MASTER

Energy services for business districts

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ENERGY SERVICES FOR BUSINESS DISTRICTS

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Preface

This master thesis elaborates on the subject of energy service companies in business districts and forms the final product of the master program Construction Management and Engineering at Eindhoven University of Technology. This research was conducted in cooperation with the Brabantse Ontwikkelings Maatschappij (BOM), the KENWIB foundation and Eindhoven University of technology.

The sustainable use of energy is currently a hot topic and the concept of energy service companies has always drawn my attention. I enjoyed researching and exploring this concept and its possibilities in existing business districts in the Netherlands. I have high expectations for the success of ESCos on the Dutch market and I hope my research can contribute to the development of this ‘’new’’ industry.

I want to thank the BOM for providing me the support for graduating on this interesting topic. The meetings with Jeroen Krijgsman as my external supervisor always gave me useful feedback, input or ideas to do this research. The BOM really gave me the freedom to explore possibilities and to choose directions within the context of my topic.

The interviews with experts in the field of sustainable energy really helped me to gain insights in the existing problems and gave me input to make a stakeholder analysis.

Furthermore, I want to thank my supervisors at Eindhoven University of Technology. Paul Masselink, for your knowledge about sustainability within the built environment. Our intensive discussions always led to interesting and useful ideas. And Brano Glumac, four your extensive scientific knowledge which helped me to structure my research design and helped finding suitable research methods to do my research.

Finally, I want to thank my friends and family for the support and needed distraction during my graduation period. Also a special thanks to my uncle, Sjef Klaassen at the municipality Helmond, for his effort to provide me with the needed case study input.

I hope you will enjoy reading this report and become just as enthusiastic about the topic as I am.

Has van der Zanden
August 2013

Management summary

The goal of this research is to get a clear overview of the influencing factors en stakeholders in the quest towards improving energy efficiency in business districts and the feasibility of an energy service company using the energy saving potential of these districts.

Business districts account for the largest part of energy use in the Netherlands. However, these districts have up to now received little attention with regard to their energy use and efficiency. This is remarkable, taking into account the high energy saving potential that can be achieved. The energy saving potential on business districts is estimated to be in the range of 30%.

The EU has set objectives regarding climate change mitigation, aiming for a reduction of 20% in greenhouse gas emissions compared to 1990 along with a 20% share for renewables in the final energy demand by 2020. To reach this, several agreements have been made with varying industries considering the type of business activity and the amount of energy use. These agreements obligate companies to implement energy efficiency measures and renewable energy individually while the government leaves the responsibility to take action with the companies. Despite the enormous saving potential within business districts, developments regarding energy efficiency and renewable energy are slow and fragmented. Awareness of the possibilities is growing but development is often constrained by the complex environment of stakeholders and responsibilities, rules and regulations and uncertainties. In the face of rising energy prices and binding regulation, energy efficiency and renewable energy will inevitably become more important. Large companies have the financial means to reach the set objectives individually but they represent only a small number on business districts. The mid-sized manufacturing industry is characterised by high energy intensity and high saving potentials. These types of businesses have less knowledge, time and money available to invest in any energy measures. This makes them lack behind on sustainable energy development and potentially endanger their business profitability and continuity.

The high and concentrated energy use of these companies makes them interesting clients for the energy service industry. An energy service company (ESCo) specialises in delivering energy services and can relieve these companies from implementing and financing energy efficiency measures and renewable energy systems by themselves. Integral Energy Contracting (IEC) is the chosen ESCo business model to assess the feasibility of energy services on business districts. When delivering energy services for business districts, several uncertainties influencing the success are determined. The uncertainty factors assessed within this research are the following; ''Demand of energy'', ''Energy prices'', ''Subsidies'' and ''Technology development''.

To study the influence of these factors, a system dynamics (SD) model was made. This model calculates the net present value (NPV) of delivered energy services by the ESCo. The uncertainty of the factors are captured by using macro-economic scenarios that give varying trends regarding the price and the demand of electricity and gas, and the availability of subsidies within the industrial sector. The uncertainty of technological developments regarding the generation of renewable energy by means of solar panels for heat and electricity is captured by assessing the grid parity situation, where the price per unit of generated renewable energy equals the price for conventional energy.

To assess the importance of each parameter in the model, representing the uncertainty factors for the ESCo, a Morris analysis was performed. This analysis pointed out the high influence on the NPV of the capacity and price with regard to the renewable energy system, and the availability of government subsidies.

The model was run using a real business district as a case study. The results under the different scenarios show that, delivering energy services for business districts by an ESCo seem to be feasible in all tested cases. The feasibility can be optimized by waiting for renewable energy systems to reach grid parity.

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1 Introduction

Business districts are important areas in the Netherlands because they provide 30% of total employment. Circa 3600 business districts provide suitable space for companies to vest. Businesses need space for production, offices, showrooms, storage facilities, infrastructure and for the possibility to grow in the future (Farla, et al., 2006).

In 2010, 109.4 billion kWh of electricity and 51.9 billion m^3 of natural gas were consumed in the Netherlands. The industrial sector is responsible for the largest part of this amount and accounted for 28% of total electricity consumption and 72% of the gas consumption. Despite the economic developments of past years, industrial energy consumption keeps increasing (Energie in Nederland, 2011).

In past years, business districts received little attention with regard to their energy use and efficiency. Obsolescence, deterioration, accessibility and security of these areas have been the subjects in the spotlights. This is remarkable, taking into account the high use of energy on business districts (Mulder & Lindt, 2010). The energy saving potential on business districts is estimated in the range of 30% based on experiences in foreign countries (PeGO, 2009). This potential can be achieved by implementing relatively simple measures and represents about 60 PJ of savings each year. This amount equals the yearly energy use of 600.000 households or 1,2 billion euros (Mulder & Lindt, 2010). Considering the total saving potential in the Netherlands, industry represents the highest potential with 38% (Daniëls & Farla, 2006).

Current electricity- and gas price trends show increasing expenditures on the energy bill. To maintain a competitive position on the global market and guarantee the continuity and profitability, the implementation of energy efficiency measures and renewable energy is of growing importance (Ministerie van Economische Zaken, Landbouw & Innovatie, 2011).

1.1 Identification of most important problems

The EU has set objectives regarding climate change mitigation, aiming for a reduction of 20% in greenhouse gas emissions compared to 1990 along with a 20% share for renewables in the final energy demand by 2020. To reach this, the Dutch government has an important role as initiator and policy maker. Therefore, several agreements have been made with varying industries considering the type of business activity and the amount of energy use. These agreements obligate companies to implement energy efficiency measures and renewable energy individually while the government leaves the responsibility to take action with the companies (ECN, Energie-Nederland and Netbeheer Nederland, 2012).

Despite the enormous saving potential within business districts, developments regarding energy efficiency and renewable energy are slow and fragmented. Awareness of the possibilities is growing but development is often constrained by the complex environment of stakeholders and responsibilities, rules and regulations and uncertainties. In the face of rising energy prices and binding regulation, energy efficiency and renewable energy will inevitably become more important. Large companies have financial means to reach the set objectives individually but they represent only a small number on business districts. The majority of businesses, 99%, belongs to the category middle and small businesses (<250 employees). This category has less knowledge, time and money available to invest in any energy measures. This makes them lack behind on sustainable energy development and potentially endanger their business profitability and continuity. The high and concentrated energy use of these companies makes them interesting clients for the energy service industry. An energy service company (ESCo) is specialized in delivering energy services and can relieve these companies from implementing and financing energy efficiency measures and renewable energy sources (Ministerie van Economische Zaken, Landbouw & Innovatie, 2011). ESCos have proven their benefit for the industrial sector in foreign countries such as the USA and Germany. In the Netherlands, ESCos can take away the barriers to the implementation of energy savings and renewable energy as well (Haan & Benner, 2005).

1.2 Problem statement

''The energy saving potential in business districts is substantial and the importance of using this potential is increasing. However, many barriers hinder development towards improving energy efficiency. Energy service companies can relieve this sector from these barriers but the industrial sector's share in the activities of ESCos is currently much lower than its potential.''

1.3 Research goal

The goal of this research is to get a clear overview of the influencing factors and stakeholders towards improved energy efficiency in business districts and the feasibility of an energy service company using the energy saving potential of these districts.

1.4 Research boundaries

This research focusses on the implementation of ESCos in existing mixed business districts in The Netherlands.

1.5 Research questions

Now, the problem statement is rephrased into the research question of this thesis;

''Will sustainable energy management on business districts be feasible for Energy Service Companies?''

To answer this research question, the following sub-questions were formulated;

''Which companies in business districts are the real problem owners? Which factors influence the development of energy efficiency and renewable energy measures in business districts?''

Answering these questions, results in a better understanding of the problem, business districts, and the factors that influence the development of implementing energy efficiency measures.

''What are ESCos and which business models are available? Which business model fits best with business districts? Who are the stakeholders and what is there power? What measures are applicable in business districts''?

To implement energy services in business districts there needs to be a clear view of what ESCos are, which models there are, who the important players are and what energy efficiency and renewable energy systems are applicable.

''What is the added value of an ESCo for business districts? What are uncertainty factors in this context? Which factors are most important? What do these factors mean for the financial results for the ESCo''?

To determine the feasibility of ESCos in business districts, the uncertain factors are assessed and tested.

1.6 Relevance

In bygone days, the Netherlands represented an innovative country on many aspects. This is not the case regarding the sustainability aspect. Energy service companies (ESCos) stimulate the sustainable energy transition and find lots of applications in foreign countries. In the Netherlands though, the energy service industry is still in the first phase of development, especially within the industrial sector (Haagendijk, 2011). Sustainability is becoming increasingly important due to foreseen shortage of fossil fuels and legislation enforced by the European Union. Therefore, implementing energy efficiency measures is important in every sector. Increasing energy efficiency is by far the most cost effective way of raising the security of energy supply, improving industrial profitability and raising competitiveness (Hansen, 2006). The industrial sector has the highest energy saving potential but development towards employment of this potential is low due to the complex environment of stakeholders and responsibilities, rules and regulations and uncertainties. An ESCo is able to cope with these barriers and implement the necessary energy efficiency measures.

1.7 Research design

This research starts with a literature study to identify the influencing factors within the sustainable energy transition of business districts, important stakeholders and to get an overview of ESCo possibilities. Findings are verified with expert interviews. Based on the outcome of this study an ESCo business model is selected. This business model forms the base for the SD model. To verify the model and to assess the most influencing factors a sensitivity analysis is performed. The scenarios are set up and include these factors. Now, a case study is selected that gives input to the SD model and the model is run. The model assesses certain risks under the stated scenarios to get more insight in the feasibility of energy services for a business district. The research design is represented in Figure 1.

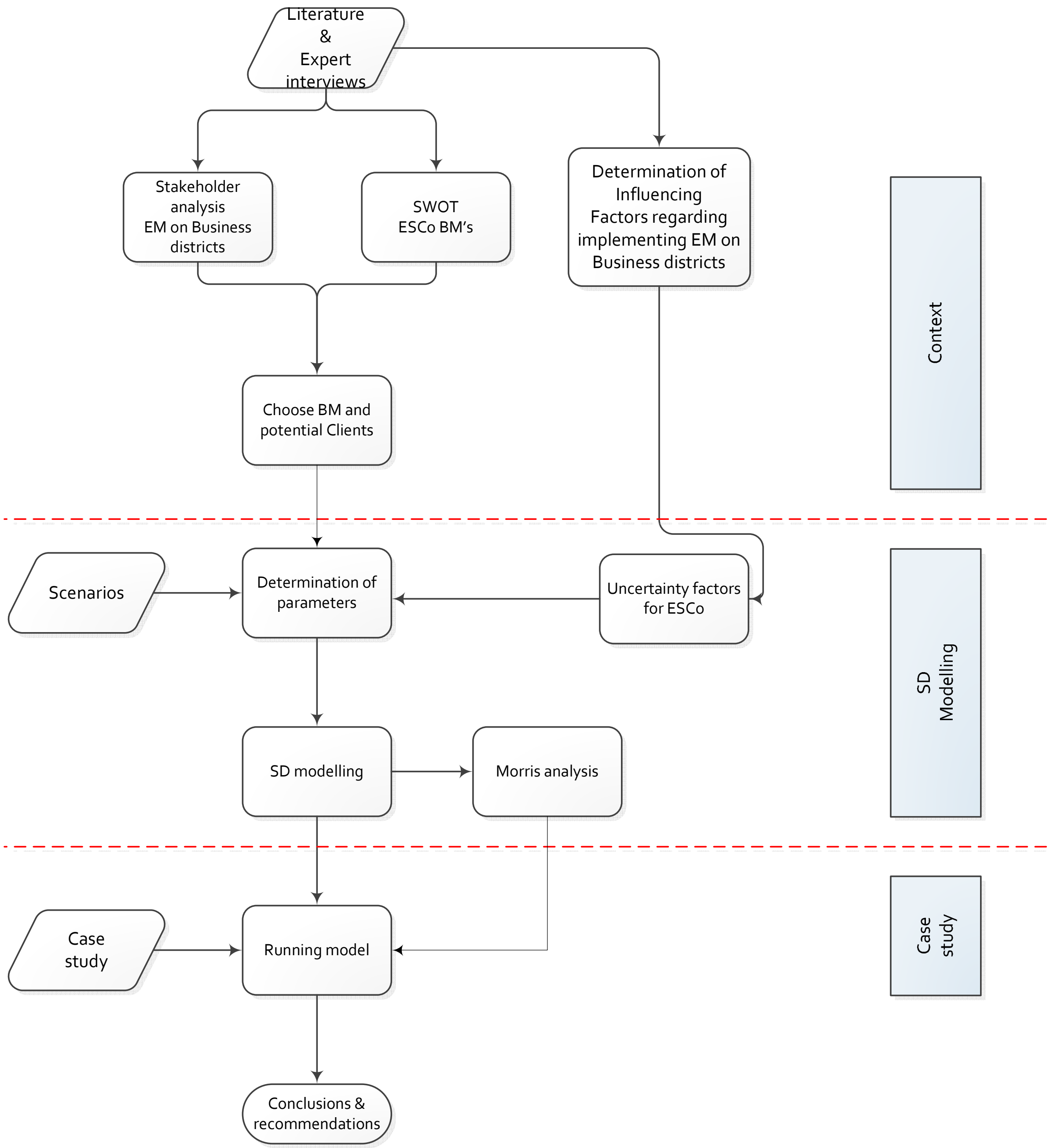

Figure 1 Research design

2 Energy services for business districts

2.1 Business districts

This research focusses on the implementation of energy services in existing business districts. First, a sound definition of what these districts entail is given. Then, the energy use in business districts in its current situation is elaborated and factors that influence the development towards the improvement of this situation are determined.

2.1.1 Definition

Business districts are spatially continuous or functionally connected areas determined for the use by establishments on behalf of diligence, trade and business services. This definition excludes areas which are mainly designated to offices, shops or the catering industry (Schenau, 2011).

Business districts include the following areas: distribution parks, mixed industry companies, high end industry companies, ports and heavy industry.

The following definition gives a more clear delineation of business districts; ''an area larger than 1 hectare, designated for trade, diligence, industry and business services. Not including: seaport areas, economic zones, office areas, areas used for the extraction of raw materials, area for agricultural purposes, areas for oil and gas extraction and landfill areas'' (Ministerie van infrastructuur en milieu , 2011).

There are several ways to categorize the different types of business districts. When types of business are assessed, the following categories can be defined:

Distribution parks: These are business district designated for companies in the logistic sector and form 2% of the total.

Mixed industry: Mixed industry districts form the majority of business districts in the Netherlands with 62% and are designated for regular businesses.

High-end industry: These districts are described as areas specifically designated for companies with high-end technological production or R&D activities. These areas form 4% of the total amount of business districts.

Heavy industry: These parks are designated for heavy industrial companies and form 12% of all districts.

This research focusses on existing mixed industry or mixed business districts because the majority of districts (62%) is of this category. Furthermore, high-end industry and heavy industry parks have often already adopted their own specific programs to save energy and are outside the scope of this research.

2.1.2 Energy on business districts

Mixed industry parks or mixed business districts use energy to condition their buildings or specific spaces within those buildings. However, most energy is used for their production processes. Companies cover 64% of the total energy-use in the Netherlands. (PeGO , 2009) The energy use for each sector in the Netherlands is shown in Figure 2. It shows clearly that the industrial sector has the highest energy use and that this use is growing each year. A remark on this figure is that heavy industry, which is not within the scope of this research, accounts for 55% of this industrial use. In past years, business districts received little attention regarding their corresponding energy efficiency. The obsolescence, deterioration, accessibility and security of these areas have been the subjects in the spotlights. This is remarkable, taking into account the high use of energy on business districts (Mulder & Lindt, 2010).

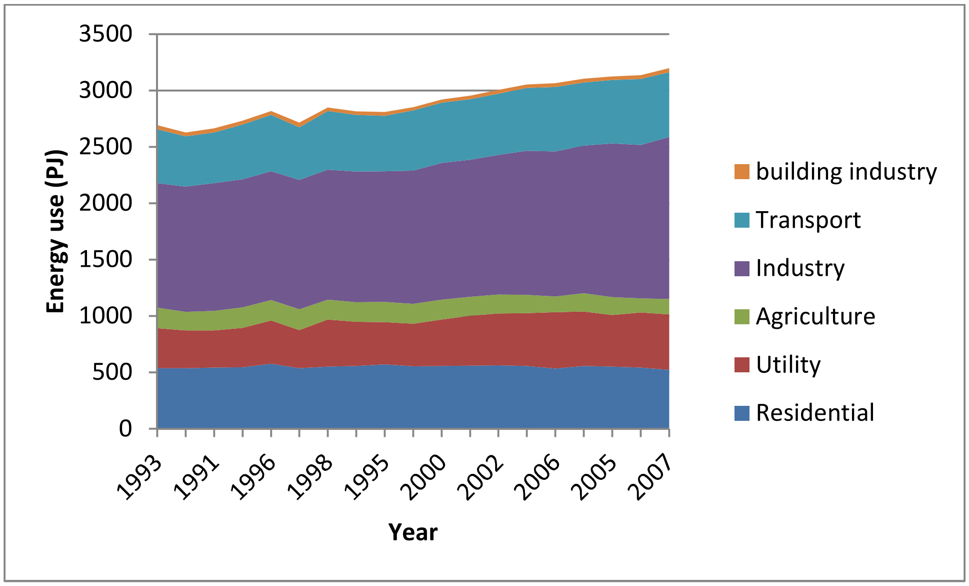

Figure 2 Energy use per sector in the Netherlands (ECN, retrieved from www.monitweb.energie.nl)

2.1.3 Saving potential

The saving potential on business districts is estimated to be in the range of 30% of current use based on experiences in foreign countries. (PeGO , 2009) This potential can be achieved by implementing energy efficiency and renewable energy measures and represents about 60 PJ of savings each year. This amount equals the yearly energy use of 600.000 households or 1,2 billion euros. Table 1 shows the relevance of this potential on national level in comparison with other sectors. There are numerous ways to save energy on business districts both on building level (individual) and on district level (collective). The total saving potential in business districts is called, technical saving potential. This potential represents a situation where all possible saving measures, both on individual and collective level are implemented without considering the corresponding costs. The technical saving potential of individual measures for mixed business districts with a 40-75% manufacturing industry is estimated to be 6% in electricity- and 36% in natural gas savings (Swigchem , et al., 2003).

Sector	Share of national saving potential
Built environment	33%
Industry	38%
Transport	17%
Agriculture	12%

Table 1 Saving potential per sector (Farla, et al., 2006)

2.1.4 Importance of energy efficiency and renewable energy for companies

The energy use of companies in business districts correlates strongly with the type of industry they are in. As stated in the introduction, awareness of the importance with regard to the sustainable use of energy is growing. For commercial companies, becoming more environmentally involved is by itself not an objective. Sustainability can however contribute to improving financial results. Corporate social responsibility (CSR) regarding energy efficiency is found to be inferior to a company's primary objectives; its continuity and profitability. To reach these objectives, companies constantly aim for higher market share and cutting costs (Vaal- van Hooren, et al., 2012). However, the CSR of companies is growing in importance. This is pointed out by research done by the ministry of economic affairs and ''MVO Nederland''. As part of this research, companies in each branch of industry were asked if their customers raised requirements regarding their CSR. Figure 3 shows the results over 2008, 2009 and 2011. Data for the year 2010 is not available.

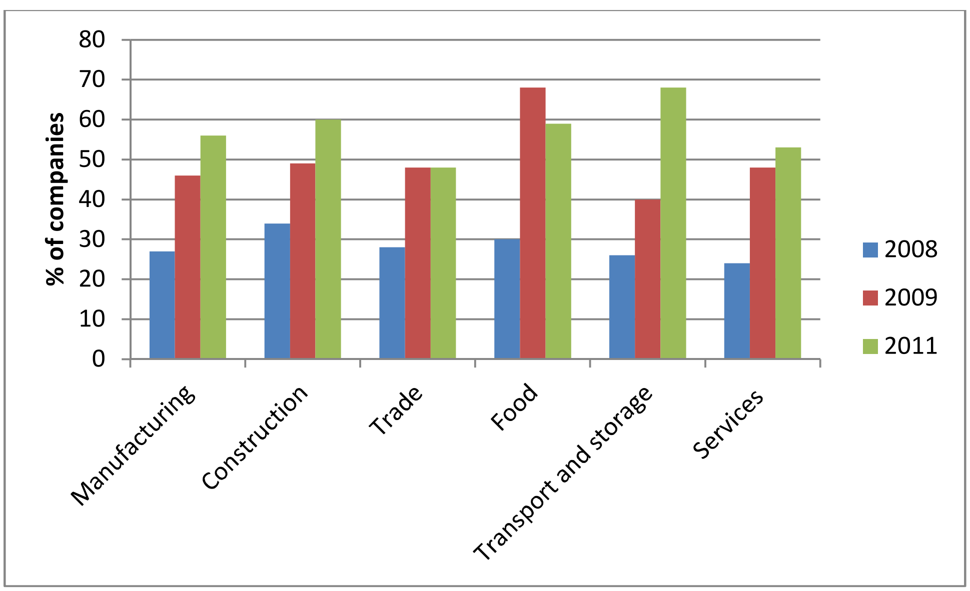

Figure 3 Percentage of companies that experienced increased requirements from their customers regarding CSR (Ministerie van Economische Zaken, Landbouw & Innovatie, 2011)

This study shows that the importance of CSR regarding customer relations for businesses is growing. This results in a situation where improvements in sustainability affect the financial results in a positive way, making investments in this field necessary to stay competitive.

As explained earlier, companies are by nature permanently trying to cut costs to stay competitive, even more so while having to cope with the current economic recession. Non-core costs, commonly called overhead, often provide considerable potential for cost savings measures. Especially small and mid-sized companies often seem to neglect many potential saving opportunities. EBS business school and Expense Reduction Analysts investigated the potential cost savings regarding the overhead costs of European companies. Table 2 gives an overview of the results and shows the importance for each expense type, making it clear that energy is the most important one, thereby also having the highest saving potential. Energy was in the top three of most important expenses among 43,3% of the participating companies. This importance is caused by the continuous rise of fossil fuel prices and the increasing significance companies give to their CO_2 emission (Schneider, et al., 2011).

Leading parties in the field of energy research and production further support this conclusion:

Optimizing energy use in industry is essential to improve industrial competiveness and achieve wider societal goals such as energy security, economic recovery and development, climate change mitigation and environment protection. Measures that are profitable for the entrepreneurs and strongly contribute to the climate and CO2 objectives set by the government (IEA, 2012).

An important incentive for companies to save or invest in energy is the financial aspect. When money can be saved under reasonable risks, companies would invest in sustainability. The potential savings regarding money, strongly depends on the given energy price for conventional energy (ECN, Energie-Nederland and Netbeheer Nederland, 2012).

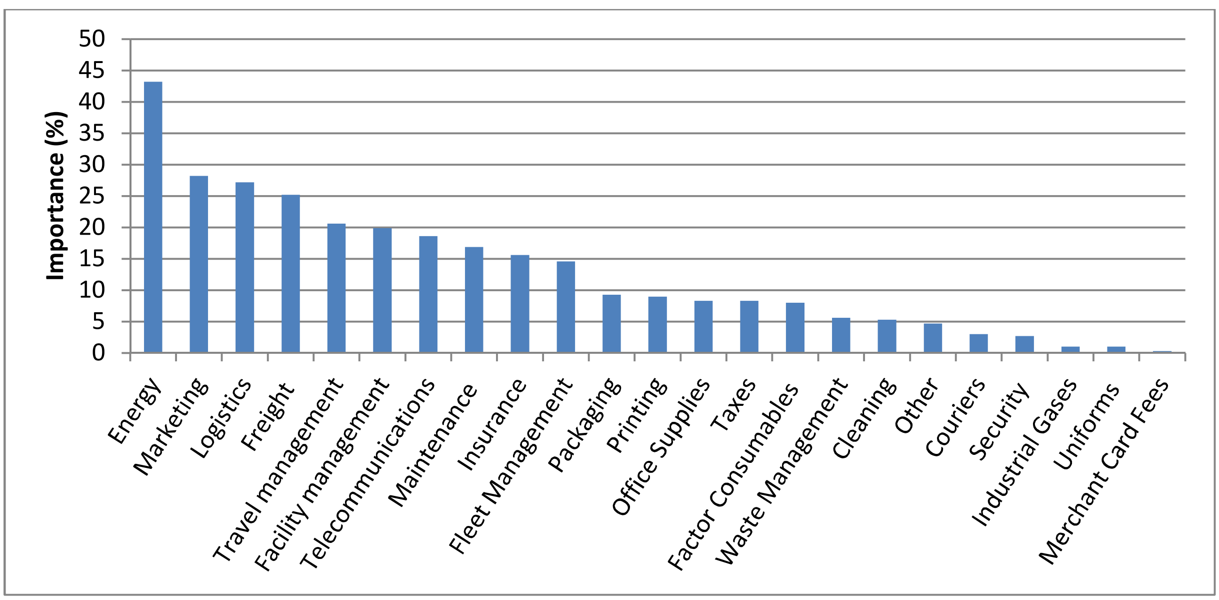

Table 2 The most important types of overhead costs (Schneider, et al., 2011)

Table 3 shows the most important overhead costs per branch of industry. Manufacturing companies by far consume the most energy in relation to other branches of industry. Hence for the manufacturing industry, this overhead cost is, together with ''other services'' the highest expenditure. Since energy has the most potential to cut costs on, energy efficiency is most important for this branch. Secondly, considering the other branches, the potential to cut costs on energy is perceived to be much lower. Therefore, this research focusses on the manufacturing industry.

Branch of industry (SBI 2008)	Total	Energy	Facility management	Inventory	Logistics	Marketing	Communication	Other services
B Mining and quarrying	8980 (100%)	94 (1%)	84 (1%)	603 (7%)	171 (2%)	58 (1%)	16 (0%)	232 (88%)
C Manufacturing	42412 (100%)	6084 (14%)	3901 (9%)	5207 (12%)	1618 (4%)	3990 (9%)	509 (1%)	6678 (46%)
D Energy supply	2812 (100%)	28 (1%)	250 (9%)	406 (14%)	47 (2%)	253 (9%)	44 (2%)	522 (64%)
F Construction	8988 (100%)	361 (4%)	1137 (13%)	1031 (11%)	2131 (24%)	591 (7%)	351 (4%)	981 (42%)
G Trade	66451 (100%)	1769 (3%)	9571 (14%)	1507 (2%)	3666 (6%)	10909 (16%)	1230 (2%)	7776 (41%)
H Transport and storage	24368 (100%)	364 (1%)	2002 (8%)	762 (3%)	12896 (53%)	982 (4%)	316 (1%)	3779 (31%)

Table 3 Overhead costs per branch of industry x mln € (CBS, 2011)

2.1.5 Energy management on business districts

Based on the conclusion that the manufacturing industry in Dutch mixed industry business districts offers the highest potential for saving on energy expenses, the question arises how this can be reached. Clearly, energy needs to be managed in a better way. Energy management includes planning and operation of energy-related production and consumption units.

The Verein Deutscher Ingenieure (VDI) released a definition for energy management, which includes the economic dimension and is therefore well suited for the focus group of this research: ''Energy management is the proactive, organized and systematic coordination of procurement, conversion, distribution and use of energy to meet the requirements, taking into account environmental and economic objectives'' (VDI, 2007).

Energy management can be used to utilize the savings potential of business districts using three approaches:

First, the energy performance on building level such as; improving isolation or optimizing installations and processes is assessed.

Secondly, the possibilities for generating renewable energy on both building and district level, such as individual or collective production of solar and wind energy and aquifer underground energy storage.

The third stage is about utilizing residual energy which is already available in the area but mostly discarded. It may still be of use in in a different process/company. Also the collective use of certain installations belongs to this stage.

The third stage is outside the scope of this research. Connecting residual energy streams and sharing certain installations is highly location specific and therefore difficult to research and even more, to draw general conclusions from. Nevertheless, this approach often brings along technically and financially feasible measures to save on energy use and can improve the total feasibility of a project. So, energy management in this research regards the implementation of energy efficiency measures and renewable energy solutions within existing business districts.

2.1.6 *Influencing factors regarding energy management on business districts*

Energy management in business districts is currently a hot topic but no big results have been reached yet. This is remarkable because of the many possibilities that are available. To know why developments regarding energy efficiency and renewable energy measures on business districts are struggling to be successful, a causal diagram is made. This diagram is depicted as a fishbone diagram and is shown in Figure 4**.** This way, the influencing factors and barriers are identified and categorized in one of the five ''fish bones''. The factors within the categories ''Organizational'' and ''Business'' represent the internal environment and the factors ''Technical'', ''Legal and Government'' and ''Financial'' cover the external environment of this event. The different factors within each category are described in detail below the causal diagram.

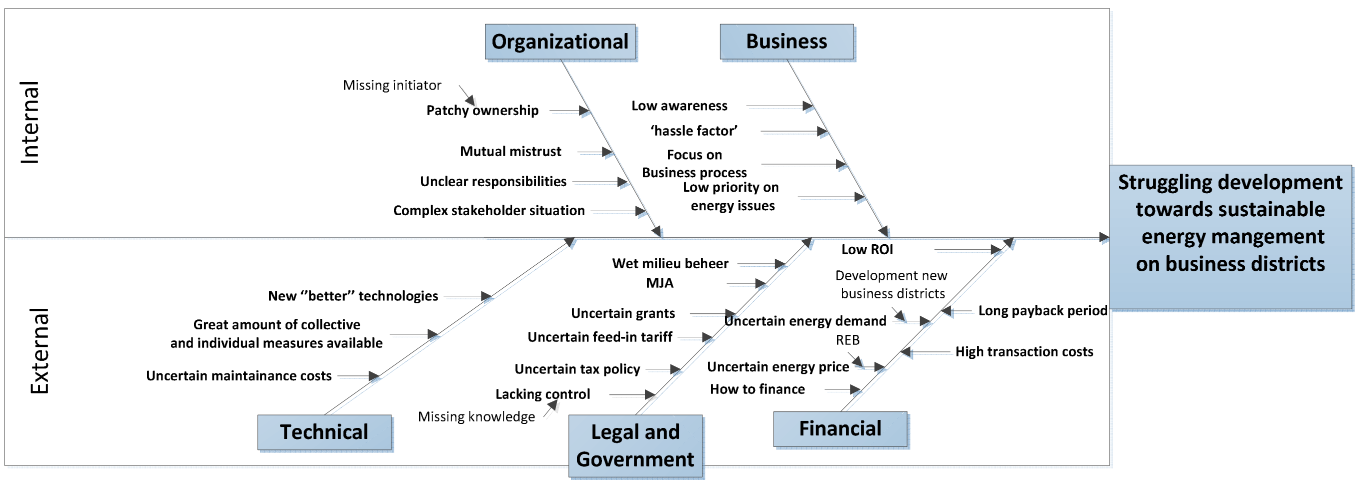

Figure 4 Causal diagram regarding ''Sustainable energy management on business districts''

Now, each category is described with it's specific factors.

2.1.6.1 *Organizational factors*

The organizational aspects of this research are important to reach an integral approach. Organizational issues on business districts hinder many developments to reach a more sustainable environment.

Patchy ownership is an important organizational aspect and is a result of the way a business district is exploited. Most plots are owned and used by the same entity (72%) which results in a highly fragmented ownership situation. This is the main reason for the general absence of a central party responsible for sustainability and energy issues of business districts. This means that collective initiatives by entrepreneurs are scarce and initiatives from the municipality suffer from the complex organization with many stakeholders (Schenau, Y. 2011).

Finally, there is a degree of mistrust among the vested companies and towards public bodies in business districts when implementing collective measures. This mistrust is detrimental to any collective initiative where financial and operational responsibilities need to be managed. "Park management" organizations on business districts normally operate as a neutral party to initiate collective services. However, energy management requires extensive knowledge and expertise that are difficult usually not readily available in a park management organization.

2.1.6.2 Business factors

Most important here is the low priority of energy issues amongst companies. Especially the non-energy intensive industrial firms have low interest in energy issues compared to their core activities. Therefore, there is a low awareness of the possibilities to reach a more sustainable and continuous business situation (Grim, 2005).

Companies concentrate on their core business, and usually do not adopt side jobs. Energy efficiency measures come with a certain ''hassle factor''. This means that these activities are seen as an obstruction to the business process, which costs time and money.

However, small and mid-sized companies are, just like large companies, increasingly confronted with requirements to work in a more sustainable way as shown in Figure 3. This, as well as the growing awareness of the effectiveness of overhead cost reductions by saving energy, results in more interest in energy efficiency.

2.1.6.3 Technical factors

The technical category represent the external technology based factors. There are numerous energy efficiency measures on the individual and collective level available. The extend of these measures keeps growing along with their efficiency. Big energy efficiency projects often have high risks and long pay-back times. Therefore, uncertainties like maintenance costs and technology prices and capacity can hinder progress because the right moment to invest is unclear.

2.1.6.4 Legal and Governance factors

This category in the causal diagram represents factors within the legal and governmental environment. First, the ''wet milieubeheer'' or the Dutch environmental Act plays an important role within the sustainable energy transition. This Act obligates companies with a yearly electricity use greater than 50.000 kWh and/or a natural gas use greater than 25.000 m^3 to implement energy efficiency measures with a payback period less than 5 years. The municipality were the company is vested has the task to maintain this Act. However most municipalities don't have the expertise or man hours available to do this which takes away the incentive for companies to act. However, the energy saving potential of this Act is acknowledged and control will be enhanced to reach those potentials (Volkers, et al., 2005).

Furthermore, companies are now targeted individually which results in an individual approach to the problem while much more effect is sorted when things are organized for the collective (USP, 2011).

In a (mixed) business district, many companies with a low and average energy use are combined with a small number of large companies with large energy uses. The Dutch government has made agreements with these large energy users within the MJA3 (meerjarenafspraken energy efficiency) and the MEE (meerjarenafspraken energy-efficiency ETS-ondernemingen). These agreements are based upon a pre-determined yearly energy efficiency improvement (Agentschap NL, 2011). Companies within this category are already working on their energy efficiency and have made investments to reach the stated objectives. Therefore, these companies have no need for active involvement in collective projects (TNO, 2011).

However, small participating companies within the MJA program also have, as stated before, growing interest in renewable energy measures. Lack of funds and expertise are often in the way of further development (Dervis & Boogaard, 2012).

The policies as described above are summarized in Table 4 and linked to three ranges of energy use.

	MEE	MJA	Environmental Act
>0,5 PJ	x		
<0,5 PJ		x	x
>25.000 m^3 natural gas and/or >50.000 kWh			x

Table 4 Energy saving policies per use (Davidson, et al., 2010)

Another factor influenced by the government is the availability of subsidies for energy efficiency measures. These subsidies can be important for the feasibility of a project. Two subsidies are important when implementing sustainable energy management in business districts;

The ''stimulering duurzame energieproductie'' (SDE+) subsidy stimulates the generation of renewable energy for companies. The price for generated renewable energy is still higher than the price of energy delivered by the energy suppliers. The SDE+ subsidy gives a remuneration to even out this difference. This difference is determined by the correction value and base value. The correction value is the average price for conventional energy given a certain year. The base value represents the costs per unit of generated renewable energy (Agentschap NL, 2013).

Another important subsidy is the ''energie investeringsaftrek'' (EIA). The EIA provides a possibility to subtract 41,5% of the investment costs for energy efficiency measures and renewable energy from the fiscal profit (Agentschap NL, 2013).

The problem with these subsidies is that they are highly uncertain as they are determined each year and depend on the governmental installment which changes every 4 years. This as well as difficulties to comply with all the requirements to receive these subsidies for individual companies, results in a barrier to development.

Finally, the energy tax is identified as a factor that has influence in energy efficiency development of companies. There are two types of taxes that have to be paid when using energy. First, there is the regulating energy tax (REB) that's designed to stimulate the efficient use of energy. Table 5 shows that the tax percentage decreases when the energy use grows. This is constructed in a staggered way, so the tax is paid per threshold, were the remaining energy use shifts up to the next one. The regulating energy tax keeps the energy price low for large users and therefore removes part of the incentive to invest in energy efficiency measures.

Elektricity demand (KWh)	TAX (euro)	Gas demand (GJ)	TAX (euro)
0 – 10.000	0,1165	0 – 186	0,1862
10.001 – 50.000	0,0424	186 – 6.330	0,1862
50.001 – 10 mln	0,0113	6.330 – 37.239	0,0439
Professional >10 mln	0,0005	37.239 – 372.390	0,0160
Non-professional >10 mln	0,0010	Professional >372.390	0,0115
		Non-professional>372.390	0,0115

Table 5 Regulating energy tax electricity and natural gas (De Energiegids, 2013)

2.1.6.5 Financial factors

The financial category includes factors that have great influence in the financial feasibility of energy efficiency projects. Big energy projects involve a high initial investment against high uncertainties combined with a low return on investment (ROI). Companies stand firm with the ''niet meer dan anders'' (NDMA) principle which states that the total costs in a new situation such can't exceed the current costs. Life-cycle costs are rarely taken into account because often, managers only care for short term results. Pay-back times longer than 3 years are only accepted when the core business is concerned. Another factor is that extra payments and loans for energy efficiency can limit the company's investment ability since these can negatively affect the balance sheet (Ürge-Vorsatz, et al., 2007).

Furthermore, uncertain future demand is a factor that can have great influence regarding collective measures. When a company moves elsewhere or goes bankrupt, an important amount of energy demand is lost. This is because of the relatively small number of clients representing most of the energy demand.

This characteristic is also playing a role in the transaction costs. Companies have different buildings and different production processes that result in a limited ability to replicate project designs and causes high transaction costs (Williams, 2010).

Finally, the uncertain energy prices are implemented in the financial category. The energy price for large users is relatively low because of the way the REB is structured, as described above. Despite the tax advantage for large users, the energy price is still rising each year but this trend is, especially for the long run, hard to predict. A rising energy price can seriously endanger the continuity of companies with a high energy intensity and is therefore an important incentive to invest in energy efficiency.

2.1.7 Outsourcing of services

A current trend on business districts is the outsourcing of services such as; security, waste management, parking and maintenance of public spaces. As stated before, this is in most cases arranged by a park management organization. Park management relieves member companies from these activities and is able to implement them in an integral manner, which results in higher quality and cost efficiency. The same advantages occur if the implementation of energy efficiency and renewable energy is outsourced. However, these services require a high level of expertise and financial means to be successful.

An Energy Service Company (ESCo) is specialized in energy management. It can cope with many factors that hinder development towards energy efficiency and renewable energy supply in business districts. Figure 5 shows the extent of services that can be delivered by such companies with regard to the categories as determined in the causal diagram (Figure 4).

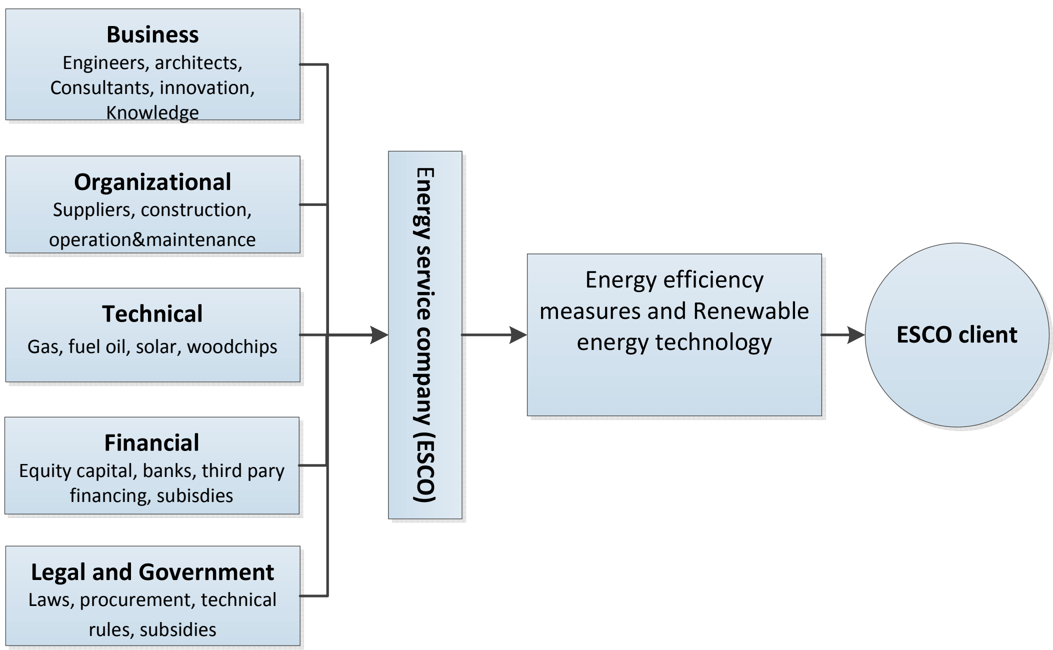

Figure 5 Expertises of an ESCo (Bleyl-Androschin, 2009)

2.2 ESCos

This paragraph starts with defining what ESCos exactly are and how this industry is developing in general. This is done by assessing the current status and the barriers that hinder the ESCo industry on the Dutch market. Then, three relevant ESCo business models are elaborated and a SWOT is made for each of them. Finally, a business model is selected which will be further used within this research.

2.2.1 Definition

To give a clear view of what is meant by an ESCo, a definition is formulated and is elaborated further to prevent confusion of different terms used.

An energy service company (ESCo) is a company that is engaged in developing, installing and financing comprehensive, performance-based projects, centered around improving the energy efficiency or load reduction of facilities owned or operated by customers (Vine, 2005).

An ESCo delivers energy services, which describe energy related services that improve energy efficiency. Energy services can be of simpler forms, such as invoicing services with energy statistics, or of a more comprehensive character. The more comprehensive energy services usually reside within a contract and are referred to as energy contracting.

Energy contracting is described as ‘’A comprehensive energy service concept to execute energy efficiency projects in buildings or production facilities according to minimized project cycle costs.’’ (Bleyl-Androschin, 2009).

2.2.2 Current status of the ESCo industry on the Dutch market

Although the Netherlands has a strong tradition in energy efficiency policy, until 2005 there was hardly any ESCO activity on the Dutch market. Recently, the Dutch ESCO market has begun developing, but the market is still in an early stage and the size cannot be compared to countries like Germany and the UK. In the Netherlands, around 25 independent companies and 25 subsidiaries of larger organizations deploy energy services as their core business (Boonekamp & Vethman, 2011). These activities used to be concentrated on new non-residential buildings but recently the focus is shifting towards existing utilities. The projects mainly focus on energy efficient architectural design and equipment and therefore the providers often offer design, built, finance, maintain and operate (DBFMO) contracts. Projects including combined heat and power (CHP), heat and cold storage, insulation, heat pumps and renewable energy systems (RES) are most commonly deployed. Energy saving technologies, like insulation, are less popular, except efficient lighting projects. Until now, the ESCOs are not really active in the residential market, although projects concerning insulation, solar heating systems, solar panels, heat pumps and energy efficiency of small installations exist. Projects developed in the industrial sector focus mainly on supporting utilities, such as compressed air systems or installations in buildings or offices. Multifamily dwellings are less common clients. Insulation, energy efficiency of small installations, renewable energy (solar heating systems, solar panels, heat pumps) projects are nevertheless being developed in the private residential sector, mainly by new services provided by utilities. The ESCo market is perceived as growing. The total value of possible energy efficiency projects in the non-residential sector with payback time up to 10 years is estimated at up to €9 billion in the industry sector, up to €9 billion in the transportation sector, in the range of €21-65 billion in the service sector and €12-62 billion in the household sector (Marino, et al., 2010).

2.2.3 Barriers to the development of the Dutch ESCo industry

There are several barriers that hinder implementation of the ESCo industry on the Dutch market.

First, potential clients seem unwilling to engage in a contract with pay-back times longer than a few years; they’re reluctant to use ESCos when the core production process is affected. This is mostly caused through unfamiliarity and perceived risks that come with the ESCo concept.

Another aspect that can be improved is the lack of awareness of energy problems and the fact that potential clients are unaware of the ESCo concept.

Third, since clients do not exactly know what the ESCo concept means, a relationship of trust between the ESCo and the client will be hard to build. However, this is essential for the process of measuring and verifying energy savings.

The uncertain future energy prices form another important barrier: on the one hand unstable energy prices might be an advantage to ESCos because clients can reduce their exposure to uncertain future energy costs by reducing overall consumption. On the other hand, it is a disadvantage because the party providing the upfront investment cannot make clear predictions about the size of the future cash flow extracted from the achieved energy savings even though the ESCo is giving a guarantee with regard to the amount of energy saved.

The lack of a proper legal framework is also hindering the implementation of ESCos. Legal conditions, both budgetary and municipal law, could be improved. Energy efficiency contracts are because of tender regulations awarded to the lowest bidder regarding the initial investment. Energy savings are not considered as a portion of the total (lifecycle) costs.

Furthermore, since this industry is relatively new in the Netherlands, there is a lack of baseline data. Baseline data is required for energy contracting based on guaranteed energy savings. This means that extensive measurements beforehand are needed in order to make accurate assumptions on the potential amount of energy saved. Potential clients are simply not accustomed to keeping accurate track of their energy use, making it hard to determine the starting point of the ESCo. The lack of experience with the ESCo concept is present at all parties and enforces this problem (Hansen & Bertoldi, 2006).

2.2.4 Business models

Several business models are used within the ESCo industry divided in Product-service-Systems (PPS), business models based on new revenue models and business models based on new financing schemes. The PPS models are relevant for this research because they consider energy efficiency and renewable energy and are determined to be applicable in the industrial sector (Würtenberger, et al., 2012). This group contains; Energy performance contracting, Energy supply contracting, Integrated Energy Contracting and these are elaborated in this paragraph. The models differ in offered services and remuneration schemes. A SWOT analysis is made of each model to later help finding the best suitable model for the industrial sector hence a business district in paragraph 2.2.5. Figure 6 gives an overview of these three ESCo business models and there position in the energy supply chain.

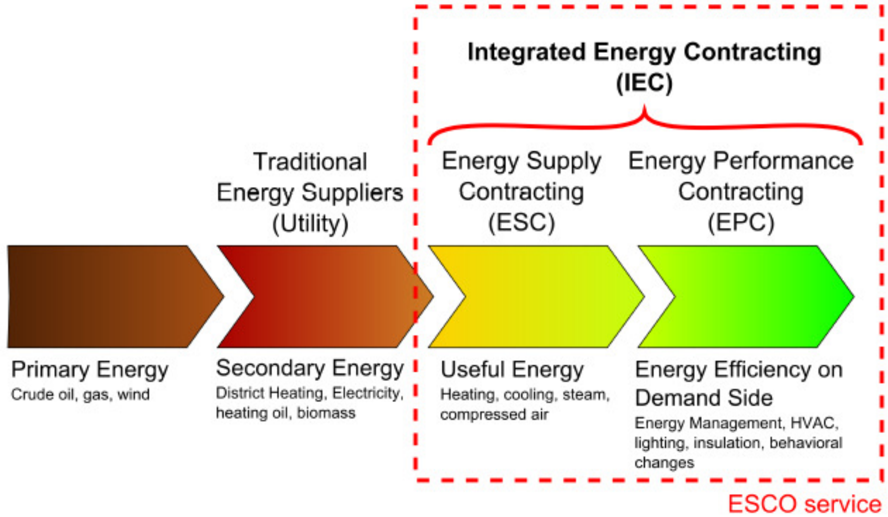

Figure 6 Overview of three ESCo business models (Bleyl-Androschin, 2009)

2.2.4.1 Energy Performance Contracting (EPC)

EPC is a performance based business model. Within this business model, the ESCo will be remunerated based on the energy savings achieved through the EPC project. Characteristic of EPC is that the ESCo will guarantee a minimum savings level that they are then responsible to achieve. To determine the real savings, an energy baseline (energy usage without energy efficiency measures) is set up before the project implementation. The energy usage after the project implementation is then compared to the baseline to determine the amount of energy saved.

There are two forms of EPC, shared savings and guaranteed savings, that differ in their ownership and financing. With shared savings the ESCo finances the project and the financial benefits from the savings are then shared between the customer and ESCo according to a predetermined split. With the guaranteed savings model, the customer will finance the project and the ESCo will in return guarantee a minimum energy savings level.

EPC is well suited for large-scale projects, especially in the public sector. The savings guarantee helps to make EPC a “safe” investment; this is especially attractive in this sector. EPC projects typically generate 20-30% energy savings and the contract duration is generally around 10-15 years. The energy efficiency measures are directed at demand side measures but supply side measures (such as setting up efficient heat boilers) can also be incorporated. EPC is a complex contract form that is not suited for smaller projects because of the high transaction costs. The long payback times that are generally associated with EPC can make it less attractive for the private sector. Setting up an energy baseline can be hard and the measurement and verification process needed to follow up on the project results can be costly. EPC is suited for large-scale projects where in most cases a number of buildings are involved. Instead of looking at buildings one by one, they are often grouped into pools. Comprehensive energy efficiency measures would not be economically profitable for many building if they were looked at individually. By grouping buildings into pools the transaction costs for the individual buildings are lowered and buildings which have a greater potential for energy saving can compensate for those with less.

If energy efficiency measures are looked at one by one it can often result in only the most profitable measures being carried out. If instead the measures are bundled together the ones with shorter payback period can help finance the ones with longer pay-back times, creating a more comprehensive set of measures. How many of the longer-termed investments are included in an EPC project varies from project to project. It can depend on how much money can be invested into the project regarding budgetary restrictions, payback time or risk acceptance (Bertoldi, et al., 2007).

In an EPC project the ESCo takes on the performance risk. The remuneration to the ESCo is based on the performance of the project. The party that takes on the financing of the project covers the financial risk. The remuneration scheme for the EPC business model is shown in Figure 7.

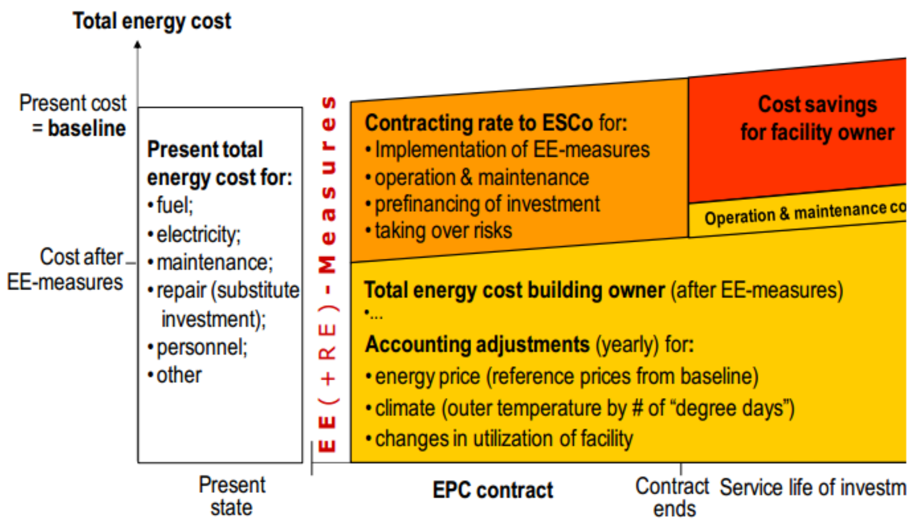

Figure 7 Remuneration scheme EPC (Würtenberger, et al., 2012)

The ESCo's remuneration in an EPC model is often labelled as 'contracting rate'. It is usally calculated as a percentage of the savings achieved through the energy efficiency and renewable energy measures. In case of underachievement the ESCo needs to compensate for the losses, but it will receive an additional remuneration in case of outperforming the savings guarantee. After the end of the contract term, the facility owner benefits from the full eneryg cost savings, though all operation and maintenance expenses are his to bear, too (Würtenberger, et al., 2012).

The strengths, weaknesses, opportunities and threats with regard to the EPC model are summarised in Figure 8**.**

EPC	
STRENGTHS Works well for a pool of buildings Large projects and longer pay-back times makes EPC especially suited for the public sector EPC creates incentives to save energy for the ESCO and the Client Secure loans may be available because of the saving guarantees given by the ESCO	**WEAKNESSES** EPC is very complex and involves many steps Transactions costs and risk surcharges can increase the total project costs and required return on investment Longer payback times Base-line assessment problems Purchase of source energy remains with the building owner
OPPURTUNITIES EPC is likely to gain future promotion considering the targets set by the EU government Large potentials in the industry sector by removing obstacles such as unwillingness for long-term investments and infringement on the core business	**THREATS** Mainly focusses on the demand side, so no real future pricing hedge The complexity of EPC can make the procurement as well as acquisition very difficult Split incentive between the building owner and the building user Often measures are limited to the ones that are easy to implement

Figure 8 SWOT EPC

2.2.4.2 Energy Supply Contracting (ESC)

Here, the ESCo provides the customer with useful (renewable) energy, such as heating, electricity, cooling, steam, compressed air etc. The provider takes over the planning and construction of energy production and distribution systems and/or systems for measurement and control technology. The ESCo will also operate the systems and handle the finance and controlling of the business. With these contracts, the customer only pays for the actual energy costs, while the ESCo takes care of all investments.

An ESC contract will often contain some sort of price guarantee for the energy. The customer may have the opportunity to bind the energy price to a fixed level, with the price depending on the binding time.

An energy supply contract doesn’t have a direct energy efficiency goal like EPC does. Though, this efficiency is indirectly affected since the customer wants to pay as little as possible. Often, requisites for signing an ESC contract are increasing reliability, outsourcing of operations and maintenance and reducing energy costs. A way to improve this cost reduction is to use energy more efficiently. The ESCo is not interested in increasing the energy efficiency at the demand side. Though, there’s a constant incentive for optimization at the supply side, hence the installations that deliver the energy (Bleyl-Androschin, 2009).

An ESC model lends itself very well to setting up solar power/heat supply. Since an ESC contract clearly defines the responsibilities of the ESCo and has a binding contract for the customer, it can help limit financial risks for both ESCo and customer when implementing projects such as this.

The ESCos remuneration is performance based and depends on the useful energy output delivered. Thus the ESC model provides an incentive to increase efficiency of the final energy conversion and to reduce primary energy demand. It guarantees for the outcome and all costs of the services and takes on the commercial as well as technical and operational risks of the project. ESC may accelerate the uptake of renewable energy systems, if theses systems are cost competitive over the lifecycle of the project because ESCOs have an inherent interest to reduce life-cycle. Figure 9 shows the remuneration scheme for the ESC business model. The energy price (per MWh of useful energy metered), covers the marginal 'consumption related' cost per MWh of useful energy supplied. The service price for energy supply includes all operational cosst, i.e. the cost for operation and maintenance, personal, insurance and management of the energy supply infrastructure as well as entrepreneurial risk. If the ESCo (co)-finances the equipment its remuneration also includes a fee for its capital costs minus any subsidies for the energy supply equipment which it may have received (Würtenberger, et al., 2012).

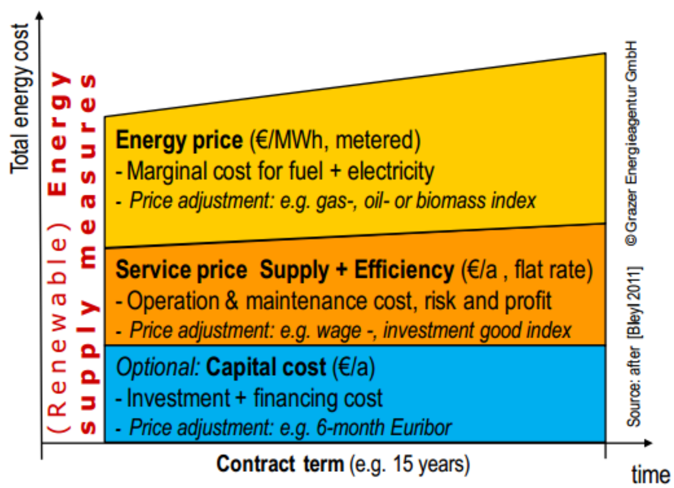

Figure 9 Remuneration scheme ESC (Würtenberger, et al., 2012)

The swot for the ESC business model is shown in Figure 10.

ESC	
STRENGTHS The lowered costs and guaranteed reliability of energy delivery allows the customer to focus on their core business without interruptions This ''obvious'' need is a far more easy investment compared to demand side measures Energy outputs can be measured directly without needing a baseline so the expenses for measurement and verification and the risks associated with the saving guarantee are significantly reduced	**WEAKNESSES** Although ESC does provide some energy efficiency aspects, these are mainly limited to the production side In certain cases, the ESCO will state a minimum delivered energy amount to the customer which means the customer has to buy at least that stated amount, which removes the incentive for the customer to implement any energy efficiency measures on the demand side
OPPURTUNITIES Suitable for smaller projects (in comparison to EPC), thus larger market potential Rising fossil fuel prices will make renwable energy and energy efficiency measures deployed by ESCos more attractive	**THREATS** If ESC is used on a large scale it needs to be complemented with demand side energy efficiency measures to meet the challenge of limiting climate change

Figure 10 SWOT ESC

2.2.4.3 Integrated Energy Contracting (IEC)

The IEC model combines both the EPC and the ESC into a new model and provides two services.

- Reduction of energy demand through the implementation of energy efficiency measures in the fields of building technology (HVAC, lighting), building shell and user motivation;
- Efficient supply of the remaining useful energy demand, preferable from renewable energy sources.

The IEC business model builds on ESC, which is known and applied in many energy end-use sectors such as public buildings, residential, commerce and industry.

As compared to standard ESC, the range of services and thus the saving potential to be utilized is extended to the overall building or commercial enterprise. The model is intended to be used for all energy carriers and consumption media such as heat, electricity, water or compressed air. The results to be achieved by the energy efficiency service encompass modernization of the installations, lower consumption and maintenance costs and improvement of the energy indicators. In addition, non-energy-benefits such as emission reductions or increase in comfort and image shall be achieved. Most energy efficiency projects differ in their contents and general conditions. Therefore, it has proved to be necessary and sensible to adapt the scope of services specifically to the individual project. This also implies the building owner can define, depending on his own resources, what components of the energy service will be outsourced and which components he carries out himself (Bleyl-Androschin, 2009).

At the same time (methodological) problems of Energy Performance Contracting (EPC), e.g. those possibly occurring when creating and adapting baselines, high measurement and verification efforts or risk surcharges on the saving guarantee, are avoided or at least reduced.

The remuneration scheme for the IEC model is shown in Figure 11. The individual quality assurance instruments (QAIs) for the installed energy efficiency measures, secure the functionality and performance of the measures, but not their exact quantitative outcome over the entire project cycle. The objective is to simplify the business model and to reduce transaction costs.

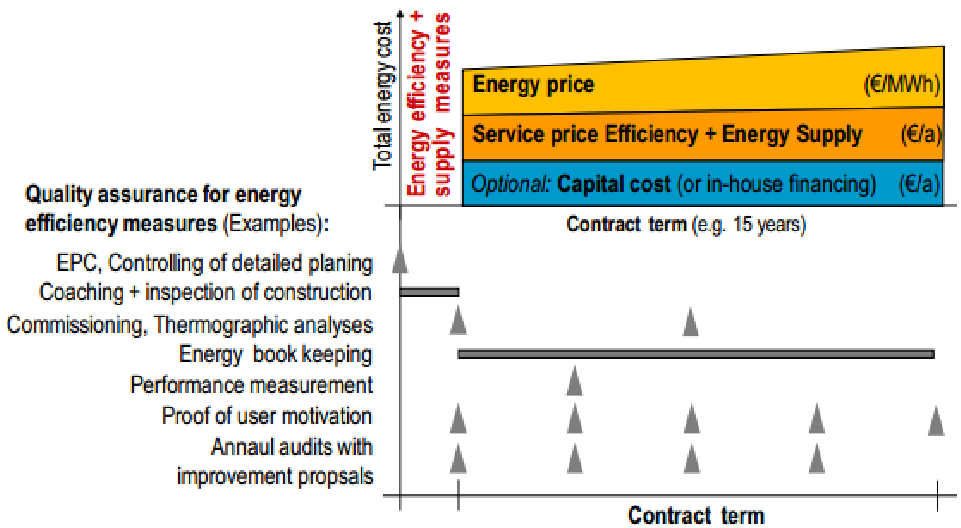

Figure 11 Remuneration scheme IEC (Würtenberger, et al., 2012)

Figure 12 shows the SWOT regarding the business model IEC.

IEC	
STRENGTHS The combined supply and demand side approach will result in higher energy savings Synergy effects can increase the effectiveness of the measures Customers will be more involved than with ESC only, so it's easier to influence their behavior Renewable energy systems and energy efficiency measures in one building as well as several buildings can be packaged in order to reduce transaction costs Gives quality assurances for savings measures instead of savings guarantee which simplifies the model and lowers the transaction costs	**WEAKNESSES** Customers might not be aware of the added benefits of working on the demand side Larger requirement for customer involvement Measures on the demand side will affect the customer
OPPURTUNITIES Markets that have a large share of ESC are also suitable for IEC More flexibility in measures to achieve win-win solutions between stakeholders Providing supply as well as demand side measures gives the ESCo more trustworthiness Lower transaction costs and shorter pay back periods increase attractiveness to commercial sectorBecause of its simpler approach, IEC has more potential on the private sector than EPC	**THREATS** IEC is a new model and has been used in only eight projects so far. The model is in a phase where it's still developing Even though IEC aims to extend the ESC model, ESC will still be simpler for the customer to choose

Figure 12 SWOT IEC

2.2.5 Business model selection

As stated before, the saving potential in business districts is about 30-40%. In general any energy related initiative should first of all focus on energy conservation by evaluating all possible demand reduction oppurtunities. Only afterwards the remaining demand should be supplied as efficiently as possible, including renewable supply options. Otherwise fossil fuel use reduction goals are not achievable (Bleyl-Androschin, 2009).

In some degree, all ESCo business models provide supply and demand side measures. The extent of these services and the verification methods differs, though.

The EPC model is suitable for large-scale projects concerning a ''pool'' of buildings. Though, this does not always result in lower transaction costs because of the remuneration method. A performance contract is set up which requires an energy cost base line. With regard to companies in a business district, these exact base lines are hard to assess since the energy use is very unstable due to changes in utilization of the enterprise. Therefore, this model is more suitable for public utility buildings that have a more constant base line.

These problems are not encountered with the ESC model, because no baseline is needed to measure savings. Therefore, ESC is more common in end-use sectors such as industry. However, demand side reduction measures are minimal and the ESCo profits come from selling energy units. A common issue that arises is the conflicting incentives for supply oriented companies (such as ESC or 'regular' energy companies) when they start looking at the demand side. If a company, that normally gets paid for selling energy units now promotes lowering the need for these energy units, the credibility might not be that high from the client point of view.

The IEC model builds on the ESC model but implements extensive demand side reduction measures as well. The ESCo takes over the entire energy management, including the purchase from conventional energy sources. This results in a situation where the ESCo needs to install the most efficient measures to make profits. This takes away the credibility issue as described above. The IEC model can lower transaction costs better considering the verification method of quality assurances instead of base line verification. Now, the remuneration of the ESCo consists of the measured real energy use. Clients are more involved because of this integral approach and synergy effects are more likely to arise. These can increase the effectiveness and the feasibility of the project.

For these reasons, the IEC model appears to be the most promising for business districts. Therefore, it is adopted as the model of choice in this research. The further use of the term ESCo in this report refers to this specific business model.

2.3 ESCos in business districts

In this paragraph, the added value of ESCos for business districts is elaborated. This is done by considering the factors shown in Figure 4 that are addressed by the ESCo activities. Then, the factors that remain will be considered, those represent the uncertainty factors for the ESCo. Furthermore, a stakeholder analysis is made with regard to the implementation of ESCos in business districts to get a better overview of important players. Finally, the potential ESCo services are further defined.

2.3.1 Addressed factors

The ESCo takes over the management of energy related services for its clients so all factors within the organizational category are addressed. Because energy services are outsourced to the ESCo, there is no need for another initiator for collective measures. The ESCo is an independent party, which can manage stakeholders unbiased so mistrust between companies is reduced.

Within the business category the ''hassle factor'' is addressed because the energy management is outsourced to the ESCo. The ESCo is responsible for installation, operation and maintenance of the measures so the clients can focus on their business processes.

An ESCo has extensive knowledge regarding the possible measures to implement and the maintenance costs so it addresses this part of the technical category.

In the legal and governance category, the Dutch environmental Act obligates companies to implement certain measures as discussed in subparagraph 2.1.6. Large companies, participating in MJA can implement these themselves but the mid-sized industry does not have the financial means and knowledge to do so. An ESCo can relieve these companies from difficulties in complying with these obligations.

The most important factor the ESCo addresses in the financial category is the finance issue. An ESCo can arrange the financial means by investing own funds or with the help of a financial institution. Companies can also invest but this forms a problem with regard to the longer pay back periods. Because the ESCo approaches the companies as a pool of buildings, it can lower the transaction costs.

2.3.2 Unaddressed factors

The low awareness and the low priority on energy issues are unaddressed factors in the business category. However, in subparagraph 2.1.3 is explained that companies become more aware of the potential of energy efficiency. These ''soft factors'' will not be further assessed in this research.

In the technical category, the development of new and improved technologies is difficult to grasp, also for the ESCo. This aspect forms an uncertainty because installations have long pay back periods and cannot simply be replaced during this period. Therefore, it's important to implement measures in the right time to increase the feasibility of the project.

In the legal and governance category, the tax policy and granting of subsidies form uncertainties for the ESCo. These factors depend on governmental policies which an ESCo cannot control.

The financial category has the most unaddressed factors by an ESCo. The low return on investment makes it more difficult to finance these projects since ESCos are commercial companies as well. The energy price and the energy demand affect the ROI and form uncertain factors that cannot be addressed by the ESCo. The highlighted factors in Figure 13 represent these unaddressed factors that are uncertainties for the ESCo. These uncertainty factors will be further assessed within this research and are reformulated as; ''demand of energy'', ''energy prices'', ''subsidies'' and ''technology development''

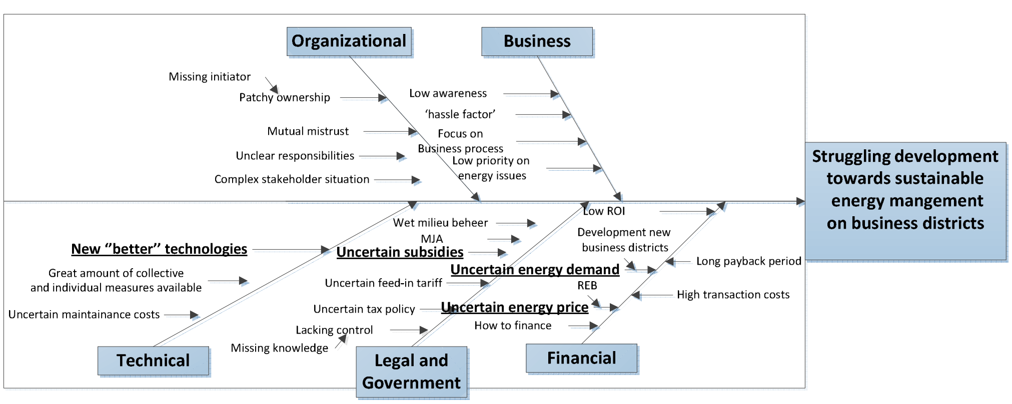

Figure 13 Causal diagram; unaddressed factors

2.3.3 Stakeholders

For energy service projects to succeed on business districts, the integral approach is important. There are many stakeholders that are important to consider when implementing energy services in business districts. Hence, for the implementation of collective energy management on a business district it's important to form a project organization that can manage the project for a longer period (TNO, 2011).

To assess the most important parties involved, a stakeholder analysis is made. This analysis is based on expert interviews and literature. Each interviewee has filled in the stakeholder table as shown in appendix A. This table shows the overall findings and average weights considering the interest, support and power corresponding with each stakeholder within the context of implementing energy services in business districts. To determine the most important stakeholders, a power VS interest diagram (Figure 14) is made. The position in each quadrant of the matrix is based on the weights that were given to each stakeholder's power and interest. The most important conclusions for this analysis are described below.

Clearly, the key player in the context of implementing energy services in business districts is the ESCo. In the end, this is the company that has to take the risk and the initiative. As stated before, business districts are interesting because they represent many potential clients with high energy uses and the potential to save energy. However, there are several uncertainties that can affect the success of an ESCo in the long run. Another important problem that occurs when trying to deliver these kinds of services to a specific sector is the demand for energy services. Large industrial companies have low interest in outsourcing energy related services because often, they are already attached to certain governmental agreements as discussed in subsection 2.1.6. Secondly, these companies have sufficient knowledge and financial means to act upon improving their energy management individually. The mid-sized industry has low awareness regarding the energy saving potential and the possibility of outsourcing services to use this potential. Outsourcing services is important for these companies because they have less means regarding time, money and knowledge to take action themselves. Park management has high interest in collective energy management projects in business districts because the quality of the area is increased when energy is managed in a better way. Although park management is suitable for arranging collective operational services, energy management demands more specialism. Therefore, park management can act as a first mediator between the potential ESCo clients on the district and the ESCo. This way, awareness of the possibilites for outsourcing energy services can be increased (PeGO , 2009).

This role can also be picked up by a public development agency, which not only can raise awareness of energy issues and familiarity with the ESCo concept but also can help financing the project when funds are insufficient. These agencies are governmental parties and are able to accept a lower return on investment by releasing revolving funds. Financial institutions are important when an ESCo has a limited amount of financial resources itself. These parties have great interest in making investments with a high return and well-defined risks. The energy service industry is still very immature in the Netherlands. Therefore, financial institutions are still skeptical towards this industry, so a strong business case is needed.

Net administrators have a strong interest in these energy projects, as they want to keep exploiting the grid for their own business continuity. Therefore, these parties are likely to be supportive towards this concept and have an important role in providing a suitable energy infrastructure, which can facilitate the generation and distribution of renewable energy.

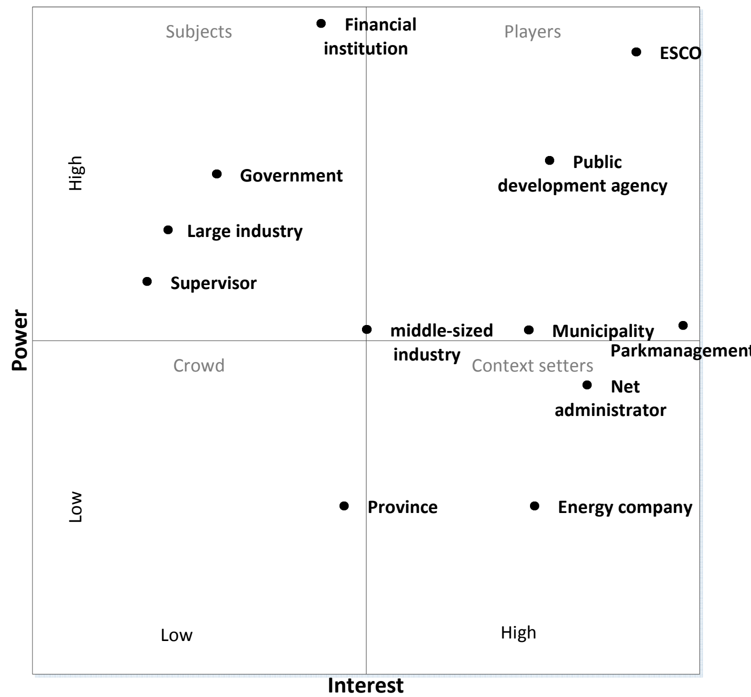

Figure 14 Power vs Interest diagram

2.3.4 Determination of energy services

The ESCo will deliver energy efficiency and renewable energy measures to the industrial clients. There are many efficiency measures to save energy within industrial processes. These are shown in Appendix A and depend on the type of manufacturing industry.

In general, industrial processes require two sorts of fuel; natural gas and electricity. Natural gas is mostly used to produce process heat (>200C°) and electricity for power and lighting. The renewable energy systems have to be able to satisfy these needs. Furthermore, these systems must be implementable for business districts in a feasible way. Appendix C shows a confrontation matrix of possible renewable energy measures. This matrix plots the financial feasibility, based upon research by DWA (2012), against the suitability for business districts.

Windmills can provide a source of renewable electricity but the installment in business districts is complicated and often restricted by the municipality.

Geothermal energy asks for a very high initial investment and a high heat demand. The clients in this research manly use process heat. This is not satisfied by geothermal systems nor by aquifer thermal energy storage (ATES) or combined heat and power (CHP) installations.

Biomass digestion plants require huge amounts of suitable biomass from its surroundings. The suitability for business districts is therefore low because the availability of biomass is in most cases to small.

Photovoltaic panels are placed in the upper right quadrant of the matrix together with solar thermal panels. Business districts have high amounts of roof surface available for these systems which are able to deliver electricity and heat. The technological development regarding these techniques is at a high pace and therefore grid parity, meaning price equilibrium with conventional energy, is likely to be achieved soon. There are solar heat systems available that deliver process heat for industrial companies so this technique fits well within this research (see appendix D). The specifications of these measures are described in chapter 4.

2.4 Context conclusions

This paragraph summarizes what has been concluded so far in the research.

- *ESCo clients*

As stated in literature and the stakeholder analysis, large energy users in business districts have little need for outsourcing their energy services. Furthermore, small energy users are not of interest to the ESCo because of their low expenditures for energy. As concluded in subparagraph 2.1.3, the manufacturing industry represents the most important potential ESCo clients in business districts. Therefore, ESCos will primarily focus on the mid-sized industry that by itself can’t implement sound and structured energy solutions .

Furthermore, there can be concluded from the stakeholder analysis that park management organizations and public development agencies are important players when implementing ESCos in business districts. They can raise awareness about the possibilities among the potential clients and support ESCo projects on both the organizational and the financial level.

- *ESCo business model*

The business model that has the best fit in business districts was selected in paragraph 2.2.5. Because of the extent of services, remuneration scheme and verification method, the IEC model appears to be the most promising for business districts.

- *ESCo services*

The ESCo will deliver supply and demand side measures to its clients. The demand side is approached with energy efficiency measures as described in Appendix B. Iinstallation of solar PV and UHV panels are currently the most promising supply side measures.

- *Uncertainty factors*

The factors ‘’demand of energy’’, ‘’energy prices’’, ‘’subsidies’’ and ‘’technology development’’ determined, influence the financial feasibility of the ESCo and have limited predictability.

3 Research methodology

This chapter explains the methodology to assess the financial feasibility of ESCos for business districts under the uncertainties as stated above. System dynamics (SD) is used to create a net present value (NPV) model that includes these uncertainty factors. To learn more about the impact each factor has on the financial result, a sensitivity analysis (SA) has been incorporated.

The SD methodology may seem complicated to start with. However, much more can be derived from this type of model and the way relations are handled than from a large spread sheet. The latter soon becoming too cluttered with many interlinked formulas. Because all investment have to deal with future uncertainties (risks), a forecast for this future needs to be provided. However, the future has too many uncertainties to give a single representation. Therefore several scenarios are used to test the model and get an oversight of the feasibility with regard to the service company's activities.

First, the SD methodology and the reason of its application in this research are explained. Then, the sensitivity analysis is elaborated.

3.1 System Dynamics

''System dynamics is a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System dynamics is also a rigorous modelling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations'' (Sterman, 2000).

SD is a moddeling methodology which represents reality and aims to simplify it in a matter that can be comprehended. The goal of the model is to make an abstraction, so that the dynamics of the effects can be investigated. In this research, SD is used to model the factors that influence the NPV of an ESCo's activities on a business district.

Sterman (2000), describes the modeling process to be iterative, which means that results of the steps taken can yield insight to revisions in any earlier step. The modeling process includes the following steps:

- Articulate the problem to be addressed
- Formulate a dynamic hypothesis or theory about the causes of the problem
- Formulate a simulation model to test the dynamic hypothesis
- Testing the model until you are satisfied it is suitable for your cause
- Design and evaluate policies for improvement

This process is shown in Figure 15:

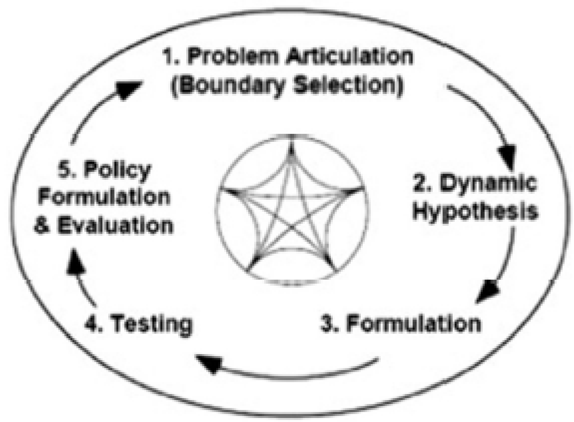

Figure 15 The SD modelling process (Sterman, 2000)

When calculating the NPV of a project, all future cashflows are discounted against a return on investment and inflation. A more common way to do this is by using a spreadsheet. In this research though, the choice was made to use SD as a tool to represent this calculation. This choice is motivated as follows:

Because of the many parameters that influence the cashflow, a visual depiction of relations is an advantage because it privides a comprehensive overview of which parameteres influence others. Furthermore, the SD model works with more easily readable equations than a usual spreadsheet. It's easier to test what-ifs with built-in simulation methods and the possibility to separate the model from the data and the output. This way, simulations can be run without changing the basics of the model. The model is used to assess the financial feasibility in different scenarios. Within the SD software, results from changing input can be easily compared. So SD gives more insight and feeling with the modelled process which is important considering the uncertainty of factors that influence the model.

3.2 Morris analysis

To assess the level of influence each parameter in the model has on the random variable (NPV), a sensitivity analysis (SA) is performed. There are a large number of approaches to performing a sensitivity analysis depending on the characteristics of the data and the research objectives. The parameters in this research change with each scenario, giving each parameter a range of possible values. Each scenario has an equal probability to occur.

Overall, two groups of sensitivity analyses are recognized: local sensitivity analysis and global sensitivity analysis. The local SA examines the local response of the output(s) by varying input parameters one at a time while holding other parameters at central values. The global SA examines the global response (averaged over the variation of all the parameters) of model output(s) by exploring a finite (or even an infinite) region (Saltelli, et al., 2000).

The goal of the analysis is to assess the level of influence regarding each individual parameter so a local SA is chosen. One of the simplest and most common approaches is that of changing one-factor-at-a-time (OFAT or OAT), to see what effect this produces on the output. This method involves:

- Moving one input variable, keeping others at their baseline values, then,
- Returning the variable to its nominal value, then repeating for each of the other inputs in the same way (Bailis, et al., 2005).

The Morris analysis is such an OAT method and reviews the corresponding of each parameter with regard to the random variable (NPV) and is used in this research.

4 Developing the SD model

In this chapter the system dynamics model is created using the software package Vensim®. This model is used to assess the feasibility of energy management in existing business districts for an ESCo, under the uncertainty of influencing factors determined in paragraph 2.3.2. These factors are represented by different parameters in the model that influence the cash flow and therefore the NPV. The structure of the model represents the IEC business model as selected in paragraph 2.2.

First, the selected business model is further explained to clarify the structure of the model and the cash flows later. Then, the parameters are elaborated. The SD model is presented and the structure is explained. Finally, the sensitivity analysis is performed to analyse the extent of influence each factor has.

4.1 Business model

The payment and service structure of the model is based on the IEC business model. This business model is visualized using the board of innovation business model format and is shown in Figure 16.

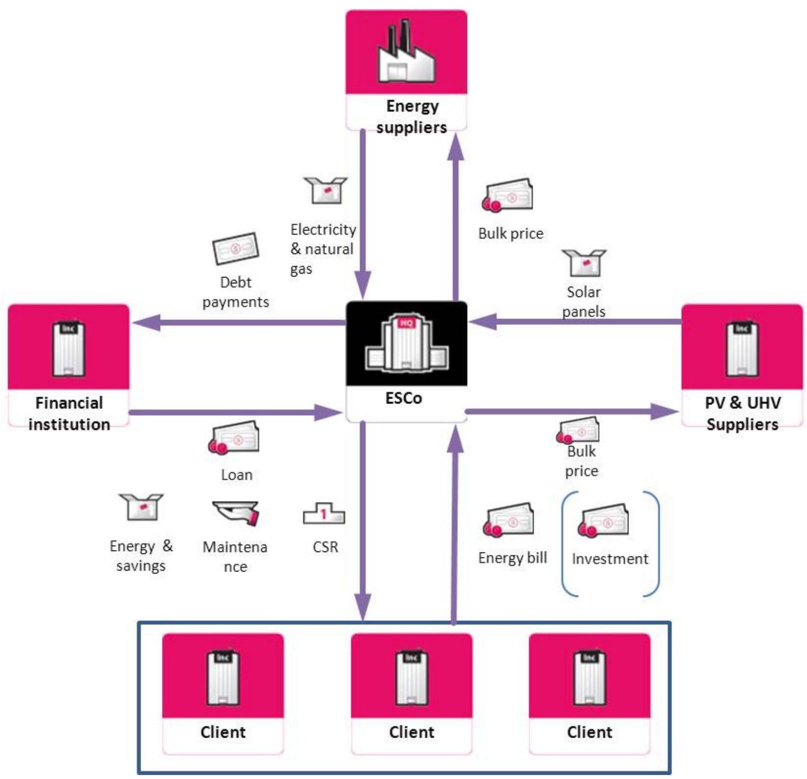

Figure 16 Business Model ESCo

The clients represent the companies within the project/business district that are served by the ESCo. The energy bill is paid to this ESCo. The energy bill is based upon the demand for energy, which is supplied by the ESCo. The delivered energy consists of generated renewable energy and conventional energy. Furthermore, the ESCo implements energy efficiency measures at each company to reduce the total demand. To manage this, the ESCo installs meters for heat (natural gas) and electricity at each client. The tariff structure satisfies the accepted principle that the total cost of energy will not be higher than without the ESCo. The way the energy bill is made up remains unchanged during the payback period of the saving measures. This way, the achieved savings lead to a reduction of energy expenses after their payback period, so at that point the clients will start tot profit as well. The PV and UHV panels are installed on the available rooftop surface of the buildings. These installations remain property of the ESCo for the full project duration. The generated electricity is distributed using the existing electricity net between the different clients. The generated heat will be installed proportional to specific client needs. The heat will therefore not be made available to all clients so no additional changes to the main infrastructure have to be made. As a result from the ESCo's services, the clients comply with energy efficiency obligations, have an increased CSR and lower energy costs over the project.

The initial investment for the project is financed by an external financial institution to which annual payment are made by the ESCo. The means to make these payments are intended to be generated with the positive net cash flows resulting from the costs for services and energy delivered being lower than the revenues from the energy sale to clients. Optionally, the clients can financially participate in the project by co-financing the initial investment.

The total energy demand minus the savings and the generated renewable energy, is purchased by the ESCo from the conventional energy supplier. Because the ESCo buys energy for the pool of companies, bulk prices can be arranged. The same goes for the PV and UHV supplier.

4.2 Determination of parameters

The uncertain factors, ''demand of energy'', ''energy prices'', ''subsidies'' and ''technology development'' influence the feasibility of the ESCo. To model the uncertain future of these factors, scenarios are used, except for the factor ''technology development''. This factor has separate future trends that will be explained later. First, the different scenarios used in this research are explained. Then, the uncertainty factors are translated into parameters that correspond with the scenario input and the SD methodology. Scenario specific and constant parameters are distinguished. The initial values for the energy demand and suitable rooftop surface for solar panels are case study specific and therefore determined in the case study chapter.

4.2.1 Scenarios

ECN, a Dutch energy research centre, has constructed several scenarios to predict future developments within the energy context. The scenarios are based upon other scenario studies where global, European and national developments from now to 2040 are described. The European economic growth scenarios are described in Four Futures (Mooij & Tang, 2003). The derived economic growth paths for the Netherlands are stated in ''Vier Vergezichten op Nederland'' (Huizinga & Smid, 2004). These scenarios are used to derive energy scenarios for developments in energy prices and demand. These are described in the ECN report ''achtergrondrapport WLo''. (Farla, et al., 2006)

ECN has constructed five different scenarios called WLo-scenarios ("Welvaart en Leefomgeving"). The characteristics of these scenarios are shown in Table 6 , except for the fifth scenario; Global Economy (high oil price). This extra scenario represents the case were the oil price will be extremely high and will provide the most beneficial circumstances for an ESCo. The five scenarios provide future trends (present time – 2040) for energy prices, demand and fossil fuel reduction policies that can be found in that can be found in Appendix E.

Strong Europe	**Global Economy**
Mediocre economic growth	High economic growth
Global trade with environmental restrictions	Free global trade
Effective international climate policy	No climate policy
Regional communities	**Transatlantic market**
Low economic growth	High economic growth
Trading business as usual	Trading business as usual
Effective national climate policy	No strong climate policy

Table 6 WLo scenario characteristics

4.2.2 Energy demand

As explained before, the manufacturing industry demands two types of energy sources; electricity and natural gas. The specific energy demand in the model is based on its initial value, which represent the total energy use of the ESCo clients in the business district. The trend in energy use is modelled using growth factors as determined in Appendix E. The exact energy use, consisting of electricity and natural gas, is harder to determine since this type of data is mostly confidential. Therefore, a method to estimate these values has to be used. This is done by assessing the average energy use per employee per year by the mid-sized industry. The average energy use per employee differs per sector in which this employee works. Hence, every industrial activity needs a certain amount of employees per unit of added economic value. Labour intensity and energy intensity are assumed inversely proportional to each other (Swigchem , et al., 2003). Table 7 shows the average energy use per employee per year for the manufacturing industry divided into varying industrial users.

		Electricity			Gas	
Description	**SBI**	Cool/freeze	Compressed air	Light/power	Process heat	Heating
Manufacturing Industry	D	1,27	1,01	142,11	340,34	47,93

Table 7 Estimation of energy use (Swigchem , et al., 2003)

The data shows that the total yearly gas demand per employee is 395.5 GJ which equals 10.180 m^3 of natural gas. The total electricity demand is 144.4 GJ which translates into yearly demand of 40.110 kWh per employee. Companies with a yearly electricity demand between 200.000 and 1.000.000 kWh and/or a gas demand between 50.000 and 300.000 m^3 will be incorporated within this research. These represent mid-sized manufacturing companies in this research. In the case study chapter the total energy use is estimated by selecting these companies and using the corresponding amount of employees to predict their energy use.

4.2.3 Energy prices

The energy prices for electricity and gas are also modeled with an initial value, which represent the price in the base year and growth factors as determined in appendix E. The price for electricity and gas consists out of three parts: transport costs, delivery costs, and taxes. The tax on energy consists out of the REB.

4.2.4 Subsidies

As determined in paragraph 2.1.6, there are two relevant subsidies when implementing energy efficiency and renewable energy measures in business districts.

SDE+: This subsidy grants a certain remuneration per generated unit of energy. As explained before this remuneration is based on the difference between the cost for conventional energy and the cost for renewables. A percentage of the difference, 5%, is determined as the SDE+ subsidy (DWA installatie- en energieadvies , 2012).

EIA: Represents a fiscal system for promoting energy efficiency measures. The investments costs for measures can be substracted from the profit of the clients. This results in an average financial advantage on the total initial investment of 10% (DWA installatie- en energieadvies , 2012).

The availability of these subsidies in the future represent the uncertainty and is determined for each scenario in appendix E.

4.2.5 Technologic development

To cut back on the use of conventional energy, energy efficiency measures and renewables are implemented. These do not depend on the WLo-scenarios as stated above. The energy efficiency measures are assumed constant and are modeled using the technical saving potential and the corresponding costs for electricity and natural gas saving measures. These values are based on the research of Swigchem , et al., (2003).

As determined in paragraph 2.3.4, the ESCo implements solar panels to generate electricity (PV) and heat (UHV). These systems are modeled with the parameters; surface, capacity and price. The parameters surface and capacity are further explained.

Surface: The amount of panels that can be installed depends on the available surface with regard to the rooftops. Though, only a fraction of the total available surface can be used to generate energy due to safety requirements and installation requirements. The maximum amount of solar panel surface in relation to the rooftop surface is assumed to be 35% (DWA installatie- en energieadvies , 2012).

Capacity: The capacity of solar panels represent the amount of energy generated per square meter of panel per year. This depends on the efficiency of the panels and the solar irradiance. In the Netherlands there is an average solar irridiance of 3 MJ/m^2/year (Boxwell, 2013).

In the SD model, no growth factors are used for these parameters because ath the moment that specific panels are installed their capacity and price are fixed. These parameters do change over time tough, so the optimal moment of installation can be argued. The cost per generated unit of energy is determined by the capacity and the price per m^2. Because of the technological developments with regard to solar panels, the capacity keeps increasing and the price keeps decreasing. This makes the price per unit of generated renewable energy drop, while the price for conventional energy rises in all economic scenarios. The point where these two meet is called grid parity (Breyer & Gerlach, 2010). The trends for the solar panel price and capacity are shown in Appendix F.

The parameters which are used in the model are structured, with regard to their corresponding units, values and sources, in appendix G.

4.3 The SD model

Now the SD model is presented and the most important parts are discussed. The model is shown in Figure 17. To better understand the structure of the model, the parameters that represent the factors and important parts are highlighted. An additional part has been added to calculate the CO_2 emission. The model calculates the NPV based on the generated cash flow of revenues and costs.

Equation 1 shows the formula to calculate the NPV from the start of the project, t=0, to the end of the project duration T.

$$NPV = \sum_{t=0}^{T} \frac{Ct}{(1+r)^t}$$

Equation 1 net present value

Where;

Ct = the net cash flow; initial investments – costs + revenues

r = the discount rate; the opportunity cost of capital

The revenues for the ESCO in the model come from the sale of energy to clients. The total energy bill is based upon both the electricity and gas demand of the clients and the energy efficiency measures that are taken over time. As stated before, the clients will only start to profit from the energy efficiency measures after these have reached their point of break even. This is 5 years for electricity measures and 10 years for gas related measures. The generated renewable energy is added to represent the revenues coming from the SDE+ subsidy. The equations for the electricity bill and gas bill are shown in the box below.

Electricity bill;

IF THEN ELSE(Time<=5,((E demand*Electricity price)+(Renewable elektricity generation*(((E Price-Electricity price)*SDE)))),((E demand*(1-E savings))*Electricity price)+(Renewable elektricity generation*(((E Price-Electricity price)*SDE))))

Gas bill;

IF THEN ELSE(Time<=10,(G demand*Gas price)+(Renewable heat generation*(H Price-Gas price)*SDE),((G demand*(1-G savings))*Gas price)+(Renewable heat generation*((H Price-Gas price)*SDE)))

The demand for conventional energy decreases with the energy efficiency measures and the generated renewable energy. This is represented by the *E use* and the *G use* in the model. The costs for the ESCo are based on these variables because this is the amount of conventional energy that has to be purchased elsewhere.

Costs;

(E use*Electricity price)+(G use*Gas price)

The investment for the energy effciency and renewable energy measures is represented by the variable *initial investment*. The variable *EIA* is added to calculate the potential subsidy on the investment.

Initial investment;

(-Investment saving-Investment E generation-Investment H generation)*(1-EIA)

Now the *net cash flow* can be defined based on the revenues, costs and initial investment.

Net cash flow;

Initial investment/TIME STEP*PULSE(0,TIME STEP)+STEP((Revenues-Costs),1)

The net cashflow is discounted against the the target *ROI* and the *inflation* which are combined in the *real interest rate*.

NPV;

NPV(Netto cashflow,Real interest rate,1,1)

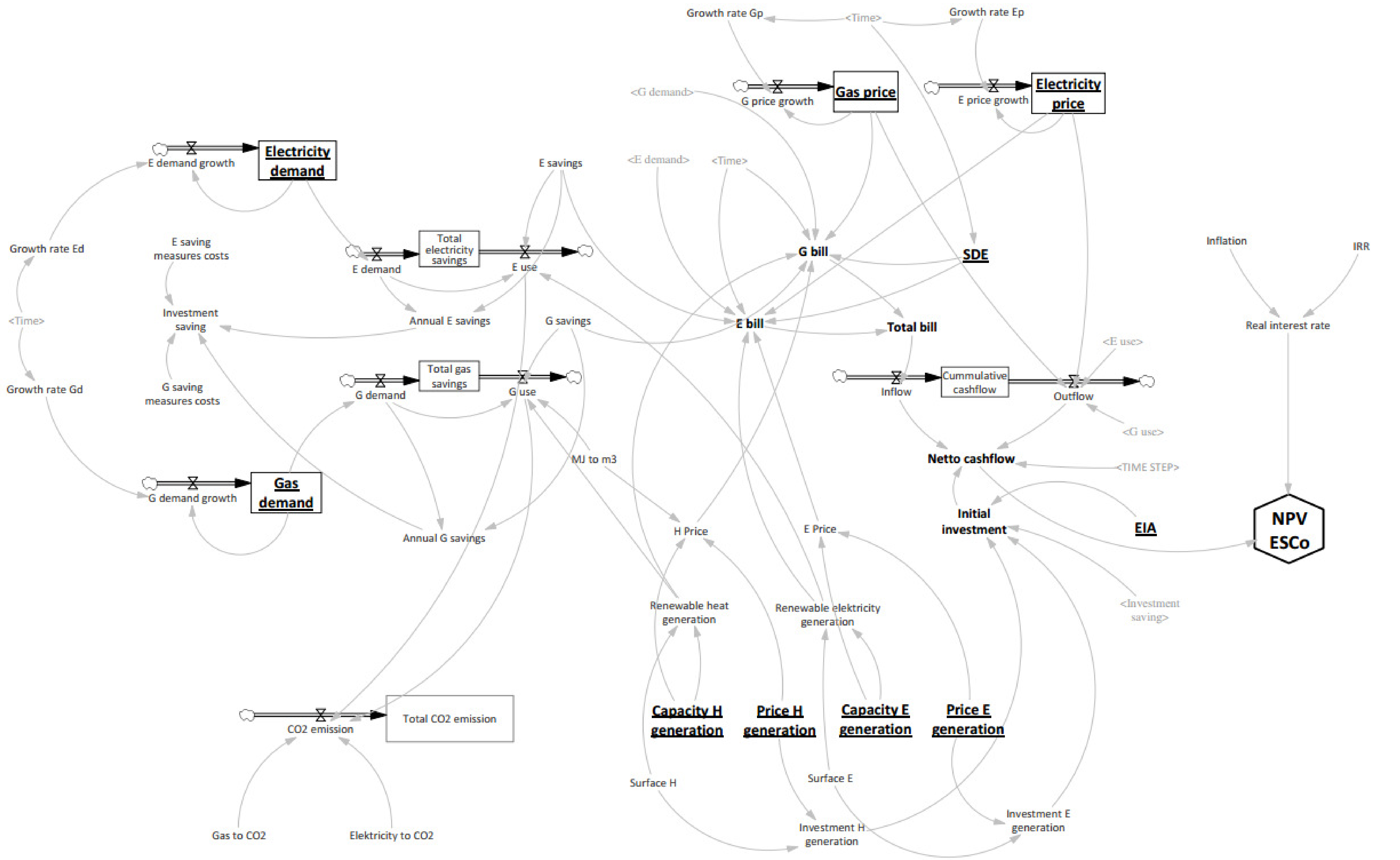

Figure 17 SD model

4.4 Morris analysis

To assess the extent of influence each factor has on the NPV, a Morris analysis is performed. The Morris analysis calculates the change of the NPV in relation to the initial values for each parameter as determined in Appendix G. Then, each specific parameter is changed to its maximum value with regard to the scenarios as determined in Appendix E. This is done for all dynamic parameters. To compare the outputs of the analysis of each parameter, the sensitivity is expressed in its relative importance. The results of the analysis are shown in Figure 18.

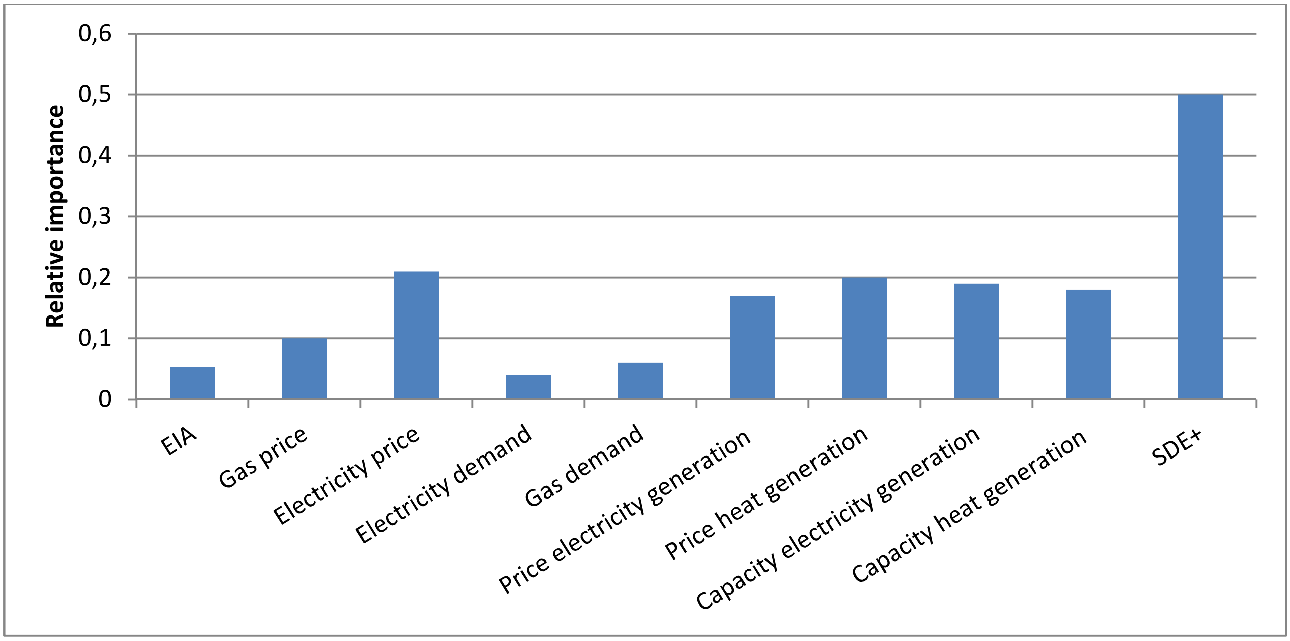

Figure 18 Morris analysis on NPV

The analysis shows that the SDE+ is the most sensitive parameter. The SDE+ is not ranged in value but just turned on or off with substantial effect on the NPV value. This gives this parameter an important risk profile. The effectiveness of the renewable energy sources is also very sensitive. These parameters don't change over time though. Hence, when panels are installed on the rooftop, the capacity will remain the same for their total life time. Both these factors are important to assess the best moment for investing in renewables. The demand for energy seems to have a low sensitivity. When a company goes bankrupt or moves, the changes in total revenues are only caused by the missing remuneration for saving measures. The generated renewable energy will be distributed among other clients.

5 Case Study

With the generated model, a simulation of an energy services project in a business district can be run. This simulation will provide a better understanding of the uncertainties and risks involved, based on realistic input. In the first paragraph, the business district will be introduced. In the consecutive paragraph, the input for the model is assessed. Finally the model is run using the scenarios, as elaborated in chapter 4, and under several differing conditions.

5.1 Business district ''Hoogeind''

As discussed earlier, this research focusses on existing, mixed business districts of considerable size and future value. There are many business districts in the Netherlands that satisfy these requirements. Because this research is supported by the Kenwib program and the Brabantse Ontwikkelings Maatschappij, a district in Noord-Brabant is chosen. The municipality of Helmond has been proclaimed to be the best entrepreneurial environment in the Netherlands for two years in a row (Ministerie van Economische Zaken, Landbouw & Innovatie, 2011). The municipality makes a great effort to maintain this status by developing existing districts into even higher quality areas. Therefore, Helmond has the appropriate economic and spatial environment for business districts to use for a case study. The figure below displays the different business districts in Helmond.

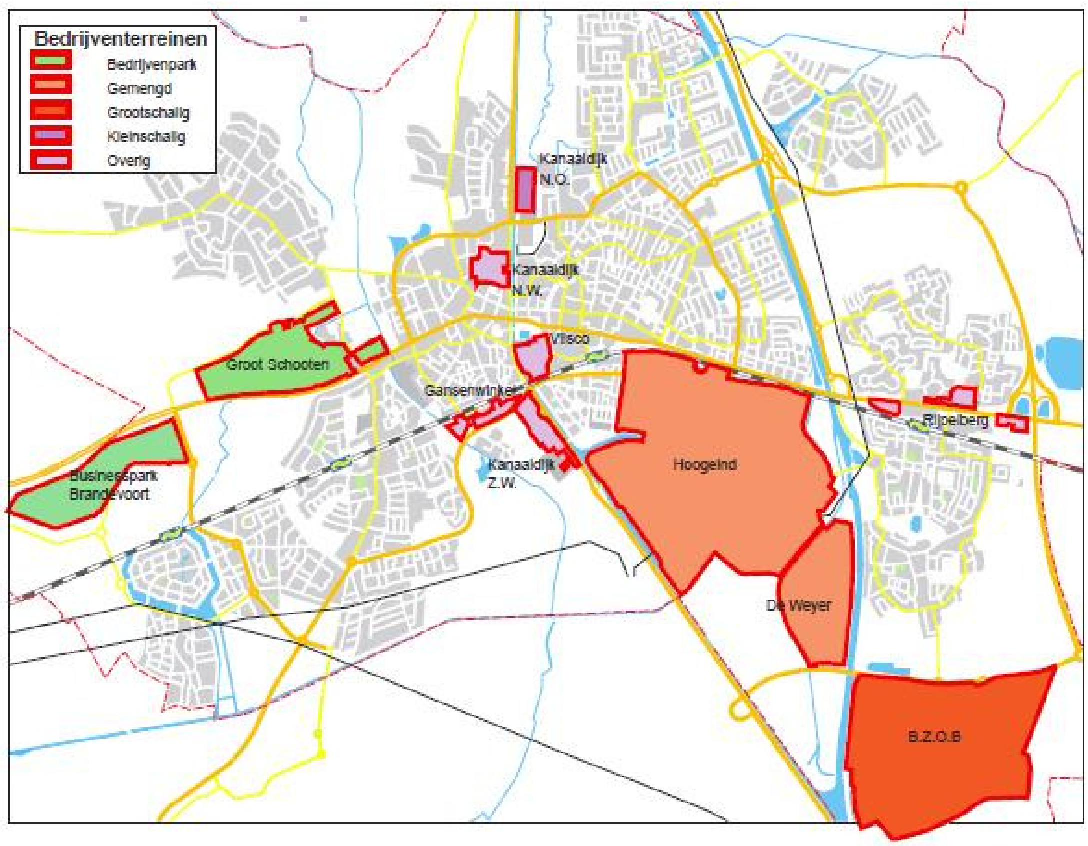

Figure 19 Business districts in Helmond (Gemeente Helmond, 2013)

Figure 19 shows that ''Hoogeind'' and ''De Weyer'' are both mixed business districts. With a surface of 300 hectares, these districts provide business locations for over 650 companies that offer jobs for 7.500 people (Bedrijventerreinen Helmond, 2012). It's easy to see that ''Hoogeind'' with an area of 250 hectares is the largest mixed business district in Helmond and will for that reason be used as the case study for this research. The distribution of different business types in the area is visualized in Figure 20. This figure shows that there are 137 companies in the manufacturing industry in business district ''Hoogeind''.

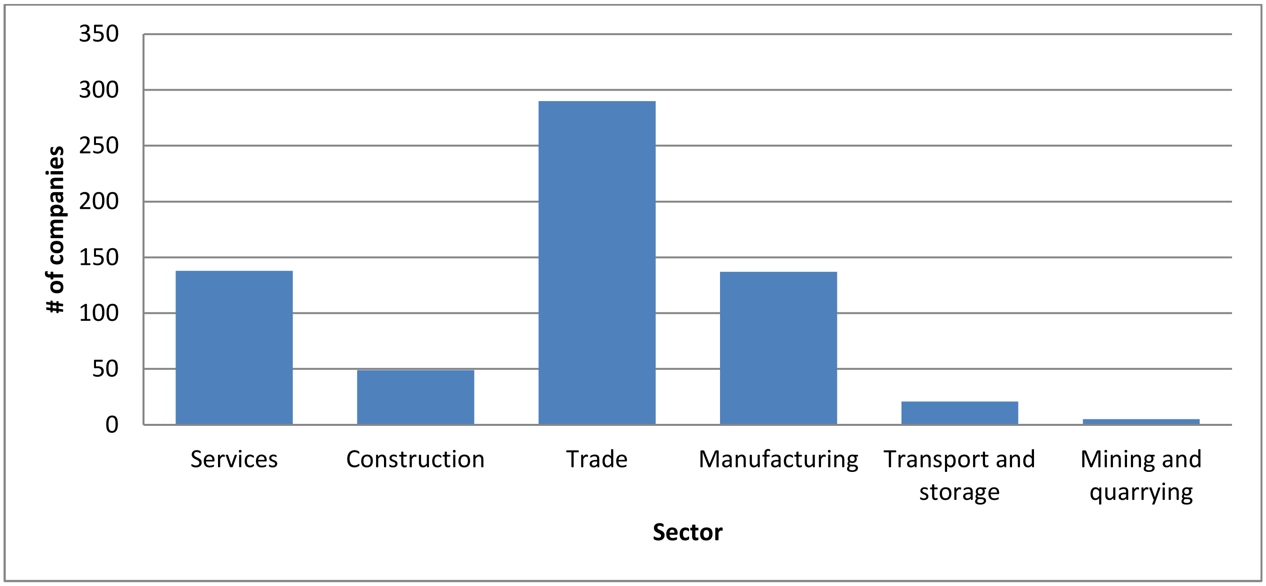

Figure 20 Companies on business district ''Hoogheind''

5.2 Model input

To run the model, the case specific parameters as described in Appendix G have to be determined.

Energy demand; The method to estimate the energy demand, divided into natural gas and electricity is explained in paragraph 4.2. Companies with a yearly electricity demand between 200.000 and 1.000.000 kWh and/or a natural gas demand between 50.000 and 300.000 m^3 represent the potential ESCo clients in this study. Assumed is that all of these companies will participate from the start of the project. Considering the specified energy use per employee, per year in the manufacturing industry, these are companies with 5-25 employees. Appendix H gives an overview of these companies filtered from a data sheet of business district ''Hoogeind''. To see is that the total electricity demand is 20.937.420 kWh and the total natural gas demand is 5.313.960 m^3. The company names are left out because of privacy issues.

Surface; Another input for the model, which depends on the case specifics is the available roof surface for generating electricity and heat. Almost every company in the production industry has a large production space with a flat roof. Appendix H shows that the available roof surface for solar installations on the buildings in ''Hoogeind'' is 98.435m2. Only the buildings used by the target group of clients are considered. As stated in paragraph 4.2, 35% of this surface will be the panel surface which gives a potential surface of 34.452m2. With this surface 25% of the initial energy use, regarding both electricity and gas, can be provided with renewables considering the solar panels capacity in the base year.

Table 8 gives an overview of used parameters to run the model corresponding with each factor.

Factor	Parameter	Description	Units	Initial value 2013
Demand of energy	Gas demand	Total gas demand of potential clients	m^3/year	5.313.960
	Electricity demand	Total electricity demand of potential clients	kWh/year	20.937.420
Energy prices	Gas price	Base year gas price (incl. tax)	Euro/m^3	0,50
	Electricity price	Base year electricity price (incl. tax)	Euro/kWh	0,147
Subsidies	Energie Investerings Aftrek (EIA)	Subsidy on investment for energy efficiency and renewable energy measures	%	10
	Stimulering Duurzame Energieproductie (SDE+)	Subsidy for generating renewable energy	%	5
Technology development	Surface E	Available rooftop surface for PV panels	m^2	22674
	Surface H	Available rooftop surface for UHV panels	m^2	11780
	Price Heat generation	Price for UHV panels	Euro/m^2	115
	Price Electricity generation	Price for PV panels	Euro/m^2	145
	Capacity electricity generation	Capacity PV (base year)	kWh/m^2/year	219
	Capacity heat generation	Capacity UHV (base year)	MJ/m^2/year	2321
Other	Return on Investment (ROI)	Return on investment for investor		
	Electricity savings	Electricity savings due to energy efficiency measures	%	6
	Gas savings	Gas savings due to energy efficiency measures	%	35
	E saving measures costs	Costs for energy efficiency measures regarding electricity	Euro/kWh	0,29
	G saving measures costs	Costs for energy efficiency measures regarding gas	Euro/m^3	0,90
	Inflation	Annual inflation	%	2

Table 8 Model input

5.3 Running the model

To assess the results under the described scenarios and inputs, the model is run. To compare the results, a ''business as usual'' case (BAS) is introduced. This case represents a situation were no energy efficiency and renewable energy measures are installed. First, the model is run using the scenarios as described in Appendix E. A ''what if'' simulation assesses the situation were no SDE+ subsidy is available at all. Then, the moment of grid parity is determined for renewables in this particular business district. The model is then used to simulate the situation when renewable energy systems are installed when grid parity, for both PV and UHV is reached. Finally, the CO_2 emission is assessed with regard to these runs. There's chosen to run the model under a project duration of 30 years. This is because the renewable energy systems in general have an average lifespan of 30 years and the scenarios almost fully cover this period.

5.3.1 Results under scenarios

Here, the model is run using the macro-economic scenarios, ''global economy'' (GE), ''global economy high oil price'' (GEH), ''strong europe'' (SE), ''transatlantic markets'' (TM) and ''regional communities'' (RC), and the input from table 8

Figure 21 shows the results for the total energy bill to be paid by the ESCo clients in business district ''Hoogeind''. This bill consists out of the electricity bill and the gas bill. The BAS case is depicted as an average trend with regard to the different scenarios to keep the figure more clear.

It shows that the clients start profiting in the year 2019 as the energy bill drops due to the installed electricity saving measures being paid off. The decrease in energy costs goes even further in the year 2023 when the saving measures on natural gas have reached their pay back time. The strong increase in costs with regard to the SE scenario is caused by the strong increase in conventional energy prices. This scenario represents the worst case for the ESCo clients and the RC scenario represents the best case. On average, the clients pay 15% less in the worst case scenario and 30% less in the best case scenario over the total period of 30 years.

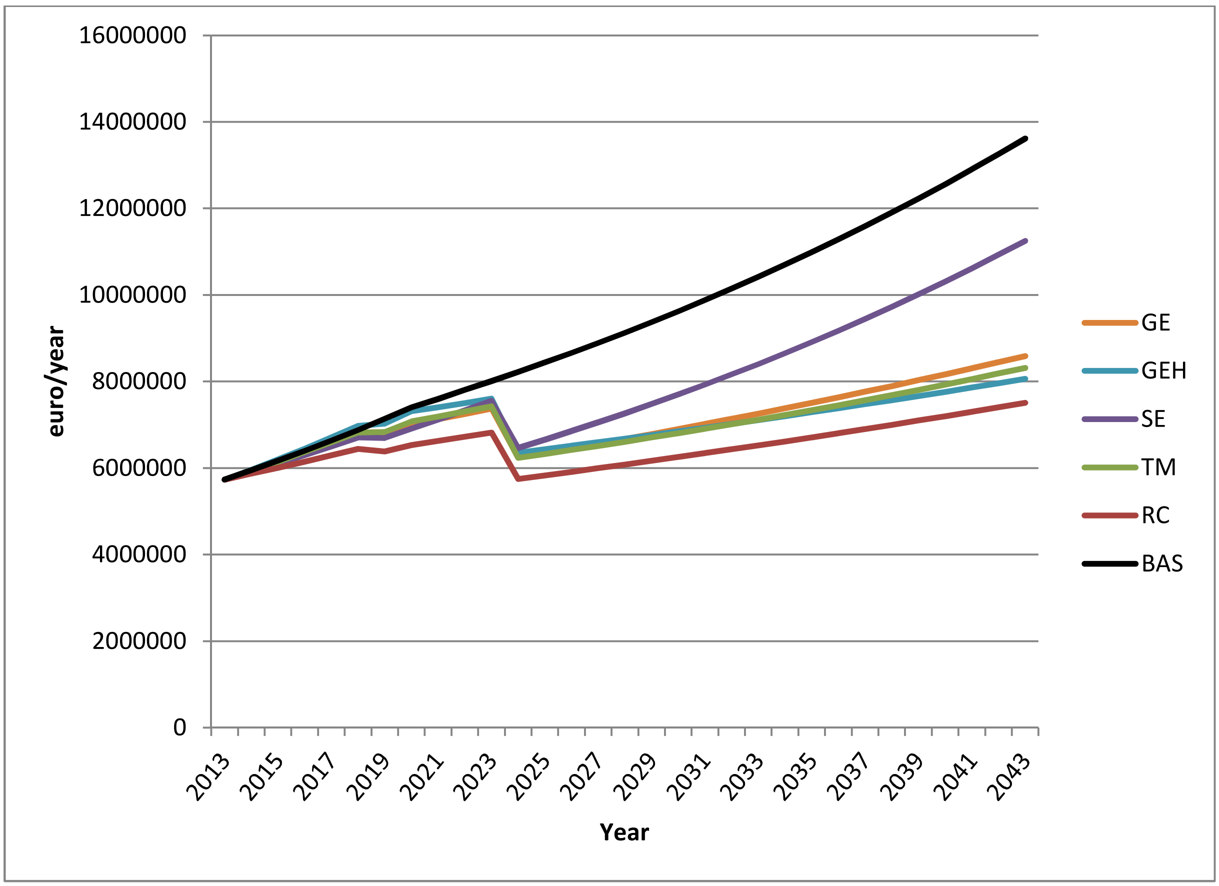

Figure 21 Total energy bill

Figure 22 shows the result on the average energy use of the ESCo clients with regard to the BAS case and the case were the ESCo implements energy efficiency and renewable energy measures. The graphs show an increasing trend due to the increasing energy demand in all scenarios. On average, the project results in a total saving of 44% on conventional energy.

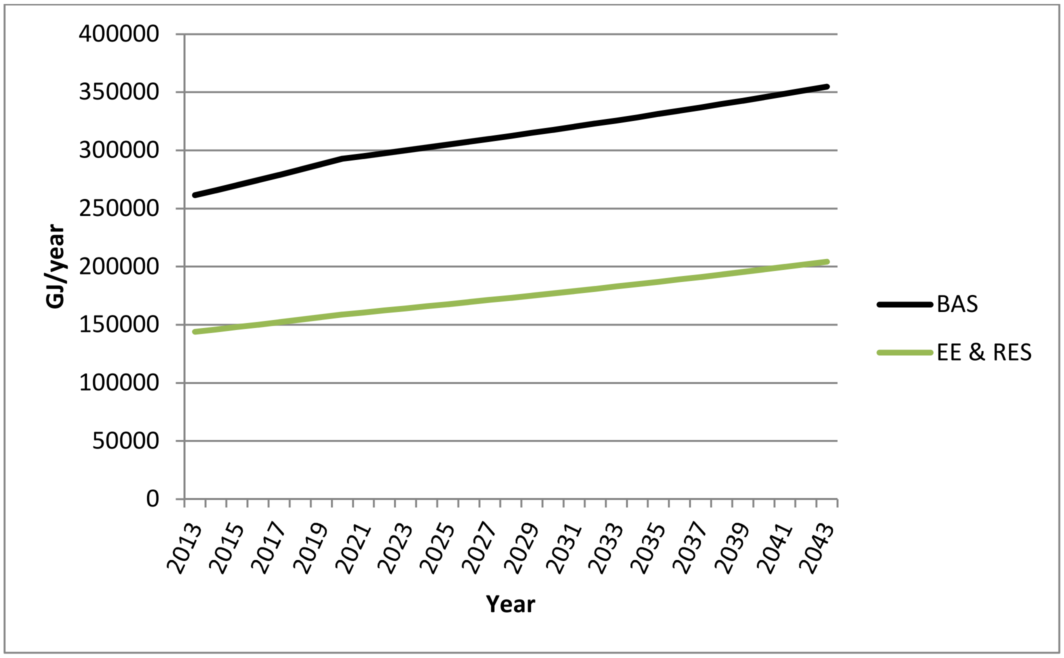

Figure 22 Energy use

The figure below visualizes the NPV for the different scenarios. The scenarios represent about the same values but the Strong Europe and Regional Communities scenarios keep increasing longer because of the prolonged SDE+ subsidy. The highest value is reached in the SE scenario; €12.598.214 and the lowest in the GE scenario; €10.602.086. The NPV increases at a much faster rate over the first 10 years in comparison with the following 20 years. This is caused by the payback times of the energy efficiency measures that are reached within the first 10 years. As stated before, the clients start to profit as a result of these measures after the payback times which explains the lower extent of increase in the NPV for the ESCo.

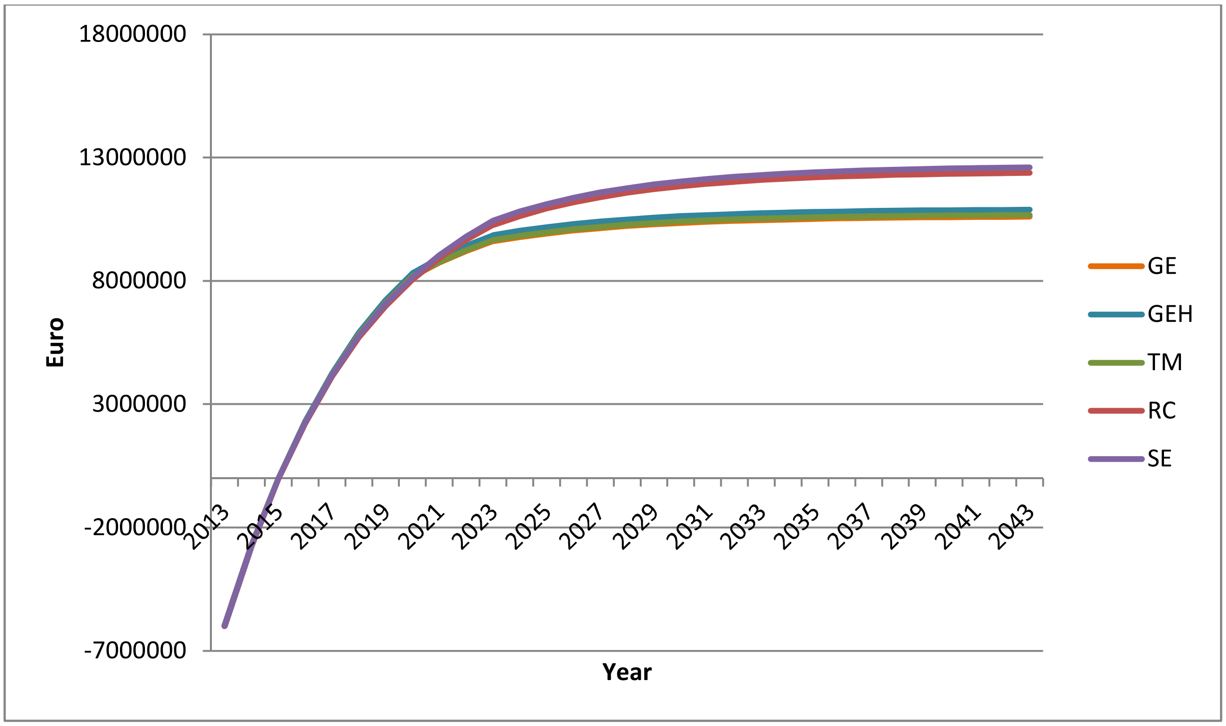

Figure 23 NPV under scenarios

5.3.2 Results under scenarios without SDE+

As assessed with the Morris analysis, the effect of the SDE+ subsidy is very strong. The risk profile for this parameter is therefore interesting to research. The next figure shows the NPV when the subsidy can't be implemented at all compared with the scenarios under ''normal'' conditions (with subsidy) shown in Figure 23.

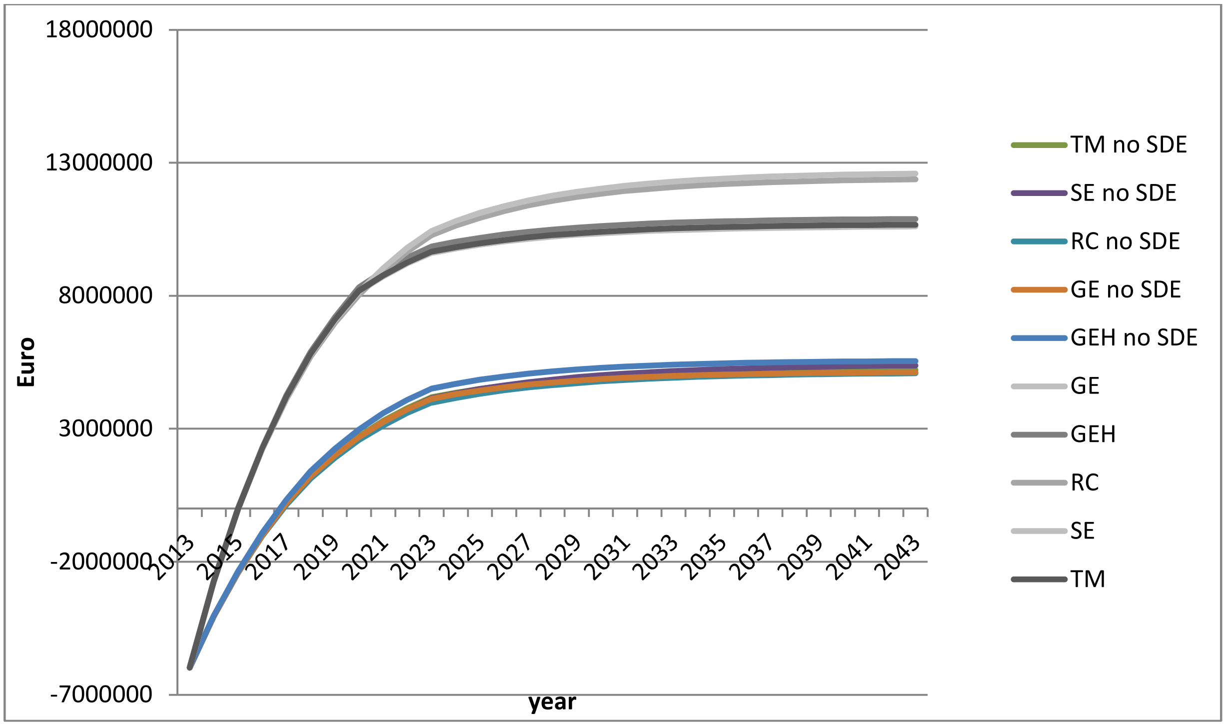

Figure 24 NPV under scenarios without SDE+

Figure 24 shows that on average, the NPV of the project in 2043 drops by 50% without SDE+ subsidy, but is still feasible since NPV>0. The highest NPV value here is reached in the GEH scenario; € 5.547.142 and the lowest in the RC scenario; €5.083.273. This shows the great influence of the SDE+ subsidy on the NPV.

5.3.3 Grid parity

As explained in paragraph 4.2 there is a strong trend towards improving the capacity and costs of renewable energy (Appendix E). The capacity and costs of PV panels and UHV collectors determine the price per kWh electricity and m3 natural gas respectively. On the contrary, the scenarios in this research state that the price for conventional energy is mostly increasing. At present time the price for solar-based renewable energy, is substantially higher than the price for conventional energy. This situation is reinforced due to the low energy prices for large users. Grid parity (GP) is reached when the energy price for a certain renewable energy source equals the price for conventional energy. In Figure 25 and Figure 26 this moment is assessed for both PV panels and UHV collectors, taking into account the target group in this study.

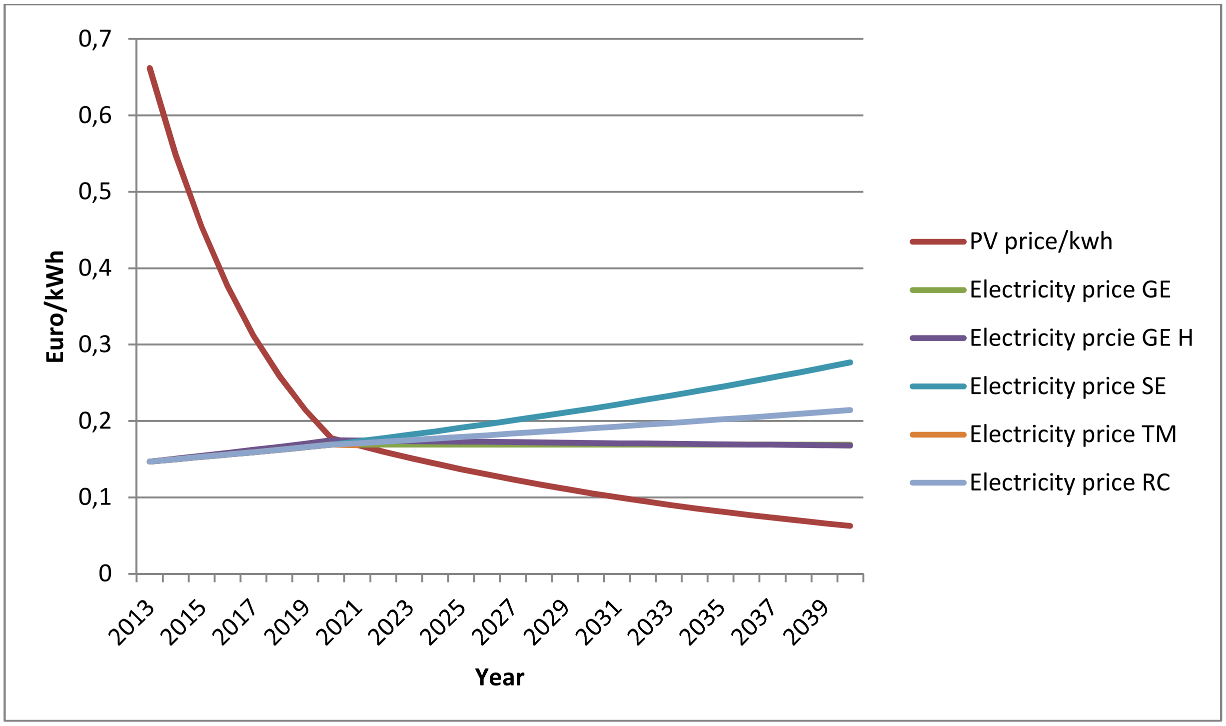

Figure 25 Grid parity PV

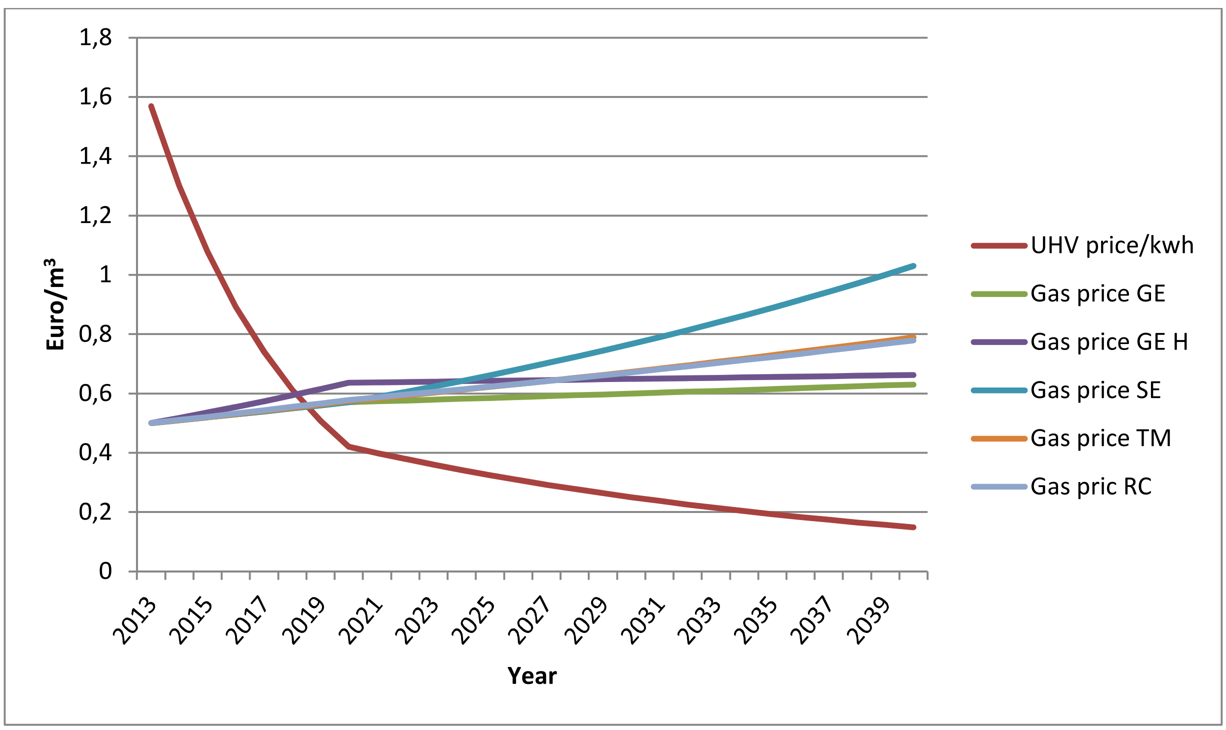

Figure 26 Grid parity UHV

Both renewable energy sources have reached grid parity in year 2020. Now, another run can be executed were the panels for generating heat and electricity are installed in 2020. The saving measures are installed in the base year (2013). This will be called the Grid Parity (GP) case. Figure 27 visualizes the average net cash flow were the delayed installation can be seen. The initial investment in the base year has decreased by 70%.

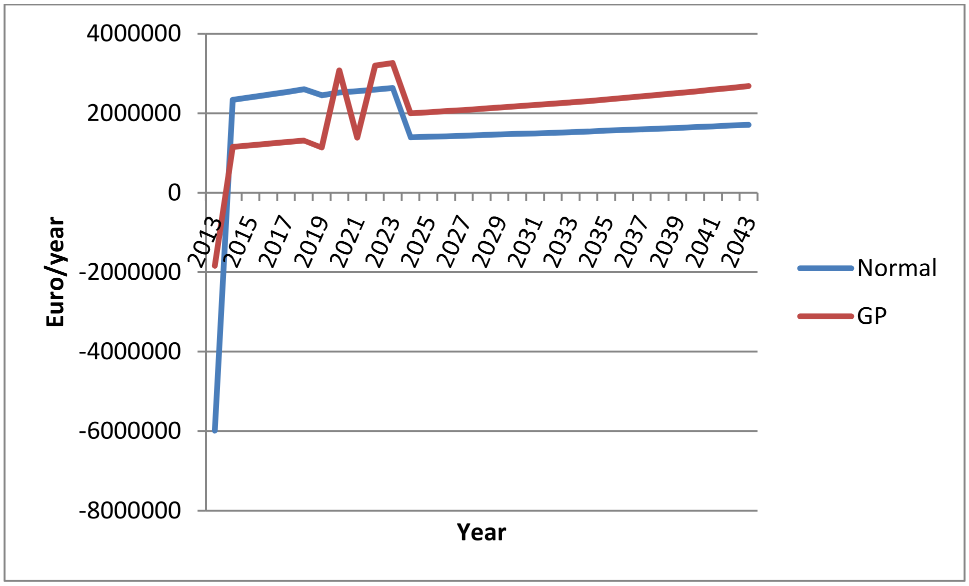

Figure 27 Net cash flow

Figure 28 showes a comparison between the original case as shown in Figure 24 with the new case were installation of renewable sources are delayed by 7 years. This graph shows the average NPV for the normal case and the GP case. This graph shows that feasibility of the project has increased against substantial lower initial investment and risk.

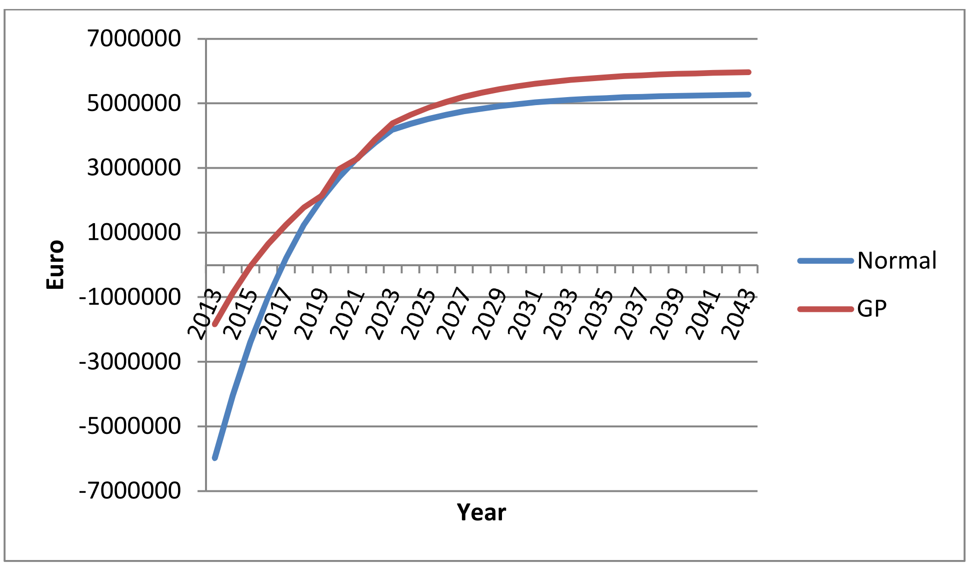

Figure 28 NPV normal case and grid parity case

5.3.4 CO_2 – emission

Besides the financial results of the project, the environmental impact should be assessed. As a means to measure this, the CO_2 savings are considered for different cases. Figure 29 shows the total CO_2 emissions in three different cases. The business as usual case were no energy services are implemented, the case were all energy services are executed in year 1 and the case were the installation of renewable energy sources is delayed to allow for grid parity to be reached. To maintain clarity in the graph, the average trend of each case is depicted. The emission in the normal case has decreased by 36% in comparison with the BAS case for the year 2040. This amount has dropped even further in the grid parity case, namely by 40%. The higher savings combined with delayed installation can be explained by the higher efficiency of future renewable energy technology.

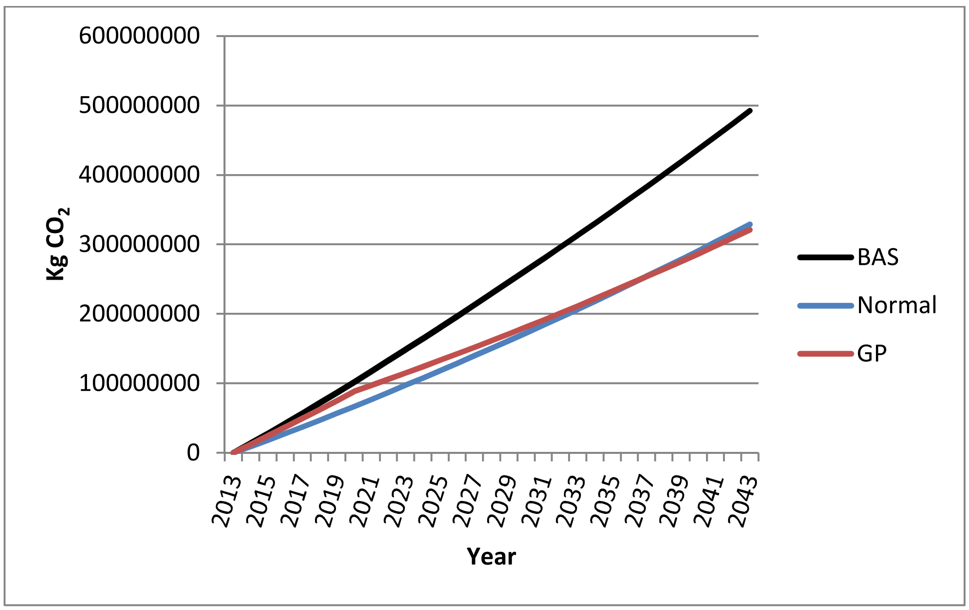

Figure 29 Total CO_2 emission

Conclusions

In this chapter, the conclusions that can be derived from this research are described. This is done by answering the research question, and its sub questions as stated in the introduction, based on the results of this research.

The problem statement for this research is described as follows;

> *''The energy saving potential in business districts is substantial and the importance of using this potential is increasing. However, many barriers hinder development towards improving energy efficiency. Energy service companies can relieve this sector from these barriers but the industrial sector's share in the activities of ESCos is currently much lower than its potential.''*

The research question with regard to this problem statement is described as;

> *''Will sustainable energy management on business districts be feasible for Energy Service Companies?''*

To answer this research question, the sub questions are answered;

Which companies in business districts are the real problem owners?

Manufacturing companies by far consume the most energy in relation to other branches of industry. Secondly, the overhead, with regard to energy is by far the highest in these companies. These companies have high potential to lower their energy use which leads to substantial savings with regard to its costs. The growing importance to comply with energy saving objectives set by the government is therefore highest in this type of industry. Large companies with a high energy use, are able to reach these objectives and stay competitive themselves, since they have sufficient financial means and in-house knowledge to do this. Middle sized industry does not have these means and is therefore defined as the real problem owner in this study.

Which factors influence the development of energy efficiency and renewable energy measures in business districts?

Many factors hinder companies as described above to implement measures to save on energy by themselves. These factors are described in paragraph 2.1.6. The most important factors here are;

- unclear responsibilities between companies when implementing collective measures;
- the extent and development of available measures;
- Uncertain future of energy prices and energy demand;
- available subsidies;
- the need to finance the measures;

- focus on the core business process where energy is regarded as an overhead expense;

An ESCo can relieve the problem owners from these factors by providing energy related services as shown in Figure 5.

Which ESCo business model fits best with business districts and what measures are applicable in this context?

Because of the extent of its demand and supply side services, remuneration scheme and verification method, the IEC model appears to be the most promising for business districts. Energy efficiency measures are implemented that improve the energy performance of the buildings and the production processes. Furthermore, renewable energy generated by solar panels (PV and UHV) is most applicable in business districts.

Who are the stakeholders and what is there power?

When implementing an ESCo in a business district, several stakeholders are important to take into account. The ESCo itself has high interest in clients with large energy use and potential to save on energy use. They can arrange the technology, expertise and financial means to reach the saving potential. However, companies have low awareness with regard to the ESCo industry. Park management and public development agencies can help raise awareness about the possibilities of outsourcing energy related services. Furthermore, since the ESCo industry in the Netherlands is relatively new, financial institutions are skeptical and require a sound business case to invest in such projects.

What are uncertainty factors for ESCos in business districts? Which factors are most important?

The uncertainty factors for the ESCo are; demand of energy, energy prices, subsidies and technological developments. The availability of subsidies and the development of renewable energy technology are determined to have the most significant influence on the outcome.

What do these factors mean for the financial result of the ESCo and its performance?

First the case as described in the scenarios was run using the business district ''Hoogeind'' as the case study for this research. These scenarios capture the uncertainty of the energy prices, demand and subsidies. The financial results are very positive as the NPV>0 in all scenarios and a 44% saving on conventional energy is reached. In this case, the availability of the SDE+ subsidy is adopted in each scenario. However, the influence on the NPV and the uncertainty of its availability creates a substantial risk factor. When the model is run without the SDE+ subsidy the NPV drops by 50% in value but remains positive for all scenarios.

The technological uncertainties with regard to the renewable energy systems are captured by assessing the grid parity situation for PV and UHV in business districts. This situation is estimated to be reached in the year 2020 for both techniques. If the ESCo uses the option to wait for grid parity, and then installs the solar panels for heat and electricity, the initial investment has dropped by 70% while the NPV ends up 13% higher. This way the risk taken is at the same time decreased, by phasing the investments, and the total value of the project is increased.

The total CO_2 emission of the companies has dropped with 36% if the ESCo implements all measures in the base year. However, despite the ‘’lost time’’ when the ESCo waits for grid parity to install renewable energy measures, the total CO_2 emission has even decreased by 40%.

From this study can be concluded that outsourcing energy related services to an ESCo by the mid-sized manufacturing industry is certainly interesting for both parties. Large wins can be made at the demand side considering the available saving potential. For the supply side measures, hence the generated renewable energy regarding heat and electricity, there can be recommended to wait for these technologies to reach higher capacities and lower prices. This way, public goals to reduce fossil fuel use may go hand in hand with an economically feasible business model.

Discussion

Within this research, several assumptions are made which aren’t necessarily wrong but can seriously influence the results and are therefore discussed.

To assess the financial feasibility of energy services for business districts a model was made to represent a simplified reproduction of reality. However, in reality there is no ESCo activity in business districts in the Netherlands. Therefore, besides research, there is little realistic data available with regard to potential energy savings and corresponding investments. Therefore, assumptions based on research regarding saving potentials within the manufacturing industry may be too optimistic.

Furthermore, the industrial sector is very reserved, when it comes to providing data about their energy use and energy expenditures. Therefore, the demand corresponding with a specific case study based on the number of employees and the type of business has been estimated. Even this basic information required great effort to acquire. With more accurate data, the case study would have greater added value.

Barriers such as lacking awareness and familiarity with the ESCo industry are not assessed within this research. However these can be of great importance when implementing ESCos in business districts. As stated in the report, park management organizations and public development agencies can raise awareness among potential ESCo clients. However, industrial companies are very reserved to let other parties, such as an ESCo, check on their core production processes. This requires trust and familiarity with the ESCo concept and company. For this reason, it is unlikely that all companies in a business district will decide to participate from day 1. This creates the challenge to find sufficient partners/clients to start the ESCo and prove the concept.

Further research

Since the potential for the ESCo industry in business districts is considerable, some concepts for further research are discussed in this chapter.

As discussed above, barriers such as awareness and familiarity with the ESCo concept are not assessed within this study. However, these factors are important when aiming on the full use of the available saving potential in companies. Especially production processes provide high potential to save energy in a relatively easy way by optimizing installations and managing processes more energy conscious. Companies are very reserved when it comes to exposing their specific production processes and techniques. A certain level of trust is needed towards the party that can optimize these. It would be interesting to assess the complications that can arise when implementing services that touch the core business of a company and which requirements companies postulate with regard to these services and forms of collaboration.

The third approach of energy management, the exchange or distribution of residual streams, is not assessed in this research. However, this approach can have a lot of potential and can strengthen a business case. It would be interesting to assess what kind of industries produce different types of residual streams that can be used by others and how such collaboration can be exploited by an ESCo. In this sense, it also would be necessary to create a business model that can implement this approach.

Another interesting concept that could make business cases stronger is energy storage technology. Storing renewable energy on a large scale is currently very challenging with regard to the financial and technical feasibility of these methods. However, some developing techniques such as the liquid metal battery (LMB) and the concept of Power2Gas seem to be promising. Activity on business districts during the weekends and at night is low so generated energy could be stored to use it later or deliver it to potential customers. Storing energy also enhances the concept of energy load management where generated energy can be used when the price is high and peaks in energy use occur. There could be researched when these methods will become financially and technically feasible and how this will affect the business case of an energy management project in business districts.

As assessed in this study, a situation of grid parity is nearing. When this situation occurs, large rooftops can be exploited in a profitable way and can become valuable. The transport and storage sector is growing in the Netherlands and this sector uses enormous distribution halls. These rooftops can be exploited by an ESCo and can give a new impulse to the NPV later in the project. There could be investigated in which level, these rooftops can become energy suppliers for the entire business district and its surroundings.

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Appendices

A Stakeholder analysis

Stakeholder	Interest	1, 2, 3, 4, 5	Power	1, 2, 3, 4, 5	Support	1, 2, 3, 4, 5	Problem
Mid-sized industry	Continuity and profitability; limit activities that deviate from core business	3	Large group of companies and the level of participation can influence the feasibility of a project	3	Maintain the NMDA principal; want to focus on the core business process	3	Limited awareness and knowledge of energy saving potential and generation of renewables; Low on financial means
Large industry	Continuity and profitability; limit activities that deviate from core business; Comply with sustainability agreements made with the Government	4	Large energy use and saving potential so power in participating	4	Supportive when sound business cases are introduced but mostly on individual level	2	Are often already involved in saving agreements or prefer an individual approach
Municipality	Facilitate high quality business districts; pursue sustainability objectives	4	Power by means of land use plan and granting permits	3	Supportive towards sustainable area development; often lack in time and knowledge	3	Limited financial means and knowledge to participate in such projects or to facilitate an supportive policy
Province	Develop regional policies to increase the quality of business districts and to better arrange these areas	3	Power by means of ''structuurvisie'' towards municipality	2	In some cases, supportive by granting financial means	2	Duration, rules and regulations
Government	Pursue formulated sustainability objectives; Create a favourable climate for companies to vest	2	Power in releasing subsidies, raising taxes and rules and regulations that can facilitate sustainable energy transition	4	Currently low in support; could have great influence through improved policies	2	These issues are too far away, no connection with industries
Energy company	High commercial stake. Maintain profitability and continuity of	4	Can be large	2	Depends on the supplier, certain mistrust from other	2	High conflicting interests within this issue; low trustworthiness and

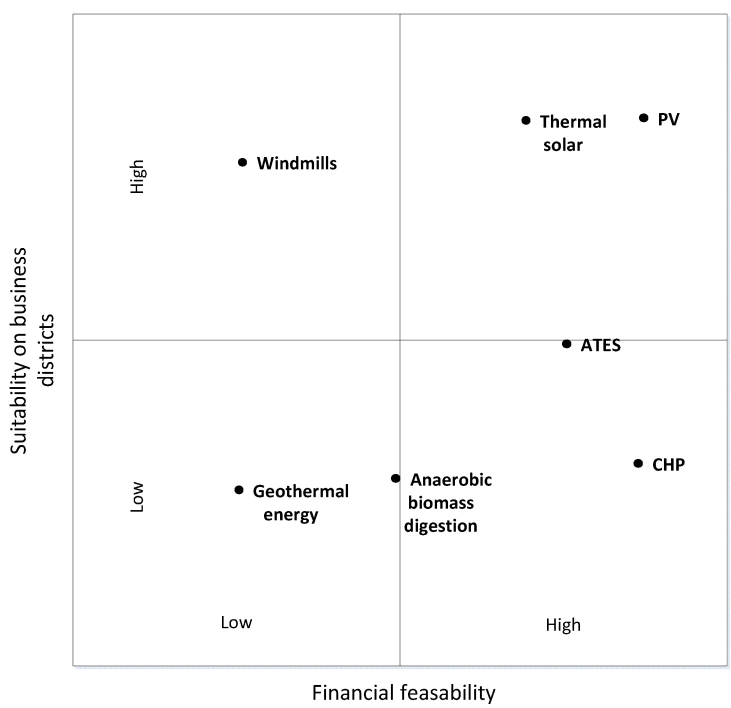
	energy industry				parties		credibility
Net administrator	Stake at changing connection is large; Also important role in facilitating a capable energy grid	4	Can be large when revaluating energy grids	3	Wants to keep exploiting the local grit and will therefore be supportive towards these projects	3	Complex situation regarding rules and regulations; Only responsible for transport
Supervisor	Maintain rules and regulations	2	Control on energy related activities	4	Neutral	3	Bound to rules and regulations; no direct contact with end users
Public development agency	Stake within the restructuring of business district, possible in a sustainable way	4	Depends on the project; may be able to help financing the project	4	Supportive when the project fall within their competences	4	Sustainability has no priority yet, lots of shareholders
Financial institution	Stake in making strong investments that pay back against limited risks	3	Can raise conditions to which the project should comply to	5	Supportive when there is a strong business case	4	Relative new industry in the Netherlands; This industry first have to prove it profitability
Park management	Depends on the type and size of the organization	5	Important to raise awareness and to introduce the possibility for energy management among the companies	3	Tries to support collective initiatives to reach an improved climate for companies to vest	4	No financial means and knowledge about energy issues; depend on the demand of vested companies
ESC0	High stake because this is their core business	5	Combination of knowledge and financial means that gives this party the power to act	5	Delivering services (support) is their core business	5	High amount of uncertainties, coming from macroeconomic aspects and rules and regulations, that form barriers to development of energy services for business districts

B Energy efficiency measures

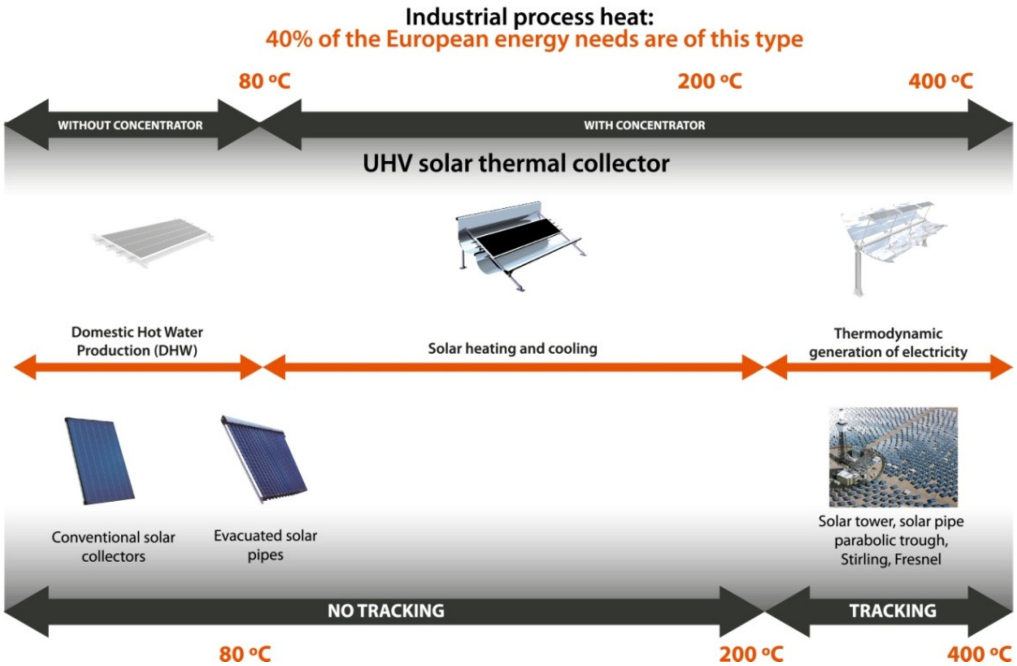
Energiefunctie	Energiedrager	Besparingsopties
Verwarmen (proceswarmte)	Aardgas	- Rookgascirculatie - Voorverwarmen ingaande stromen met gerecupereerde warmte - Efficiënter proces - Betere procesisolatie - Good housekeeping/betere procescontrole - Warmteterugwinning - Efficiënter stoom consumerend proces - Warmterecuperatie
Koelen	Elektriciteit	- Hergebruik restwarmte vrijkomend bij koeling m.b.v. warmtepomp
Kracht/licht	Elektriciteit	- Efficiëntere procestechnologie - Efficiëntere randapparatuur (verlichting, elektromotoren) - Good housekeeping/betere procescontrole - Efficiëntere opwekking

Source: (Swigchem , et al., 2003)

C Confrontation matrix renewable energy systems



D Application of UHV collectors



Source: (SRB energy, 2013)

E Scenario trends

	Trend electricity price (%)		Trend natural gas price (%)		Trend energy demand (%)	
Scenarios	Base -2020	2020-2040	Base -2020	2020-2040	Base-2020	2020-2040
Global economy	2	0	1,9	0,5	1,4	1,5
Global economy (high oil price)	2,5	-0,2	3,5	0,2	1	1,3
Strong europe	2	2,6	1,9	3	1,2	0,2
Transatlantic market	2	-0,3	2	1,6	1,5	1
Regional communities	2	1,2	2,1	1,5	0,3	0,1

Growth rates (Farla, et al., 2006)

	SDE+		EIA	
Scenarios	Base-2020	2020-2040	Base-2020	2020-240
Global economy	Available	/	available	/
Global economy (high oil price)	Available	/	available	/
Stong europe	Available	Available	available	available
Transatlantic market	Available	/	available	/
Reional communities	Available	Available	available	available

Subisidies (Farla, et al., 2006)

F Solar panel trends

PV	**Base**	**Base-2020**	**2020-2040**
Capacity (annual growth)	20	5	2,7
Price (per m2)	145	-13	-2,5
UHV	**Base**	**Base-2020**	**2020-2040**
Capacity (annual growth)	20	5	2,7
Price (per m2)	115	-13	-2,5

Source: (Sinke, 2012) (SRB energy, 2013)

G Overview used parameters

Parameter	Units	Initial value
Gas demand	m^3/year	Case specific
Electricity demand	kWh/year	Case specific
Gas price	Euro/m^3	0,50
Electricity price	Euro/kWh	0,147
EIA	%	10
SDE+	%	5
Growth rate Ed	%	(appendix E)
Growth rate Gd	%	(appendix E)
Growth rate Gp	%	(appendix E)
Growth rate Ep	%	(appendix E)
Surface E	m^2	Case specific
Surface H	m^2	Case specific
Inflation	%	2
ROI	%	15
Price Heat generation	Euro/m^2	115
Price Electricity generation	Euro/m^2	145
Capacity electricity generation	kwh/m^2/year	219
Capacity heat generation	MJ/m^2/year	2321
Electricity savings	%	6
Gas savings	%	35
E saving measures costs	Euro/kWh	0,29
G saving measures costs	Euro/m^3	0,90
Gas to CO_2	Kg/m^3	0,535
Electricity to CO_2	Kg/kWh	0.5246
MJ to m^3	MJ/m^3	31,65

H Potential ESCo clients business district "Hoogeind"

Company	Type	Employees	Roof surface (m^2)	Natural gas use (m^3)	Electricity use (kWh)
A	Manufacturing	10	0	101800	401100
B	Manufacturing	24	12000	244320	962640
C	Manufacturing	11	750	111980	441210
D	Manufacturing	12	1600	122160	481320
E	Manufacturing	22	3000	223960	882420
F	Manufacturing	8	1725	81440	320880
G	Manufacturing	10	2100	101800	401100
H	Manufacturing	11	600	111980	441210
I	Manufacturing	10	1000	101800	401100
J	Manufacturing	8	0	81440	320880
K	Manufacturing	15	2100	152700	601650
L	Manufacturing	15	650	152700	601650
M	Manufacturing	14	1000	142520	561540
N	Manufacturing	6	2400	61080	240660
O	Manufacturing	5	5250	50900	200550
P	Manufacturing	8	1500	81440	320880
Q	Manufacturing	6	1100	61080	240660
R	Manufacturing	8	900	81440	320880
S	Manufacturing	6	1500	61080	240660
T	Manufacturing	8	4800	81440	320880
U	Manufacturing	7	2750	71260	280770
V	Manufacturing	5	700	50900	200550
W	Manufacturing	9	2250	91620	360990
X	Manufacturing	8	1600	81440	320880
Y	Manufacturing	8	3900	81440	320880
Z	Manufacturing	8	1000	81440	320880
AA	Manufacturing	5	1000	50900	200550
BB	Manufacturing	18	2560	183240	721980
CC	Manufacturing	13	3150	132340	521430
DD	Manufacturing	9	720	91620	360990
EE	Manufacturing	21	6400	213780	842310
FF	Manufacturing	8	700	81440	320880
GG	Manufacturing	7	1200	71260	280770
HH	Manufacturing	20	2700	203600	802200
II	Manufacturing	10	5200	101800	401100
JJ	Manufacturing	6	650	61080	240660
KK	Manufacturing	7	680	71260	280770
LL	Manufacturing	8	1.000	81440	320880
MM	Manufacturing	5	0	50900	200550
NN	Manufacturing	18	500	183240	721980
OO	Manufacturing	13	600	132340	521430
PP	Manufacturing	11	950	111980	441210
QQ	Manufacturing	24	3000	244320	962640
RR	Manufacturing	6	1000	61080	240660
SS	Manufacturing	5	2500	50900	200550
TT	Manufacturing	8	500	81440	320880
UU	Manufacturing	7	2400	71260	280770
VV	Manufacturing	7	600	71260	280770
WW	Manufacturing	6	750	61080	240660
XX	Manufacturing	8	1000	81440	320880
YY	Manufacturing	10	2500	101800	401100
TOTALS			**98.435**	**5.313.960**	**20.937.420**