO to maximize their profits, due to the fact that customer's payment does not depend on his energy consumption. Thus, increase in energy savings, caused by policy toughening will lead to the following increase in ESCO's profits.

Fact that 80% of newly constructed buildings do not comply with the initial energy requirements (Wik 2013) indicates that either energy efficiency targets were not reached during building's construction phase or tenants during usage phase destabilized building's energy system, which caused significant increase in energy consumption. Nevertheless, serious energy efficiency renovation is required in the buildings where evaluation identified significant difference between actual and planned energy consumption. Thus, such building's energy evaluation creates a business opportunity for ESCOs, because buildings, which require energy efficiency renovation, are already identified and there is no need to search for customers. Due to that ESCOs could decrease their costs for customers search and concentrate their resources on actual projects implementation.

Another important policy aspect is that there is no regulation, which obligates ESCOs to publish results of their energy efficiency renovation projects. Even though there are energy declarations, which must be prepared for the big energy efficiency renovation projects and mandatory evaluation of the energy performance for newly constructed buildings, which must be conducted 2 years after construction. All these documents are not publically available. Reports published by ESCOs and placed on the companies' websites are prepared for shareholders and dedicated only to general economic results of the whole company and do not include information about specific energy efficiency renovation projects results (Siemens 2013, E.ON 2013, Schneider 2013). While such information in the reports could help ESCOs to attract new clients and improve their reputation.

Due to the fact that rules for energy tenders are standardized, such approach allows municipalities to avoid corruption and spent money in a most effective way. ESCO companies, which work with a long-term perspective, win tenders and became well-known. It creates an advantage for them during next tenders. Thus, some companies end up in market outsiders, other companies who showed viable results on previous tenders became market leaders. Such standardized approach allows to separate unverified companies from reliable companies. What in turn helps to develop the ESCO energy efficiency renovation market and insure stable energy savings results of the conducted projects.

5.2 Technological Aspects

Analysis of the municipality energy efficiency projects and strictly residential projects demonstrates that systematic complex approach allows reaching a higher energy savings. Results gained by Siemens in different municipality renovation projects prove E.ON's concept that in order to achieve 50% energy savings it is necessary to use complex approach to the whole system. Renovation of the energy supply side is equally important as renovation of the energy demand side.

Apparently, effectiveness of the energy renovation project also depends on what technical solutions were implemented. However, choice of technical solutions differs from project to project, because it depends on several factors:

- age of the buildings;
- maintenance conditions;
- climate conditions.

Moreover, tenants' desire to implement concrete technologies also has a significant impact on final choice of conducted energy efficiency improving measures. Assessment of the list of the implemented technical measures (see Table 4-2-2-1 and Table 4-2-2-2) by both companies indicates that technical measures are rather different. However, it is possible to notice several similarities. Most of the projects include renovation of the ventilation system and insulation improvement. It is well known that energy consumption depends on outer climate conditions, for example, in winter energy consumption rises due to cold weather. The fact that renovation of the ventilation system and insulation improvement are the most frequent technological solutions indicates that outer temperature and wind are the most important climate conditions, which influence residential building's energy consumption. However, weather monitoring system is not integrated in the current typical building's energy system. Although such data as wind speed and direction, humidity, outside temperature are crucial for following energy system adjustment and further reduction of energy consumption.

Both companies mentioned that poor maintenance of the buildings is one of the main technical barriers for even higher energy savings. Due to this maintenance of the building could be considered as a separate energy service. Together with constant monitoring of the energy system it could improve efficiency of the building's operation. In order to do it, as it is evident from the Chapter 4, Siemens installs building automation systems in majority of its project. However, in most of the cases customers should operate and control energy system of the building by themselves using newly installed equipment, which leads to poor maintenance level and misbalance of the building's energy system.

5.3 Economic Aspects

As it follows from conducted research and interviews, the average amount of energy savings in residential sector in Sweden is 22.3%. This figure corresponds with E.ON's claim that the possible results in energy saving, which could be reached in residential sector, are about 25%. However, there is a significant difference between projects financed only by customers, and projects which used additional financing (See Table 4-2-3-1). Both projects AB Hultfreds Bostäder and Brf Riddarsporren used some third party financing and their results are much higher in comparison with the other projects. AB Hultfreds Bostäder reached 48% of energy savings, while Brf Riddarsporren saved 36% of energy. Thus, results of the projects with additional financing are almost twice as high as energy savings gained during projects financed only by customers.

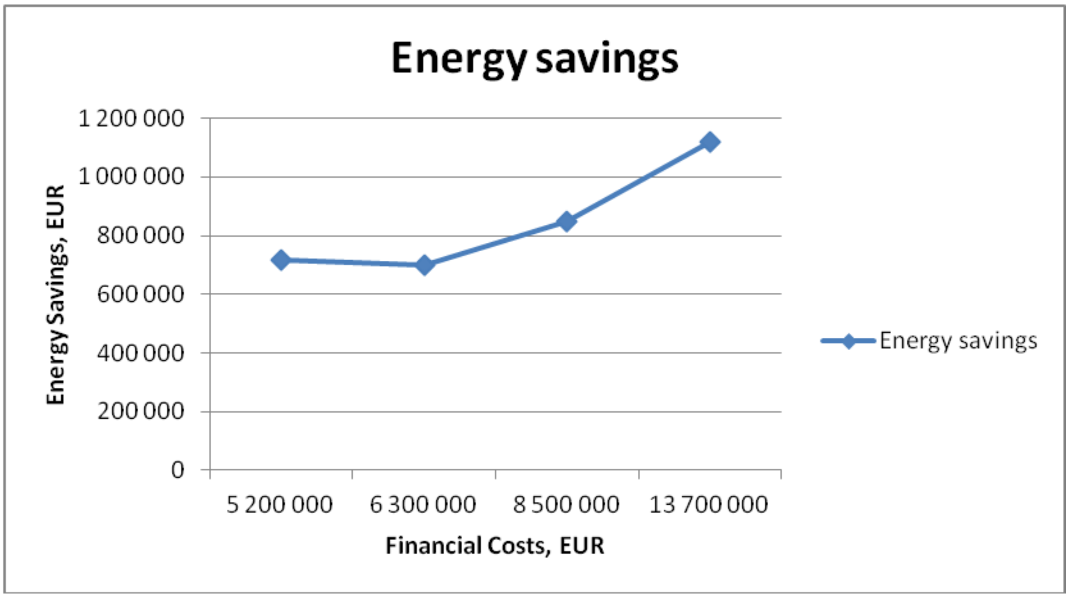

Figure 5-3-1 Financial Equivalent of Energy Savings

Data Source: Siemens 2014

Moreover, all Siemens's municipality renovation projects have attracted additional third party financing and reached rather high energy savings results. According to the received data about Siemens's renovation projects, average energy savings per year in financial equivalent are about 9-13% from the initial costs. Thus, average payback period of the residential energy efficiency renovation projects is about 9 - 11 years. However, as it was found during research many clients ask to reduce it to 6 - 7 years, which is done by reducing costs of the project by implementing cheaper and less efficient technologies, what in turn leads to lower rate of energy savings.

Graph 5-3-1 was made on the basis of received data (see Table 4-2-3-1). It shows that energy savings in residential buildings increase with the growth of investments in renovation project. Of course, amount of energy savings in financial equivalent depends on the size of the project, but there is a direct relation between energy savings and amount of investments in the residential renovation project. This statement not only follows from the available data, but also it was confirmed by both companies during interviews. However, as it was mentioned earlier customers often do not choose the best available technologies and prefer to implement cheap and less effective solutions. Thus, residential energy efficiency renovation projects are often simplified down to "picking low hanging fruits".

The research, conducted for the thesis shows that such ineffective choice of energy solution could be explained by 2 factors. First of all, by lack of financial resources as it was stated in the previous paragraph. But another reason is that energy consumption reduction is not always a primary goal of clients (see list of customer's goals in Appendix C). Sometimes clients are implementing energy efficiency renovation projects to rise comfort of living or to improve internal climate conditions. In such cases energy savings are just positive side effect. Mr. Paul Kenny during his presentation on the conference World Sustainable Energy Days in Vienna (2014 pers. comm.) called improvement of the comfort living the main reason why individual residents decide to renovate their houses in Ireland.

However, the situation is different in Sweden. If residential buildings are renovated as a part of a complex municipality renovation project, then the goal actually is improvement in energy efficiency. Such projects are initiated by local municipal authorities, who execute order of the national government to increase energy efficiency by 50% up to 2050. The crucial point about these projects is that residential buildings are not widely presented in municipal renovation projects. Residential buildings are just a small part of such projects. It follows from the list of renovated buildings during municipality renovation projects (see Appendix C). Moreover, municipalities prefer not to include residential buildings, because it is much harder to renovate them. It is much easier to renovate the building, where no one lives, there are no behavioral peaks in energy consumption, there is only one owner of the building, etc. Due to this, there are many municipal renovation projects, which do not include residential buildings at all. Such projects are not listed in this thesis, because they do not correspond to the purposes of the current thesis. Although such projects reach significant results in energy saving. Moreover municipal renovation projects do not have problems with financing, because they are financed by local budget or by credits from the bank (see description of the financing mechanism in Appendix C). Banks willingly provide credits to municipal renovation projects, because banks are sure that if something goes wrong, government will compensate the loses. Thus bank's financial risks are minimized.

Money savings is often a primary goal in the projects, which are strictly residential and initiated by the customers. It is important to understand that even though energy savings lead to the following money savings it is a completely different goal, because customers whose goal is to save as much money as possible, would not invest in the long term project. That is the reason why many Swedish tenants choose to "pick low hanging fruits", which leads to higher rate of money savings in the short term perspective, due to lower investment costs.

Another thing, which proves, that financing is a crucial issue, is that both Siemens and E.ON use only EPC model with guaranteed savings (see projects description in Chapter 4). It indicates that customers doubt about the success of the project and they need guarantees to be sure that their money will return.

5.4 Social Aspects

Tenant's behavior has a very strong influence on residential building's performance. That is the reason why both companies are organizing special seminars for the tenants and operational staff (see sections 4.2.4 and 4.3.4). But such seminars and educational programmes often do not reach desired results, because of the several reasons. First of all, tenants, especially in residential areas which unite several multi dwelling buildings, usually have different social and cultural status and they have a different opinion about energy conservation goals. Secondly, single seminar is often not enough to persuade a person to change his behavior. Moreover, none of the interviewed companies work with NGOs for the sake of energy efficiency renovation promotion.

Currently it is rather problematic to find detailed information about implemented energy renovation projects. As it follows from the Chapter 4 of the thesis, even after conducted research and interviews there is lack of information about what level of energy savings was reached or how much money does the project save to the customer throughout the year, due to confidentiality. However, availability of such information could improve understanding of the current state of the building's energy market and stimulate its future development.

6 Recommendations

Recommendations for the further development of the residential ESCO energy efficiency renovation sector are provided on the basis of the conducted PEST analysis.

6.1 Political Aspects

Based on the conducted literature review and analysis of the political and social aspects it was identified that there is no legislation, which forces ESCOs to make data about results of residential energy efficiency renovation projects publically available. Due to that it is recommended to develop such regulation, which could be useful for improving citizen's level of awareness about energy issues and possible solutions for the residential buildings sector. Moreover, regulation, which will organize an open access to energy declarations could also improve the situation with the minimum costs, because declarations are already prepared on a regular basis.

Another useful recommendation, based on the conducted PEST analysis, is to develop a legislative act, which will force landlords to make an energy audit of the building every 7-10 years. As it was found during research average payback period of the residential energy efficiency renovation project is about 10 years (see Economic section of Chapter 5). Due to that conducted energy audit will allow to identify if the buildings perform in the planned way. Moreover, technologies could significantly change in 7-10 years, due to that conducted audit will help to plan future steps for even deeper energy efficiency renovation.

Moreover, during interviews and literature review it was identified that building's energy performance evaluation is conducted two years after the building was constructed. However, if the energy consumption is higher than planned amount nothing has to be done. Thus as a recommendation it could be suggested to add the obligation to renovate the buildings, where high energy consumption was identified after the mandatory evaluation. Furthermore, together with suggested energy audit every 7-10 years it could create a stable base for constant energy efficiency improvement in residential buildings sector.

6.2 Technological Aspects

As it was found from the conducted PEST analysis of E.ON's and Siemens' municipality cases, projects, where energy supply side was renovated as well as demand side, achieve higher energy savings. Due to this it is recommended to ESCO to improve energy production and distribution if it is possible. As a part of renovation project ESCO could try to communicate with the energy supplier in the building's area. Cooperation with the energy supplier could help to reach significantly larger energy savings as it is demonstrated in the E.ON's Retrofit case and Siemens's municipality projects.

Based on the conducted analysis of the technological aspects it was identified that most of the projects include renovation of the ventilation system and insulation improvement. Due to this, paying special attention to those aspects could be a feasible recommendation for ESCOs. Moreover as it was shown climate conditions are crucial for residential buildings energy performance (see technological section in Chapter 5), thus installation of the energy monitoring system together with weather monitoring system, which will register current water, heat and electricity consumption as well as inside and outside temperature, wind speed and direct, humidity will lead to better energy system adjustment and lower annual energy consumption. Of course, positive output from the monitoring systems will be reached only if correcting activities will be conducted as soon as possible based on data from the sensors and meters.

During interviews both companies mentioned that poor maintenance level of buildings is the main reason of high energy consumption in buildings. Thus, it is suggested to provide maintenance as an absolutely separate energy service, which could solve the problem with unbalancing of the building's energy system, increase energy savings, generate additional profits for ESCOs and make tenants life easier, because they will not need to worry about adjustment of their energy equipment.

6.3 Economic Aspects

There are several recommendations, which could help to overcome the financial barriers. First of all, based on conducted PEST analysis (see Chapter 5-3) wise strategy of work with customers is required in order to increase the amount of money, which customers would like to invest in energy efficiency renovation project. ESCO should explain carefully to the customers that additional financing will lead to additional energy and money savings. Another good option is if ESCO be able to offer some financing by itself. Of course, ESCO will have to take larger part of energy savings as a profit in order compensate its costs, but such situation allows increasing energy savings, which means there will be a surplus for ESCO to take back their costs. Eventually, it will lead to higher energy savings for a customer and higher profits for ESCOs.

Conducted interviews with Swedish ESCOs indicated that the only business model, which is used by ESCOs for residential energy efficiency renovation purposes in Sweden, is EPC. However, implication of other models could create new opportunities for the ESCO residential energy efficiency market development, it could attract new clients and increase energy savings in some cases with specific conditions. For example, for ESCOs, which have their own energy production sites like E.ON, Chauffage could be an interesting solution. On one hand customers will get permanent and cheaper energy service, on another hand ESCO will have an opportunity to promote their core business, sign longer energy service contracts and operate in a more effective and optimal way.

6.4 Social Aspects

Due to significant difference in social and cultural status of the tenants, which was identified during interviews and conducted PEST analysis (see Chapter 5.4), in order to reach maximum energy efficiency results, ESCO should use different types of communication canals.

It is necessary to inform society about the goals of the planned energy renovation project and about the results, which were managed to reach. It will help to convince society that energy renovation projects are important and they actually bring benefits to the economy and environment. Small scale marketing and advertisement campaigns could be useful for this purpose. Moreover, such campaigns could attract new customers for ESCO's renovation projects. Transparent results' sharing is also very important, as it follows from the political and social sections of the conducted PEST analysis.

Another important recommendation for ESCOs is to include NGOs in this awareness rising activities, because conducted research indicated that there is no cooperation between ESCOs and NGOs in this field at all. Involvement of NGOs is beneficial for ESCOs as well as for NGOs itself. NGOs could attract initiative population groups and use their own financial and human resources for further development and promotion of the energy renovation projects. Moreover, NGOs could be a good intercessor in relationship and communication between ESCOs and local authorities. Such relationships are beneficial for ESCOs, because they stimulate future cooperation between business, social and administrative parties.

As it was found from the conducted PEST analysis (see Chapter 5.4) ESCO companies often face the problem that not all tenants are willing to participate in energy seminars or educational programmes. A possible solution to such problem is to change a format of the first meeting. After the end of the project's implementation stage a little celebration for the tenants could be organized. Such event will not lead to significant financial costs for ESCO, but it will give an opportunity to gather tenants together and in an entertaining way explain them what new features have their building received, what is the best way of using new technologies, how the energy system should be treated, etc. Moreover, such event is a good opportunity to invite residents of the nearest buildings (potential customers), representatives of the NGOs and local authorities. Thus, several ESCO's objectives could be reached at the same time: educate tenants, improve maintaining of the building, present results of the project, find new clients and improve ESCO's reputation.

Taking everything into account, mentioned recommendations in this chapter could stimulate further development of the residential renovation sector and lead to the real practical improvements in residential energy efficiency renovation projects.

7 Conclusions

Different business models, which are currently used in energy efficiency improving projects in the residential sector, were analyzed in the current thesis. Several of the most important models were chosen on the basis of literature analysis and presented in this thesis: Energy Performance Contracting (EPC) with shared and guaranteed savings, Chauffage and Preferential loans. It was identified that EPC model with guaranteed savings allows to decrease the risk of not achieving project's energy savings goals, however, those goals are usually lower in comparison with EPC model with shared savings. The literature analysis demonstrated that the Chauffage model is the most suitable model for ESCOs, who has their own energy production sites. The preferential loans model is rarely used as a separate business model, but it allows to attract additional financing for ESCOs energy efficiency renovation projects and therefore to increase energy savings generated by the conducted project. However, the research based on semi-structured interviews with representative of Swedish ESCOs, showed that only one business model is mostly used in Sweden - EPC with guaranteed savings. It often leads to "low hanging fruits picking" and low rate of strictly residential projects implementation.

An applied PEST framework was found to be useful for evaluating residential ESCO energy efficiency renovation projects. Such an approach, together with a developed methodological framework, makes it possible to systematize received data and to develop conclusions and recommendations (which are presented in the previous chapter) for further improvement of ESCO's activities in renovation sector of residential buildings. A PEST analysis is also recommended in future similar researches, because it provides rational results and will give an opportunity to track the changes in each of the sectors (political, economic, social or technological). Results of this thesis, which is based on Swedish energy efficiency renovation projects, could be extended and adapted to other countries in the European Union by considering their special characteristics of geographical location and cultural mentality.

Based on the PEST framework, the following political conclusions were drawn:

Sweden has a broad and well developed regulation regarding energy efficiency improvement. However, there are no legislative acts that would stimulate usage of private funds of the financial institutions and publication of the results of the residential ESCO energy efficiency renovation projects. Such a situation leads to a low number of implemented energy efficiency renovation projects in the Swedish residential sector, due to a lack of citizens' awareness about ESCO energy efficiency renovation projects and approaches, and lack of financial resources to pay for the project. Thus, even if ESCO residential energy efficiency renovation projects are conducted, customers often choose to decrease the payback period by using cheaper and less effective energy efficiency improving technologies. A significant improvement in the number and effectiveness of residential ESCO renovation projects could result from development of the legislative acts dedicated to the involvement of the financial institutions' funds for residential energy efficiency renovation purposes, and from legislative acts that aim to make projects' results and energy declarations publically accessible and available.

In addition, implemented PEST analysis indicates that the average payback period of an ESCO residential energy efficiency renovation project is 10 years. Therefore, an energy audit every 7 - 9 years (together with an existing mandatory energy evaluation after a significant energy renovation or 2 years after construction) would determine whether the building's energy system is performing as planned. The building's energy system could be adjusted for balance and to decrease energy consumption. Moreover, technologies could significantly change in 7 - 10 years. An audit would help to plan future steps for even deeper energy efficiency renovation. Therefore, development of legislation to require a building's energy audit every 7 - 9 years is recommended.

Based on the PEST framework, the following economic conclusions were drawn:

Energy efficiency renovation projects do not reach the best possible results in energy savings because of the lack of financial resources and implementation of only the EPC business model. Therefore, the use of additional business models (EPC with shared savings or Chauffage) is recommended. These models are able to divide a project's risks between different stakeholders and attract new investors. Moreover, the direct relation between the amount of invested financial resources and a project's energy savings was identified during a PEST analysis. Therefore, the following strategy needs to be emphasized to customers: further investment will lead to more energy savings; use long-term investments instead of short-term.

Based on the PEST framework, the following social conclusions were drawn:

During execution of the current thesis, it was found that tenants living in residential energy efficiency renovated buildings are not fully aware of the benefits that could be realized after implementation of such renovation projects. Awareness-raising campaigns and environmental education in connection with realized energy projects could stimulate further development of the energy service market and increase results of the implemented energy efficiency renovation projects. A special event to celebrate and present a finished residential energy efficiency renovation project is a good opportunity to invite residents of the nearest buildings (potential customers), representatives of the NGOs, and local authorities. Several of ESCO's objectives could be reached at the same time: educate tenants, improve maintenance of the building, present results of the project, find new clients, and improve ESCO's reputation.

Based on the PEST framework, the following technological conclusions were drawn:

Analysis of the case studies (by Siemens and E.ON) indicates that projects where both the supply side and demand side were renovated show more energy savings than ESCO energy efficiency renovation projects where only the demand side (residential buildings) was renovated. Therefore, it is recommended to renovate the supply side in addition to the demand side, if possible. In addition, analysis showed that outside climate conditions are very important factors in achieving energy savings. Therefore, it is recommended to install not only energy monitoring systems in buildings, but also weather monitoring systems. Together, both systems would allow the current state of the energy system to be controlled in real-time with faster adjustments to weather changes. Moreover, the availability of data about energy consumption in relation to weather conditions would improve the quality of energy consumption predictions for future projects.

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Appendix A

Questionnaire

1. Political Questions

- What are the barriers and drivers for ESCO to go into renovation project?
- Do you have any standard operation procedures (documented instructions or regulations) regarding renovation projects and ESCO contracts?
- What taxes are paid during renovation project and afterwards?
- Does energy consumption indicators influence the amount of taxes paid by the company?

2. Economic Questions

- Who is financing the project?
- What financial models are used for the renovation (EPC contracts, loans, risk sharing, etc.)?
- What is the main reason for the customer to realize a project (energy, comfort, bills or something else?)
- How do you estimate results of the projects? What specific indicators do you use?
- What are your main competitors on ESCO market and on residential buildings renovation market? Do you have any cooperation during any projects?
- How do energy efficiency renovation projects correlate with other business activities?

3. Social Questions

- Who usually is an initiator of the contract (whose idea is to implement a renovation project)?
- Is there any marketing promotion of ESCO renovation conducted by your company?
- What are the goals of your renovation projects in residential sector?
- Is it important for sake of ESCO contracting if property and land owners are different persons?

4. Technological Questions

- Could you describe, please, the typical ESCO renovation project scheme (stages)?

- How long does an average renovation project take?
- When do you measure results and efficiency of the project (immediately after the end or sometime later)?
- Could you provide some examples of energy efficiency renovation projects carried out by your company?

Appendix B

List of Siemens Strictly Residential Projects

1. AB Hultfreds Bostäder

The energy renovation project includes apartment buildings in Hulfstred in areas Oredan 16, Omlastaren 5 and Cypressen 2. The EPC contract was signed in 2004.

Energy efficiency improving measures:

- New building automation system
- Electric heat pump
- Reconstruction of the pipe system
- New water circulators
- Energy system adjustment for the operation efficiency improvement

2. AB Svenljunga bostäder

The contract was signed in 2005. The project was financed only by the customer.

Energy efficiency improving measures:

- New building automation
- Adjustment of the radiators' temperature
- Water saving measures
- Energy system adjustment for the operation efficiency improvement

3. Brf Riddarsporren

The EPC contract was signed in 2003. The energy renovation project covers seven buildings, which were built in 1970. Renovated buildings consist of 168 apartments and some public organizations located on the ground floor of the buildings (kindergarten, etc.). The building complex initially had its own boiler for heat supply; however it was upgraded in 1995 and used for district heating purposes. Heat recovery was not considered in the ventilation system.

Energy efficiency improving measures:

- New building automation
- Adjustment of the heating system
- New air handling units with heat recovery and demand control

- Roof insulation
- Individual temperature controllers in the apartments
- Energy system adjustment for the operation efficiency improvement

4. Brf Väduren

Brf Väduren is the second largest housing area in Sweden with approximately 900 apartments. Buildings were built in the period between 1968 and 1971. It is one of the first energy efficiency renovation projects conducted by Siemens in Sweden. The contract was signed in 1998.

Energy efficiency improving measures:

- New building automation
- Ventilation control system
- Water saving measures
- Electricity procurement
- Energy system adjustment for the operation efficiency improvement

5. Bågen 233 Brf

Brf Arch No. 223 is a large tenant-association with 283 apartments and 25 premises. Buildings were constructed in 1990 - 1991. The association consists of a big arc-shape house and three smaller buildings connected in the line near Stockholm South Station. Tenants were complaining about constantly "jumping" temperature in the flats and noise from the fans (Claesson 2007). Moreover, there was excess heat from the garages, which was not used anyhow. In order to find a solution to these problems association of tenants decided to use help of the professional consultants. The budget for the consultant services was 200 000 SEK (22 000 EUR), but only 150 000 SEK (16 000 EUR) from it was really used. Several projects were prepared and presented to the tenants' association and eventually the contract was signed with Siemens in 2006. The costs of the project were calculated as 5.2 million SEK (0.6 million EUR), excluding value-added tax, and the duration of the contract was eight years. That tenant's money was spent on the following energy efficiency improving measures:

- Installation of the energy efficient and quieter fan equipment
- Installation of the demand controlled ventilation system
- Computerization of the heating and ventilation systems
- Improved heat recovery in the garage from the chillers
- Tenants training
- Optimization of the ventilation system and heat recovery

6. Hallbo

Hallbo renovation project includes several residential buildings located in Hallsberg, Östansjö, Pålsboda, Knonoberg, Sköllersta and Hjortkvarn. The EPC contract was signed in 1999 and it according to it following measures were implemented:

- New building automation
- New ventilation units
- Demand controlled ventilation system
- Oil boilers were replaced by geothermal heat pumps
- Energy system adjustment for the operation efficiency improvement

7. HSB Hallsberg

HSB Hallsberg renovation project consists of 266 apartments, which were built in the period between 1935 and 1970. EPC contract was signed in 1998.

Energy efficiency improving measures:

- New building automation
- Demand controlled ventilation system
- Water saving measures
- Energy system adjustment for the operation efficiency improvement

8. Norabostäder AB

EPC contract was signed in 2001, according to it, following energy efficiency improving measures were conducted:

- New building automation
- Demand controlled ventilation system
- Training of the operating personnel
- Initial adjustment of the heating system
- Energy system adjustment for the operation efficiency improvement

9. Norabostäder AB, Gyttorp

Retirement house was renovated during this project in 2002.

Energy efficiency improving measures:

- New building automation

- Demand controlled ventilation system
- Reconstruction of the heat substations
- Initial adjustment of the heating system
- Energy system adjustment for the operation efficiency improvement

10. Nordostpassagen 3659

It is a rather new project, which started only in 2010.

Energy efficiency improving measures:

- Energy efficient fans
- Heat recovery
- Building automation
- Improving operating efficiency

11. Nordostpassagen Brf

This project includes several residential buildings; however some of the apartments in it are occupied by commercial organizations. EPC contract was signed in 2006 and includes following energy efficiency improving measures:

- New building automation
- Heat recovery ventilation system
- New demand-controlled lighting
- Energy system adjustment for the operation efficiency improvement

12. Sandvikenhus 2

This project includes big apartment building in Sandviken, which was renovated in 2009. The following energy efficiency improving measures were conducted during the project:

- New building automation
- Demand controlled ventilation with new efficient fans
- New dryers in drying room
- Initial adjustment of water network
- Energy system adjustment for the operation efficiency improvement

13. Sandvikenhus AB

This project was conducted in 2005 and following energy efficiency improving actions were realized:

- New building automation
- Demand controlled ventilation with new efficient fans
- Water saving measures
- Energy system adjustment for the operation efficiency improvement
- Initial adjustment of water networks

14. Simrishamns Bostäder AB

EPC contract for this project was signed in 2001 and the following measures were conducted:

- New building automation
- Adjustment of the radiators' temperature
- Exhaust fans replacement
- Adjusting ventilation flows

15. Sunne Bostads AB

This is one of the latest Siemens EPC projects in residential sector in Sweden. EPC contract was signed in 2010. The following list of energy efficiency improving measures is implemented during the project:

- Heat recovery
- Additional insulation
- Building Automation
- Training of operators

16. Vårgårda bostäder

This project was executed in 2006 and the following energy efficiency improving measures were conducted:

- New building automation
- Demand controlled ventilation system with new efficient fans
- Water saving measures

Energy system adjustment for the operation efficiency improvement

Appendix C

List of Siemens Municipality Renovation Projects

1. Vellinge Municipality

Vellinge is a municipality in the southern Sweden with 33 500 inhabitants and a total building area of approximately 120 000 m^2. The building stock consists of public buildings such as town halls, administration buildings, schools, nursing homes, public baths, etc.

Goal for the energy efficiency project was formulated in 2006. According to this goal, municipality's energy consumption after the project's implementation should be reduced by 30%.

Velligne Kommun project was so successful that Siemens received the European Energy Service Award for this project in 2012. Eventually energy consumption has been reduced by over 30% on the average in the whole municipality and by 26% particularly in the residential building sector. Overall energy savings of the project are approximately 11 000 MWh per year. Total CO_2 reduction is about 3 500 tonnes per year and the guaranteed savings are approximately one million Euro per year. Green house gases emission before the project implementation was about 16 000 tonnes per year. Old heating equipment has been replaced by modern technological solutions and a new building automation system was installed. Buildings are continuously remotely monitored by energy specialists from SOC (Siemens Operation Center), what, according to the plan, will lead to the continuous further energy improvement.

2. Karlstad Municipality

Siemens conducted an EPC renovation project in Karlstad. It was partly financed by the municipality itself and party by the third party, which means that customer obtained some supplementary funds for the project from the additional sources. Most probably Karlstad Municipality used a preferential loans model and took a credit to finance the initial stage of the project. However, unfortunately company did not share any more information about project's finance sources.

Facilities which were included in the EPC renovation project consist of public buildings, schools, preschools, sports facilities, *residential buildings*, water plants, fire stations, office buildings, libraries and public baths. Overall 180 buildings were renovated, which is about 330 000 m^2. Before the implementation of the project the main energy sources in the city were oil, district heating and electricity. Average energy consumption in the city was approximately 175 kWh/m^2 per year. The following project goals were formulated by the landlords (EESI 2013):

- Reduction of energy demand, but other measures that increase net operating income are also interesting;
- More efficient operation and maintenance of buildings;
- Improvement of indoor climate;
- Change of the energy sources.

EPC model with guaranteed savings was used as a business model for this project (see chapter 2). The whole project was implemented in 3 stages. According to the project's specification, the following measures were done:

- Education of the customers and new equipment operators;
- Minimization oil usage as a source of energy;
- Installation of the new ventilation units;
- Installation of the heat pumps and solar collectors;
- Measures for water economization in all buildings;
- Roof insulation;
- Direct electric heating replacement by the water-based heating.

Legal contract relationships: ESCO has a contract with the end customer and, according to this contract ESCO has to execute all guarantees (construction and renovation part of the project) and savings (performance on the third stage). ESCO gets only stage 1 agreement and customer has an option to start stage 2 or not, when the evaluation of the first stage's outcome is done. If the second stage is implemented, then stage 3 is mandatory because of the savings guarantees. Due to such structure of the project, the first stage is paid by the customer, when results of the energy audit are presented. Stage 2 is paid according to the progress of the conducted measures. The third stage is a maintaining and service stage, therefore it is paid by the customer on the monthly or quarterly basis.

3. Landskrona Municipality

The EPC project in Landskrona is similar to the project in Karlstad. It is also an EPC project with guaranteed savings. Monitoring and verification are done by the means of follow up and guaranteeing calculated savings using new automation and regulation control systems, as it is in the previous project. The third party financing was used in this project as well.

Facilities which were included in the EPC renovation project consist of public buildings, schools, kindergartens, sports facilities, *residential buildings*, water plants, fire station, office buildings and a library. Overall 85 buildings were renovated, which is about 160 000 m^2. Before the implementation of the project the main energy sources in the city were oil, district heating and electricity. Average energy consumption in the city was approximately 230 kWh/m^2 per year. The following project goals were formulated by the landlords (EESI 2013):

- Energy demand reduction;
- More efficient operation and maintenance of buildings;
- Improvement of indoor climate.

Structure of the EPC model with guaranteed savings, which was used in this project, is absolutely identical to the business model used in Karlstad's project. Due to that it will not be described here in order not to create duplications. According to the project's specification, the following measures were implemented:

- Operation optimization;
- New automation and regulation control systems;
- Change of the energy sources (replacement oil by other energy sources);
- Installation of the air ventilation systems with heat recovery.

4. Umea Municipality

Umea Municipality is also a typical EPC project with guaranteed savings. The structure of the project, legal relationships are identical to the 2 previous projects. Third party financing was used in this project as well.

Facilities which were included in the EPC renovation project consist of public buildings, schools, kindergartens, care centers, municipal buildings, buildings for recreation activities, *residential buildings* and commercial buildings. Overall 130 buildings were renovated, which is about 425 000 m^2. Before the implementation of the project the main energy sources in the city were oil, district heating and electricity. The following project goals were formulated by the landlords and local authorities (EESI 2013):

- Energy demand reduction;
- Cost reduction caused by more efficient operation and maintenance of buildings;
- Include other activities that increase net operating income.

According to the project's specification, the following measures were implemented in order to reach stated goals:

- Installation of the new fans;
- New ventilation units installation;
- Direct electric heating replacement by the district heating or other water-based heating;
- Installation of the fluorescent lamps.