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Energy Services for Business Districts

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Abstract

Business districts account for the largest part of energy use in the Netherlands. However, these districts have up to now little attention with regard to their energy use and efficiency. The mid-sized manufacturing industry is characterized by high energy usage therefore high energy saving is possible. Because of this reason energy service companies (ESCo) might be interested. The feasibility of an ESCo depends on various factors. These factors can be dived on internal and external ones. In addition, within the internal two aspects are identified: ESCos organization and ESCos business alertness. The external factors can be divided as technical, legal and governance and financial aspects. To study the influence of factors belong to mentioned aspects this study introduces a system dynamic (SD) model. The case study has been use to test the model. As an outcome this study provides a feasibility insight when energy services are outsourced from a manufacturing company to an ESco. **key-words**: ESco, sustainable transformation, business districts, system dynamics, morris analysis

1. Introduction

Business districts are important areas in the Netherlands because they provide 30% of total employment. 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). Approximately, around 3600 business districts in the Netherlands provide suitable space for companies to invest. Businesses need space for production, offices, showrooms, storage facilities, and infrastructure 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). Therefore, 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.

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 (IEC). The models differ in offered services and remuneration schemes. The IEC model builds on the energy supply contracting 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

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situation where the ESCo needs to install the most efficient measures to make profits. The IEC model can lower transaction costs better considering the verification method of quality assurances instead of base line verification. Now, the remuneration of this 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.

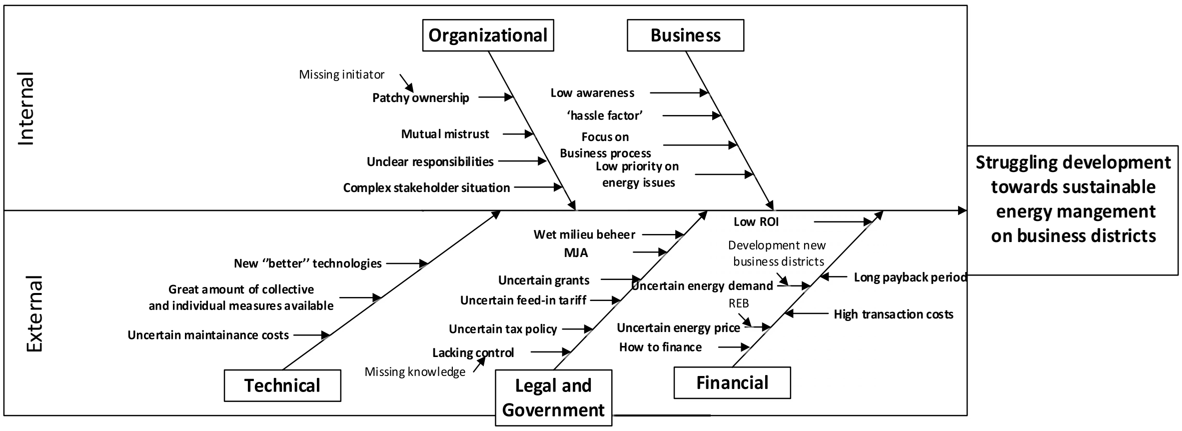
In order to assess the financial feasibility of ESCo for business districts, a system dynamic model has been proposed. System dynamics (SD) is used to create a net present value (NPV) model that includes these uncertainty factors. To learn more about the impact each factor has on the financial result, a sensitivity analysis (SA) has been incorporated. 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.

To run a model, data from a case study has been used as an input. 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). Therefore, Helmond has the appropriate economic and spatial environment for business districts to use for a case study. Several parameters in the model are case specific: gas demand, electricity demand, and surface. On the other hand, some of the parameters as an input use macro-economic data (section 4).

First, this paper introduces a list of factors that cause the struggling path to the implementation of the ESCos. Further, a perspective method to manage and estimate the optimal option of an ESCo has been proposed and explained in section 3. In section 4, a result regarding the comparison between ESCo and no ESCo implementation has been addressed under different economic scenarios. Finally, conclusions and suggestions for further research have been described in section 5.

2. Obstacles in implementing ESCos for business districts

The barriers are identified and categorized in one of the five cause categories that effect currently struggling energy management on urban districts. 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 (Fig. 1.).

Fig. 1: Causal diagram regarding "Sustainable energy management on business districts"

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.

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. This, as well as the growing awareness of the effectiveness of overhead cost reductions by saving energy, results in more interest in energy efficiency.

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.

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 m3 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). There is also a problem with the subsidies. Usually, 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. In the Netherlands, 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.

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 cannot 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 high energy intensity and is therefore an important incentive to invest in energy efficiency.

3. System dynamics and sensitivity analysis in energy urban district management

First, this paper uses literature survey 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 basis for the SD model. To verify the model and to assess the most influencing factors a sensitivity analysis (Morris 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.

''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 modelling 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 modelling process to be iterative, which means that results of the steps taken can yield insight to revisions in any earlier step. The modelling process includes the following steps: (1) articulate the problem to be addressed; (2) formulate a dynamic hypothesis or theory about the causes of the problem; (3) formulate a simulation model to test the dynamic hypothesis; (4) testing the model until you are satisfied it is suitable for your cause; (5) design and evaluate policies for improvement.

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: (1) moving one input variable, keeping others at their baseline values; (2) 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.

Prior to introducing a model, the most important factors their representative parameters with description and units have been provided in the following table (Tab.1). As an addition, the last column (Tab. 1) informs a reader about the initial values that has been set to simulate the model for a specific case study (Section 4).

Tab. 1: List of factors and related parameters used in the system dynamic model

Factor	Parameter	Description	Units	Initial value 2013
Demand of energy	Gas demand	Total gas demand of potential clients	m3/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/m3	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	m2	22674
	Surface H	Available rooftop surface for UHV panels	m2	11780
	Price Heat generation	Price for UHV panels	Euro/m2	115
	Price Electricity generation	Price for PV panels	Euro/m2	145
	Capacity electricity generation	Capacity PV (base year)	kWh/m2/year	219
	Capacity heat generation	Capacity UHV (base year)	MJ/m2/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/m3	0,90
	Inflation	Annual inflation	%	2

Now, the model is shown below (Fig. 2). To better understand the structure of the model, the parameters that represent the factors and important parameters 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.

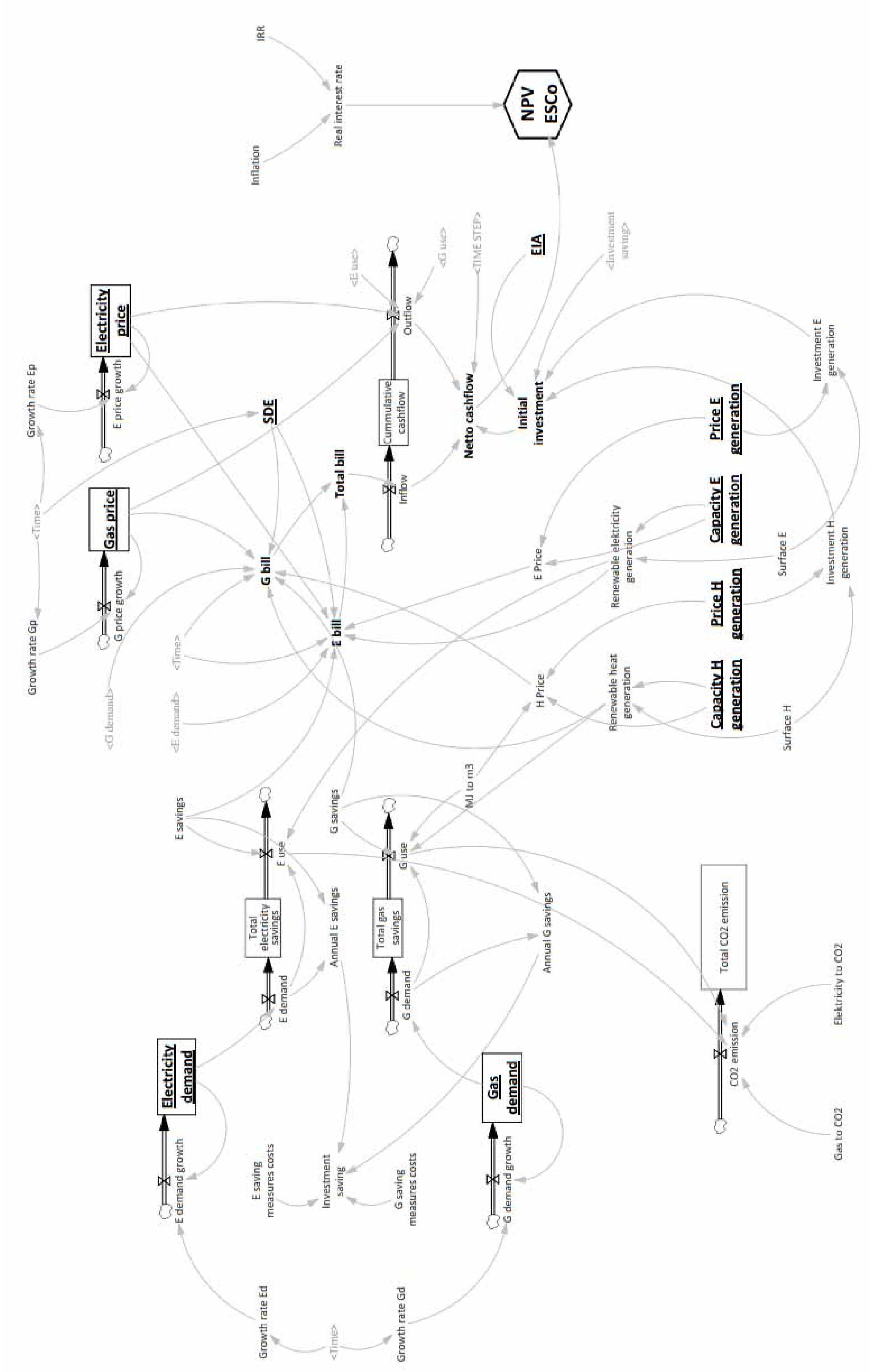


Fig. 2: Stock & flow model for energy management on business districts

4. ESCO performance under different scenarios

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.

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 Tab. 1. Then, each specific parameter is changed to its maximum value with regard to the scenarios as determined in previous study (Farla, et al., 2006). 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 below (Fig. 3).

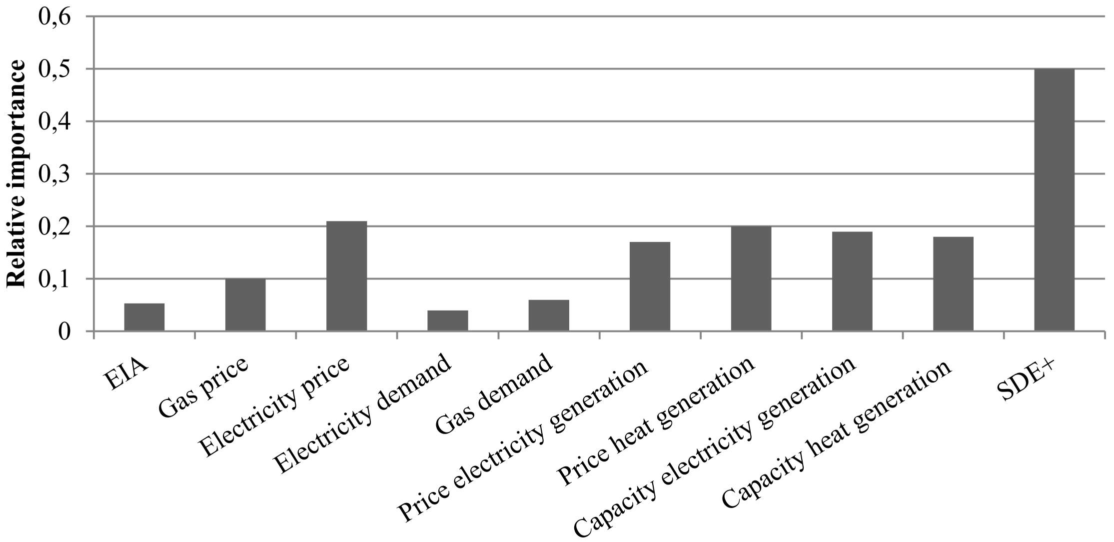


Fig. 3: Morris analysis on NPV

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.

To assess the uncertainty of the factors over the life span of an ESCo project, scenarios are used. 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). For the technologic development, trends are used with regard to system's capacity and price. 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. Fig. 4 shows the results for the energy bill to be paid by the ESCo clients in business district ''Hoogeind''. The BAS case is depicted as an average trend with regard to the different scenarios to keep the figure clearer. 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 payback 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.

There's chosen to run the model under 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.

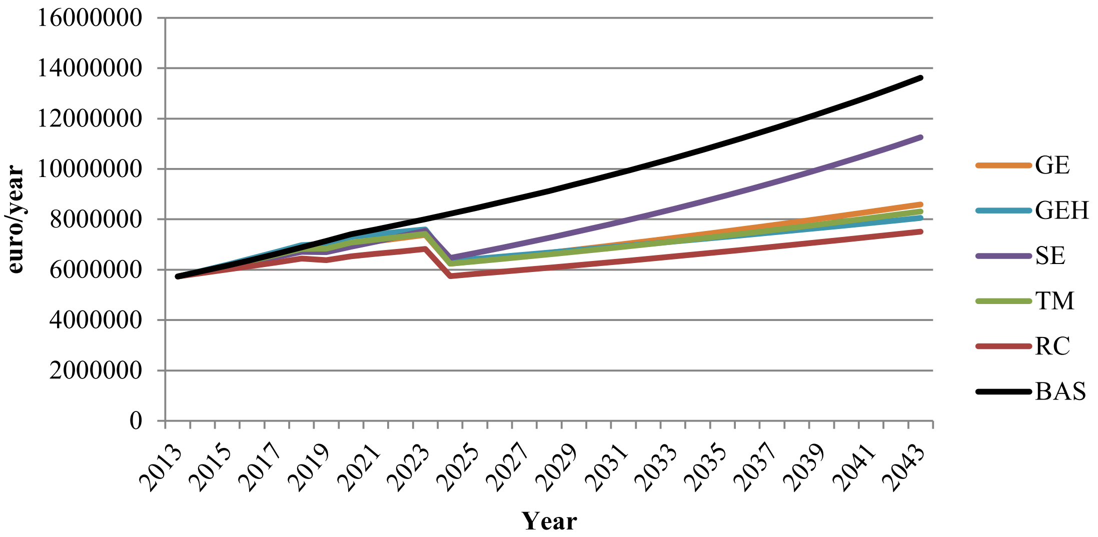


Fig. 4: ESCos feasibility under multiple scenarios

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 (Fig. 5) shows the NPV when the subsidy cannot be implemented compared with the scenarios under conditions with subsidy.

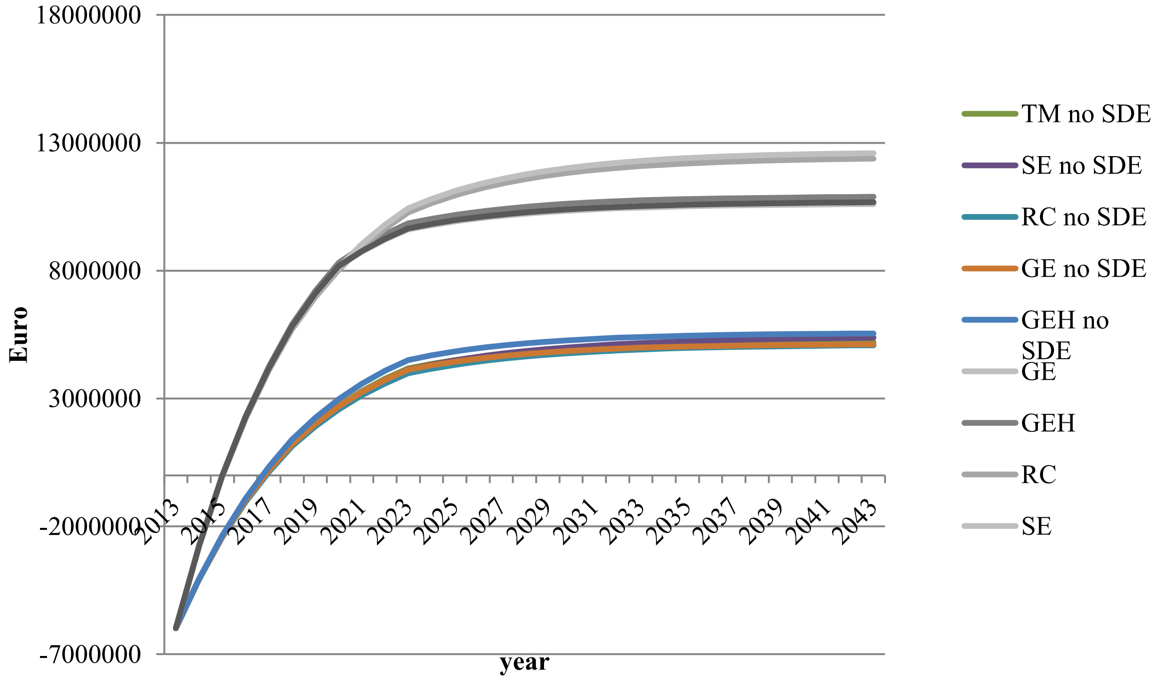


Fig. 5: NPV under scenarios without SDE+

Fig. 5 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. Conclusions

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.

Many factors hinder these companies to implement measures to save on energy by themselves (Fig. 1). An ESCo can relieve some of the problems for these companies by providing energy related services. 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.

In addition, inorder to make a best judjment of potetial of certain ESCo several uncertain factors play a major role. The uncertainty factors for most of the ESCo are: demand of energy, energy prices, subsidies and technological developments. As shown in this paper as well, the availability of subsidies and the development of renewable energy technology are determined to have the most significant influence on the outcome.

The models has been tested on a selected case study ‘’Hoogeind’’. Previously described 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. Important to notice, when the model is running without the SDE+ subsidy, the NPV drops by 50% in value but remains positive for all scenarios.

Finally from this paper, it 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.

References

Agentschap NL. (2011, November 22). *Energiebesparing Meerjarenafspraken energie-efficiency*. Retrieved May 21, 2013, from AgenschapNL: *http://www.agentschapnl.nl/nl/programmas-regelingen/meerjarenafspraken-energie-efficiency*

Bailis, R., Ezzati, M., & Kammen, D. (2005). Mortality and Greenhouse Gas Impacts of Biomass and Petroleum Energy Futures in Africa. *Science, 308*, 98-103

Dervis, R., & Boogaard, L. v. (2012). *Maatwerk duurzame energiestudies industrie.* Utrecht: AgentschapNL.

Energie in Achtergrondrapport WLO, ECN, Petten.

Energie – Nederland, (2011). *Energie in Nederland 2011*. Energie – Nederland, Den Haag.

Farla, J., Mulder, M., Verrips, M., Gordijn, H., Menkveld, M., Dril, A., Boerakker, Y., (2006). Hoofdstuk *Energie in Achtergrondrapport WLO.* ECN.

Grim, M. (2005). Energy Performance Contracting: an opportunity for the private service building sector or a tool for public buildings only? ECEEE.

Ministerie van Economische Zaken, Landbouw & Innovatie. (2011). *Energierapport 2011*.

Saltelli, A., Chan, K., & Scott, M. (2000). *Sensitivity Analysis: Probability and Statistics Series*. New York: John Wiley & Sons.

Schenau, Y. (2011). *Private investeringen als redmiddel herstructurering van bedrijventerreinen?*. Rotterdam: RBOI.

Sterman, J. (2000). *Business dynamics; Systems Thinking and Modeling for a Complex World.* Jeffrey J. Shelstad

TNO. (2011). *Plan van aanpak collectieve realisatie energiemaatregelen op bedrijventerreinen*. TNO.

Ürge-Vorsatz, D., Köppel, S., Liang, C., Kiss, B., Nair, G., & Celikyilmaz , G. (2007). *An Assessment of on Energy Service Companies (ESCOs) Worldwide*. WEC ADEME.

USP. (2011). *3-meting Monitoringsonderzoek campagne Slimme Energie, EPA, IPS en Wet Milieubeheer*. Agentschap NL.

Volkers, C., Menkveld, M., & Simpma, J. (2005). *EnergiebesparingsMonitor Wet Milieubeheer. Tool voor het bepalen van de potentiële besparing als gevolg van de Wet milieubeheer/activiteitenbesluit*. ECN.

Williams, H. (2010). *Energy Efficiency Program Management*. Harris Williams.

Würtenberger, L., Bleyl, J., Menkveld, M., Vethman, P., & Tilburg, X. v. (2012). *Business models for renewable energy in the built environment*. ECN.