Energy Performance Contracting

A risk management decision model for the promotion of energy efficiency by using Monte Carlo simulation

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Preface

This thesis presents my graduation thesis for the master Real Estate Management & Development at the Eindhoven University of Technology. This thesis is the last step in the complementation of my master. My final research was conducted as part of the KenWib initiative (supported by the master; Construction Management & Engineering), a program that has been established to develop and share knowledge regarding energy neutral cities. The research is performed in cooperation with Ballast Nedam, a listed construction company in the Netherlands.

This thesis is written for different target groups. The purpose of Ballast Nedam was to get more insights regarding energy efficiency in leisure related real estate. I also intended to give public parties more information concerning the financing of energy efficiency in the existing built environment, in particular Dutch swimming accommodations. Besides, I want to inspire other KenWib students to look into the interesting and actual topic of energy efficiency and energy performance contracting. Huge challenges are in prospect in order to achieve a 'sustainable' live environment. Achieving a sustainable society should everyone's mindset.

In the beginning of my graduation period, it was quite hard to find an interesting and applicable topic. The subjects, within the KenWib program, were comprehensive but therefore very interesting. Finally I found a subject which was very interesting for me, for Ballast Nedam, and for the KenWib program. The achieved result was not possible without the help of my family, friends, and supervisors. Many thanks for that help and support!

I hope you enjoy reading my Master's thesis,

Ruud Coppens

Energy Service Companies

Changing 'chairs' during a process will give you insight in each other's interests. 'Energy Performance Contracts' are agreements between provider and customer. The revenues and risks have to be divided between both parties, but in what extent? This metaphor is a simplified version of the process, more parties are involved.

This thesis aims to 'change chairs' in order to highlight both interests.

Reading instructions

The graduation thesis can be divided in three parts. The first part of the thesis, chapter 2 / 3 / 4, consists of a brief literature review concerning energy efficiency (marco > meso level). The second part of the thesis, chapter 5 & 6, describes energy performance contracting more in depth (meso > micro level). The last part of the thesis, chapter 7 / 8 / 9, gives an extensive explanation of the constructed model (micro level). A schematic structure of the report is given below;

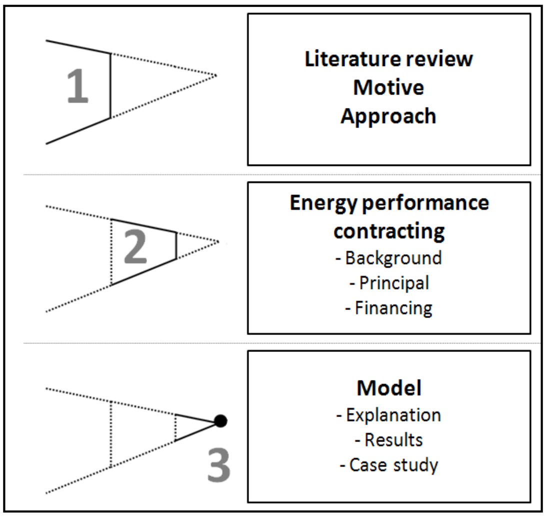


Figure 0.3: Schematic structure thesis

Glossary
Several terms in the thesis are underlined. These terms may require some more explanation, the explanation of the underlined terms can be found in the appendix; glossary.

1. Introduction

Demographical changes and global warming

The 21 century has been seen as an urban century by many experts. Huge challenges are in prospect to face with the increasing number of people on our planet, which will probably rise to more than 9 billion people in 2050. The expectation is that most of these 9 billion people are going to live in urban cities. Developing 'Smart' cities will have a crucial role in facing the enormous population growth and the global warming issue. Changing the way of consuming energy and natural resources are going to have an important position in the development of 'Smart' cities. Besides the demographical issue, the problem of global warming will take an important position the coming decades. Ignoring these developments is wrong, the only viable route to achieve a 'sustainable' and livable society is the swift and massive scaling up of clean technologies combined with a fundamental shift to sustainable production and consumption patterns.

'Cities are going to be in the forefront of driven the clean revolution forward' (Kenber, 2011).

Oil based economies

Nowadays, countries that own natural resources such as crude oil or gas are wealthy and powerful. These resources are seen as the drivers behind the current economies, it can be stated that our current economies are oil based economies. It is almost never been written in official reports, but many violent frictions in the world are partly based on oil dependency and interests of countries. Human rights are often violated in conflicts because of the oil as well as economy interests. The world might look different if the dependency will decrease seriously or even disappear? Scaling up and implementing clean technologies could have a share in this perhaps utopian vision. The change of oil based cities & economies to low carbon and oil independent cities & economies should be in everyone's mind. Gandhi, the man who lead the Indian people to independency from British rule in 1947, wrote down some fundamentals for changing the world. One of his famous fundamentals is the applicable metaphor; *'You must be the change you want to see in the world'*.

Creating wide support concerning energy efficiency

Many people are embracing the way of changing our way of consuming and producing energy. Different motives for this embracement vary from ensuring corporate profitability to advance the global climate changes. However, many people have unfortunately not seen the great economic and social importance of low carbon cities yet. Many new business models are developed and implemented by many parties to promote energy efficiency. Many research projects have been set up to investigate the opportunities of low carbon cities, although the Netherlands seems lagging. Another challenge, besides the challenge which is discussed so far, is to spread the research and knowledge across the world over all the different involved parties. The awareness of becoming more sustainable is part of the global challenge of global warming and the increasing energy demand.

This research thesis, a risks management decision model, has been developed for the promotion of energy efficiency in Dutch swimming accommodations. This model can be used by private as well as public parties. The awareness regarding the opportunities and risks can be reduced by using the model. Supporting the massive scaling up of available clean technologies in urban cities by business model innovation is the main motive for this research thesis.

Figure below gives a schematic overview of the motive for energy efficiency.

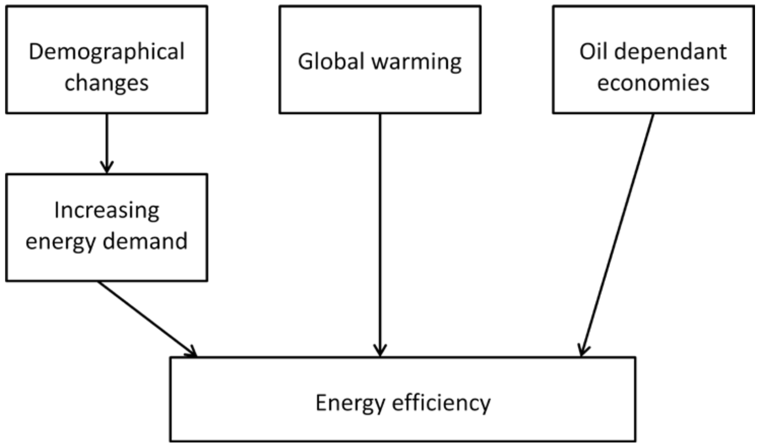


Figure 1.1: schematic overview of the motive for energy efficiency

2. Position Netherlands towards global warming

Brief overview literature; environmental aspect

2.1 Introduction

Strong urban economies are dependant for generating the resources needed for public and private investments in infrastructure, education, health, improved living conditions and, particularly, poverty alleviation (Unece, 2011). Although, these economic developments have also a reverse effect. Strong economies generally produce many tons of CO_2 (Edgar, 2009). Global warming caused by the increase of CO_2 emissions is one of the main issues regarding the energy transition. The position of the Netherlands compared to the world in facing the problem of global warming is discussed below.

2.2 Greenhouse gas emissions by country

There is a strong relationship between energy use in the built environment and the CO_2 emissions which are responsible for the climate changes (Lowe, 2005). Strong economies such as United States and Australia produce the highest level of CO_2 per capita. The Netherlands do not belongs to the top of the world, although the production is relatively large compared to other countries with 10 to 15 CO_2-eq/capita. The aim of the Kyoto protocol, which is explained extensively in the next chapter, was to lower the total CO_2 production. Europe as well as the Netherlands have to reduce the CO_2 emissions with 20% in 2020 compared to 1990. Recent figures (July 2012) show that the Netherlands is far behind the objectives which are signed in Kyoto. The average reduction of the CO_2 emissions of Europe consists 6,9%. The realized reduction of the Netherlands so far is less with 0,2% (UNFCC, 2010). Achieving the targets of the Kyoto protocol will be a great challenge the coming years.

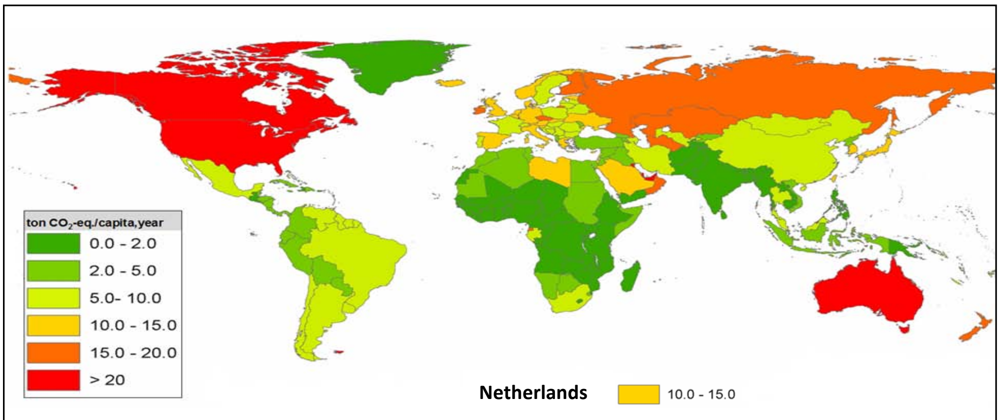


Figure 2.1: World map CO_2 emissions (Edgar,2009)

2.3 Energy use Netherlands

The energy use in the Netherlands has deviating values compared to other countries. The gas consumption in the Netherlands is significant higher than other countries. This is not very strange because of the gas reserves in Groningen, the province in the north of the Netherlands. The consumption of oil and electricity is comparable. The emission factors of the different energy sources are different. The emissions factors of gas are higher than electricity (Climate Neutral Group, 2011).

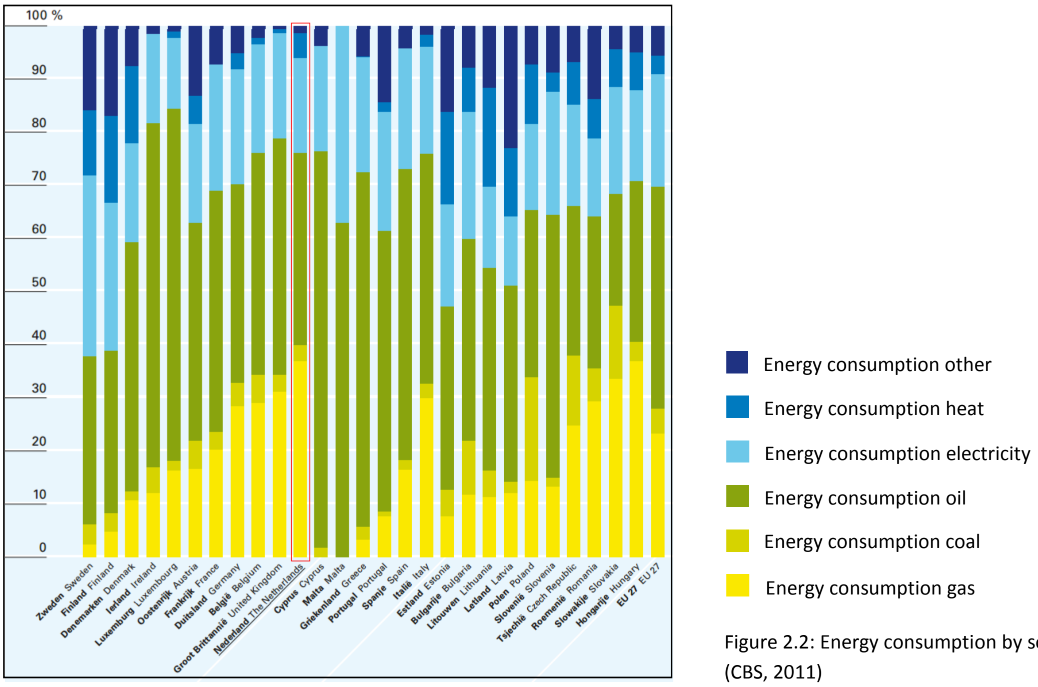


Figure 2.2: Energy consumption by source (CBS, 2011)

2.4 Trias Energetica

The Trias Energetica is developed by the University of Delft and forms a roadmap towards climate neutral building and cities, also part of becoming a ‘Smart’ city. The first and most essential step is cutting back the energy consumption. Reducing the energy demand is the most efficient way in reducing the CO_2 emissions and to eliminate the issue of the increase of energy prices.

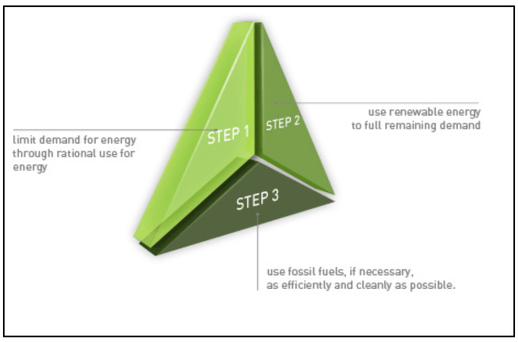


Figure 2.3: Trias Energetica (Everop,2012)

The energy demand, which contains after the reduction in step 1, is the second step in the Trias Energetica. The remaining demand should be obtained by renewable energy sources such as solar PV or geothermal heat. The last step in the Trias Energetica is the use of fossil fuels, if necessary. The model gives a clear view of the process of becoming more energy efficient in the built environment.

2.5 Renewable energy use Netherlands

The disappointing reduction of the CO_2 emissions has a strong relationship with the renewable energy consumption as well as the production of renewable energy. Besides the second step in the Trias Energetica, the Kyoto protocol prescribes also a renewable energy consumption, 20% of the total energy consumption have to be renewable. Figure below shows that the Netherlands is far away from that level. Other European countries do really have a better position in this process. Again a catch-up effort for the Netherlands.

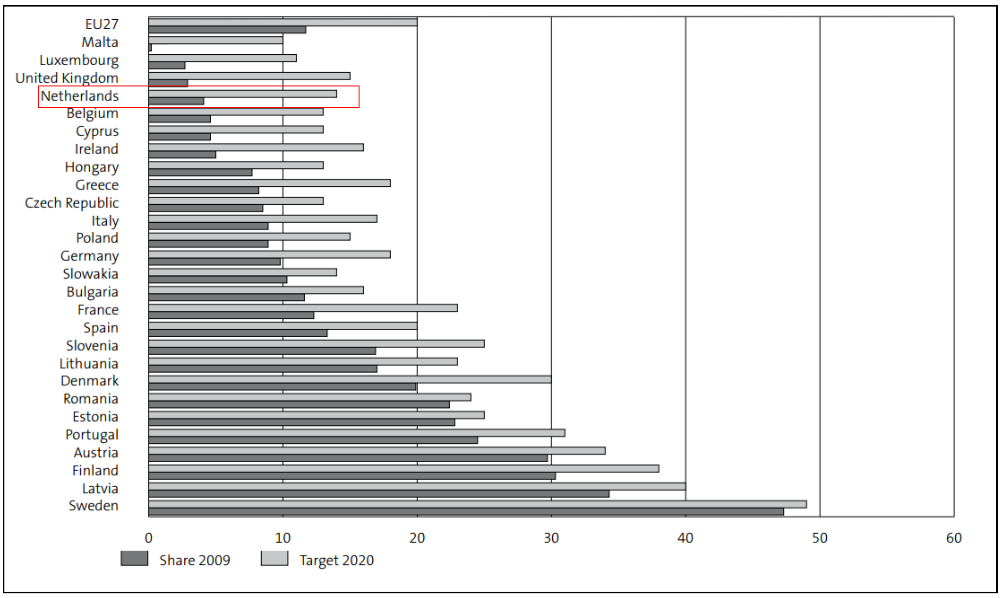


Figure 2.4: Renewable energy consumption (CBS, 2011)

2.6 Conclusion

The position of the Netherlands towards other European countries is substandard. Every country, thus also the Netherlands, should take their responsibility to contribute their part in the global warming challenge. The Trias Energetica constitute an useful roadmap to become energy neutral in the built environment. Energy reduction as well as energy production will go hand in hand in every project regarding the promoting of energy efficiency in the built environment.

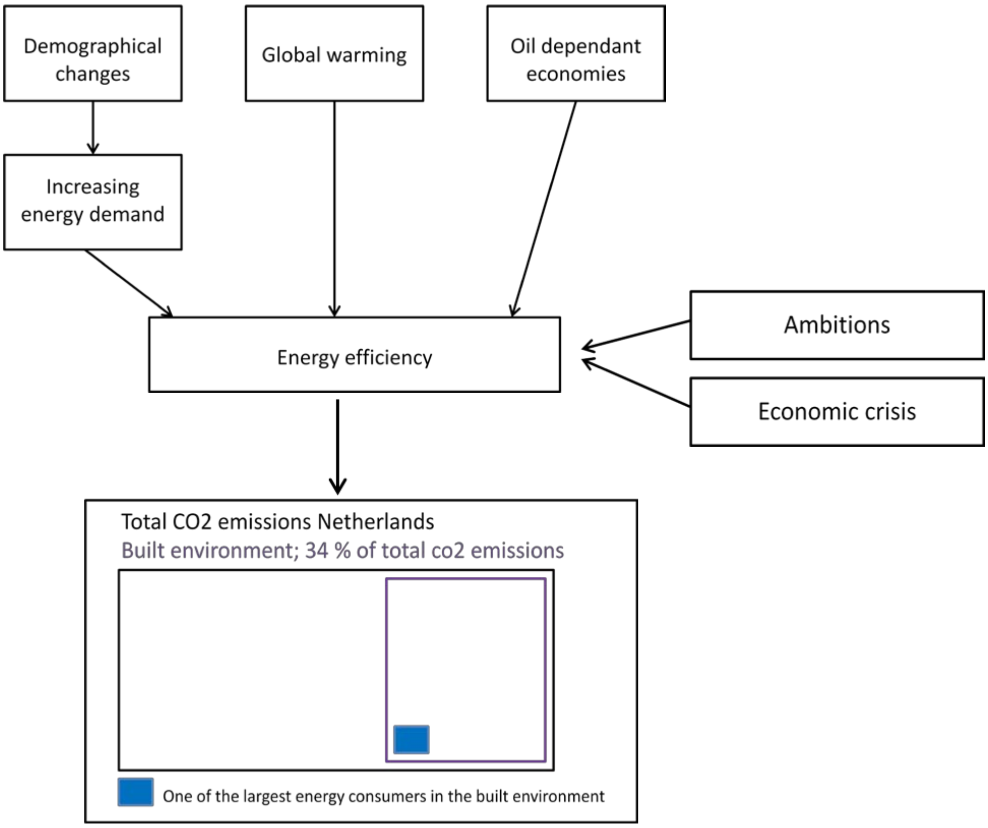


Figure 3.1: Schematic overview of the motive and problem focus

3. Motives & Problem focus

Description of the motive and problem focus for energy efficiency

3.1 Introduction

Cities has a crucial position in the social and economic development of countries. Today, only 600 urban cities generate about 60% of the global gross domestic product (Spelman, 2011). This percentage will still increasing the coming decades. The built environment constitutes an important part of the sustainability challenge discussed in the introduction of the report. Besides the motive of global warming, becoming more energy efficient has more incentives. Figure 3.1 gives a schematic overview of the motive and problem focus of energy efficiency in Dutch swimming accommodations.

3.2 Energy efficiency in the built environment

Since the industrial revolution at the end of the 19th century, all the developing countries became energy dependant (the start of oil dependant economies). The availability of energy and the costs of energy were not an issue during that time. Although, this came to an end in the period between 1970 and 1979. The prices of oil increased heavily, this caused an increase in the price of energy. At the same time, the club of Rome presented in 1972 a report about the limits of growth and the effects of the economic growth concerning the global warming. The 70s were therefore the starting point for worldwide experimenting with renewable energy. However, the falling oil prices in the 80s retained this development to renewable energy sources (Lindgren Soroye and Nilsson, 2010). Nowadays, the expected long term trend on energy prices and the awareness of global warming have stimulated the quest for a transition to renewable energy solutions.

Potential of the built environment

The built environment in the Netherlands is responsible for 34% of the total CO_2 emissions (AgentschapNL, 2012). Interventions in the built environment forms a great challenge and opportunity for municipalities, real estate owners, investors and other involved parties in real estate. The total size of the municipal real estate in the Netherlands consists of 42 million square meters. This amount is comparable to the whole Dutch office market (Lindenbergh, 2012). The municipalities have a leading position in achieving the ambitions and are responsible for an important part of the sustainability challenge. Generally, the sustainability of their 'own' real estate has been stated as one of the main points on their political program the common years.

The economic crisis; problem and opportunity
The economic crisis has their impact in the financial situation of real estate owners, especially municipalities. Regarding to municipalities, large scale austerity measures are made in order to cover the decreasing benefits of land development projects, taxes and incomes out of the municipality funds (Kant, 2013). The crisis caused a decrease in the municipality exploitation that has been used for statutory provisions. These provisions were normally used for the exploitation charges of municipal real estate (Schönau & De Vos, 2011). However, these funds will decrease and the necessity of saving money becomes more and more important. Concerning the economic crisis, promoting energy efficiency can create jobs, strengthen economic growth and enhance energy security (Kenber, 2011).

Political ambitions concerning energy efficiency
Worldwide climate changes created awareness for the transition to renewable energy sources. Traditional energy resources such as oil and gas are the main causers of the CO_2 emissions and thus the problem of global warming. This awareness led to the introduction of a protocol in 1998, called the Kyoto Protocol. Numerous countries as well as the Netherlands agreed and signed the Kyoto Protocol. The members of the protocol committed themselves (with respect to 1990) a reduction of their CO_2 emissions of 20%, a reduction in energy use of 20% and the production of 20% renewable energy compared to the total energy use (Commissie van Europese Gemeenschappen, 2008). The Netherlands aims a leading position within this protocol; the Netherlands wants to become one of the cleanest and most efficient countries in the world. Within these ambitions, the different municipalities in the Netherlands have formulated their own ambitions to achieve the national goal. For instance, the ambition of the municipality of Eindhoven is to become completely energy neutral in 2035-2045 (KenWib, 2012).

3.3 Focus area
Within the built environment, swimming accommodations are one of the largest energy consumers. Besides the issues which are described above, the expectation is that the energy prices will increase the coming years. These developments forms a serious risk for the future exploitation of swimming accommodations. Figures show that 12% of the swimming accommodations in the Netherlands are nominated for closure by financial reasons (Van der Werff, 2011). If no interventions will be taken, more swimming accommodations will be nominated for closure.

Potential of Dutch swimming accommodations
The Netherlands counts approximately 1500 swimming accommodations (zwembad monitor, 2012), which are mostly owned by municipalities. The average consumption of a swimming accommodation is equal to the energy consumption of 400 households. After the wages of employees, the energy costs constitute the largest part of the budget. The energy costs of all the municipal swimming accommodations together consists of more than 400 million euro. Besides the current high energy costs, the expectation is that the energy prices will increase

the common years (CBS, 2012). Energy efficiency in swimming accommodations is important for the future exploitation. Around 40% of the swimming accommodations in the Netherlands are built in the period between 1970 and 1989. Another 20% were built in the period between 1990 and 1999. (Van der Werff et al., 2012) Many swimming accommodations are dated, but have great saving potential. Despite the exploitation problems, new swimming accommodation are still built. This is an indicator of the market supply for swimming accommodations. Something has to be done to keep the budget of municipal real estate i.e. swimming accommodations reasonable. Promoting and implementing energy efficiency in swimming accommodations should be higher on the priority list.

Social context of swimming accommodations

Energy efficiency in swimming accommodations seems to have great financial benefits. However, besides financial benefits (moreover very important), there are more reasons to promote energy efficiency in swimming accommodations. Swimming is the most practiced sport in the Netherlands; 34% of the citizens in the Netherlands is practicing a sport, 36% of this amount practices swimming (ZKA, 2009). In addition, young children and elderly people are important target groups regarding swimming accommodations. Aging is an important process which will continue the common years. The tradition for young children is to learn swimming in the early stage of life. Besides the financial benefits, there is also a serious social context. The national government even decided to perform a 'Green Deal' in order to support the energy efficiency in Dutch swimming accommodations.

3.6 Conclusion

The built environment plays a crucial role in the reduction of CO_2 emissions. The largest energy consumer within the built environment are swimming accommodations. Different incentives to become more sustainable have been discussed so far; financial benefits, social importance, and the problem of global warming. The techniques to become more energy efficient are available in the current market. Then the question arises; why have swimming accommodations owners not invested in energy efficiency so far. An initial investment has to be done in order to achieve a positive cash flow the next years. The lack of own equity, connection to the capital market, and the awareness might be the explanation. However, energy performance contracting is seen as an important vehicle to promote and enable sustainability in swimming accommodations. However, it has a lot barriers and challenges to become successful (Lee, Park, Noh & Painuly, 2003).

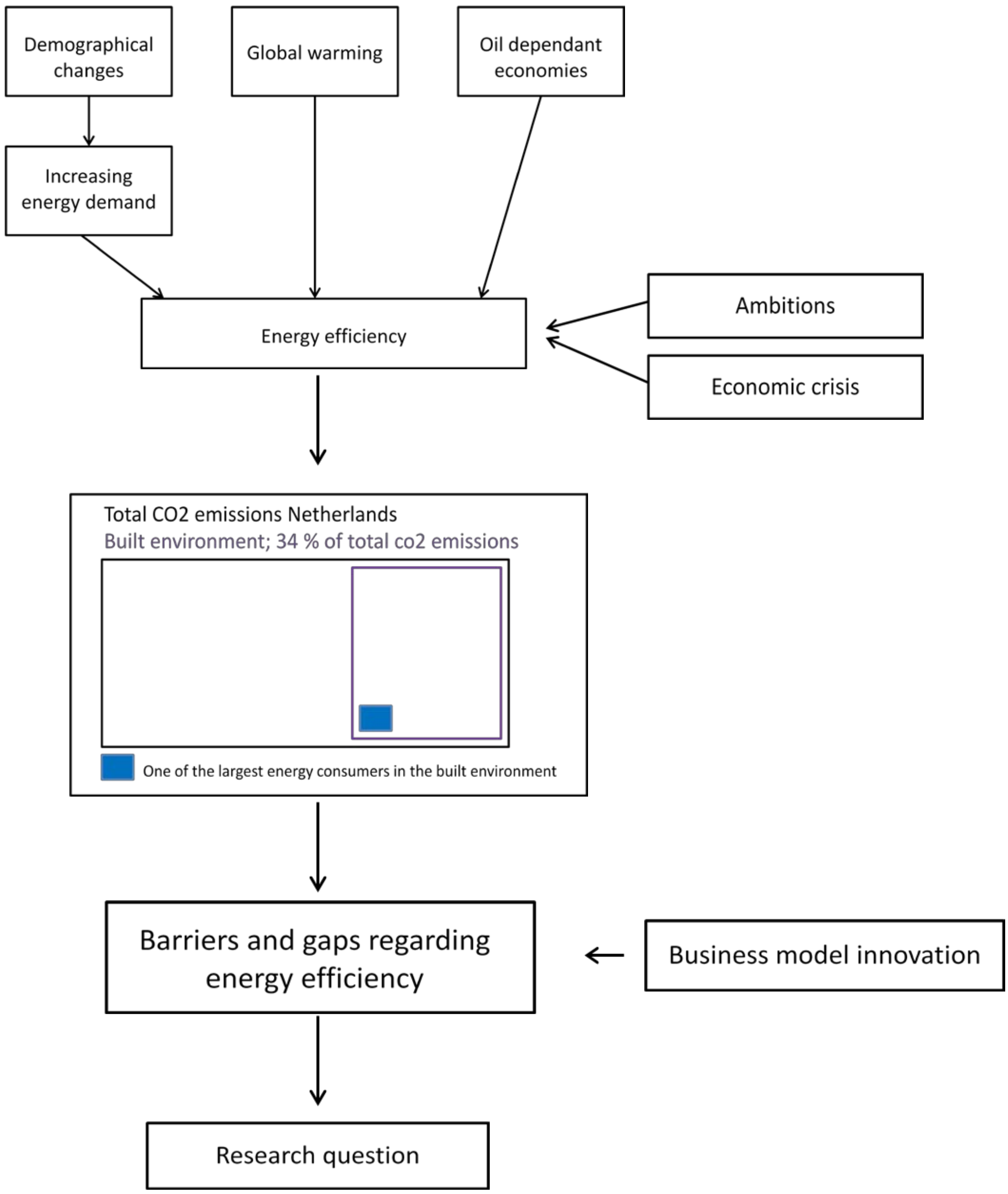


Figure 4.1: Schematic overview research approach

4. Research approach

4.1 Problem definition

Energy service companies are seen as an important vehicle in promoting energy efficiency. The lack of knowledge and awareness in the world of energy service companies is one of the most important barriers in the development of ESCo's in the Netherlands. It is important for public parties as well as commercial parties to gain more information concerning energy performance contracting. This research aims to fill in (have a contribution) the information gap between public and private parties concerning energy performance contracting. Starting with one of the largest energy consumer, swimming accommodations, could be a perfect business case for both parties.

4.2 Research question

The research question in this research is formulated as:

> *'Is there an opportunity to create a risk management decision tool which can be used by the customer as well as the ESCo to get insights in the benefits and risk regarding energy performance contracting?'*

The following sub question are related to the research question:

'What are the basic thoughts behind Energy Service Companies?'
'How is the market of Energy Service Companies comparing to other countries?'
'Are there different contract types in the world of energy performance contracting?'
'What variables influence the energy performance contracts over a certain time horizon?'
'What are the pros and cons of collaboration in energy performance contracts?'

4.3 Research objective

The objective is to create a model (public/private or used by both) which gives insights in the financial benefits and risks regarding energy performance contracting. The dependant variables around energy efficiency in swimming accommodations will be investigated and discussed. The model could give incitement to collaborate in the energy efficiency within swimming accommodations. Figure below gives an schematic overview of the model;

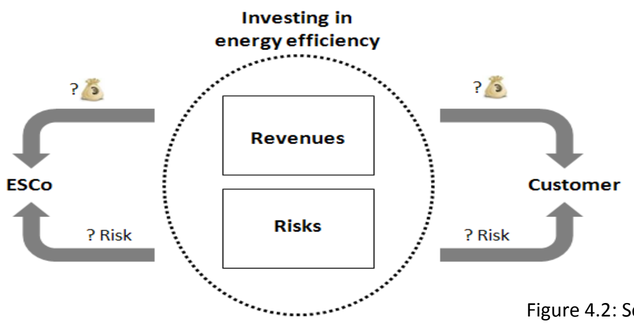


Figure 4.2: Schematic overview research objective

4.4 Research model

The first step is to gain more information about energy performance contracts (EPC's), EPC's are rather unknown in the Netherlands but regularly used abroad. Different contract types will be looked after and the dependant variables will be determined. Some methods are used to quantify these variables in order to create a reliable model. This model will be applied to a private and public owned swimming accommodation. The research model constitutes also the structure of the next chapters. Figure 4.1 gives a schematic overview of this research thesis.

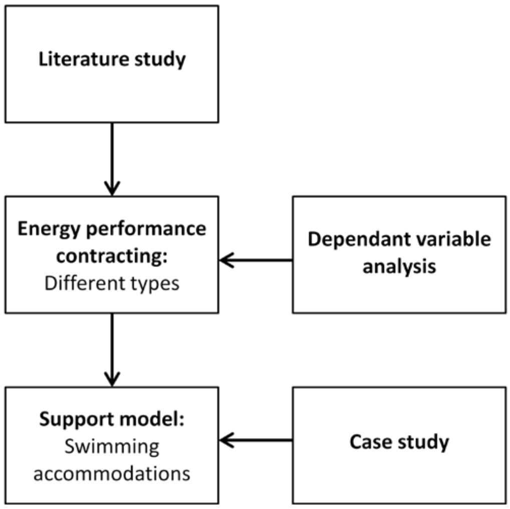


Figure 4.3: Research model

TU/e   Ballast Nedam

5. Basics - Energy Service Companies

'How is the market of energy performance contracts comparing to other countries?'

5.1 Introduction

As already mentioned in previous chapters, the concept of ESCo's is a rather unknown phenomenon in the Netherlands, although regularly used abroad. In this chapter, first a brief overview of the concept of energy performance contracting is discussed. Second, the situation of the Netherlands regarding energy performance contracts is described. Finally the barriers concerning energy performance contracting are summarized in a SWOT analysis.

5.2 Definition Energy Service Companies (ESCo's)

Much literature describes the energy service companies in different ways. There is no uniform term which is used in the literature, however, the principals and context are quite similar. Three descriptions out of different literature sources are given, the framed description will be continued in this thesis.

''*An ESCO, or Energy Service Company, is a business that develops, installs, and arranges financing for projects designed to improve the energy efficiency and maintenance costs for facilities over a seven to twenty year time period. ESCOs generally act as project developers for a wide range of tasks and assume the technical and performance risk associated with the project.*" (Clinton Climate Initiative, 2009)

"*Energy service company (ESCO): a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria*." (Bertoldi, Boza-Kiss & Rezessy, 2007)

"*An energy service company (ESCO) is a company that is engaged in developing, installing and financing comprehensive, performance-based projects, typically 5-10 years in duration, centered around improving the energy efficiency or load reduction of facilities owned or operated by customers*." (Vine, 2005)

An energy service company (ESCo) is an external organization which is engaged in developing, installing, maintaining and possibly financing performance-based energy reduction projects during a fixed time horizon. The payment for the service company is based on the achievement of the energy efficiency improvement i.e. the decrease of the energy bill.

An EPC is the contractual arrangement between the beneficiary and the provider. The term EPC should not be confused with the Dutch term '*energie prestatie coëfficiënt*' which is also used in the context of energy efficiency.

5.3 Brief historical overview ESCO's

Since the industrial revolution at the end of the 19th century, all the developing countries became energy dependant. The availability of energy and the costs of energy were not an issue. Although, this came to an end in the period between 1970 and 1979. The oil crisis caused a heavy increase in oil prices and thus the prices of energy. This increase in energy prices stimulated private companies in the United States to reduce their energy consumption. One of the first enterprise, which introduced a device to automate the switching lights and other equipment to regulate energy use, was located in Texas (United States). Selling their new products was not a success, customers doubted that the saving would actually materialize their investment. This was in the late of the 1970s the basis for the introduction of energy service companies (ESCo's).

Besides the introduction of ESCo's in the United states, European countries and companies also discovered that phenomenon in the 1990s. In the case of Europe, the development of ESCo's is strongly driven on governmental legislation. The Government of the United Kingdom, France and Italy introduced a saving obligation. In addition, France introduced in accordance with Germany interesting financing requirements along with investment funds. Especially in German and Belgian, the national government served as 'launching customer'. This led to numerous initiatives in energy efficiency, however, the development of ESCo's in the Netherlands remained though (Barneveld, 2011).

5.4 Barriers concerning energy efficiency in the Netherlands

Until 2005, there was hardly any activity on the Dutch market concerning energy service companies. The Dutch ESCo market has just been developing the last few years, but the market is still in an early stage. Also the size cannot be compared to other European countries such as Germany and France (Boer, 2011). Several parties in the Netherlands discovered the benefits of energy performance contracting. Several barriers for the Dutch market are described below.

Market & social barriers

The energy costs in buildings are relatively low compared to others costs for private or public companies. The incentive for investing in energy efficiency is therefore low. Nearby, the indirect benefits such as comfort, health impacts from pollution, and climate change are not included in the price (price distortion). The benefits from implementing energy efficiency may be outweighed by the transaction costs and efforts required for gathering information of installing new equipment in a building which is already in use; the 'hassle' effect (ECN, 2012).

Information failures

There is a general lack of awareness in the Dutch market around energy efficiency. If viable energy efficiency alternatives are unknown, they are not taken into account by investors. Therefore, investors are calculating their return on the basis of the BAR. The decrease of the energy costs are not included in this parameter, it would be better to use the NAR (Van Loo, 2012). Even if building owners have the willingness to implement energy efficient measures in their real estate, they often find it difficult to obtain qualified, objective, and independent financial experts (ECN, 2012). Generally, the risks of energy efficient projects have been set higher than conventional investments.

Regulatory barriers

The information barriers ensure that the legislation is also not sufficient in the promotion of energy efficiency in the built environment. Restrictive procurement rules and cumbersome building permitting processes constitutes the implementation of energy efficiency measures.

Financial barriers

Many energy efficiency projects are not yet competitive than other investment opportunities. Competitive investment combined with the lack of information results in low investments in energy efficiency. Many energy efficiency projects require a substantial initial investment, this poses a barrier to invest. Besides the low transparency in the energy efficiency investments, these projects usually have relative high transaction costs. In addition, the low access to the capital market is for many customer an important barrier.

SWOT analysis

The SWOT analysis overviews the strengths, weaknesses, opportunities, and threats concerning energy efficiency. Two SWOT analysis will give the barriers and opportunities for both parties.

SWOT analysis customer

Strengths	***Weaknesses***
- Reduce energy costs - Increasing comfort level - Opportunity financial benefits	- Lack of awareness - Lack of financing options - Access to the capital market - The ‘hassle’ factor - Price distortion - Regulatory barriers
Opportunities	***Threats***
- Hatch to price increases - Benefit opportunities - Political awareness	- Increasing exploitation costs

Figure 5.2: SWOT analysis customer

SWOT analysis Energy Service Companies

Strengths	*Weaknesses*
- Access to the capital market	- Split incentives - High transaction costs - The 'hassle' factor - Price distortion
Opportunities	***Threats***
- Political awareness - Lack of awareness customer - Information gap customer - Regulatory barriers customer - Economic situation customer	- Market and social barriers - Information gap customer

Figure 5.3: SWOT analysis customer

As you can see in the both SWOT analysis, the matrixes are complementary. Threats for the customer concerning energy efficiency can be an opportunity for the Energy Service Company. Energy Service Companies could fill in the gap of the weaknesses and threats of the customer. This is a situation which creates collaboration opportunities, both parties are connected to each other. Hereby, energy performance contracting can function as an important vehicle to realize energy efficiency projects.

5.5 Principals of Energy Performance Contracting

Energy performance contracting has a fundamental different approach than traditional tendering. The emphasis in traditional contracting is achieving the best economic performance (EMVI). Energy performance contracts do not assume a project but a exploitation business case with a certain time horizon. The ESCo guarantees the energy savings and/or provisions of the same level of energy service at a lower cost by implementing an energy efficiency project (Boer, 2011). Whereas the ESCo is rewarded performance based, the higher the performance i.e. result, the greater the reward for the ESCo. This results in a continuous incentive for the ESCo to improve the energy efficiency of the installations. Another advantage of the incentive is that the implementation time will be decreased, the implementation time affects also the result. Figure 6.1 gives a schematic overview of the differences between traditional tenders and energy service companies.

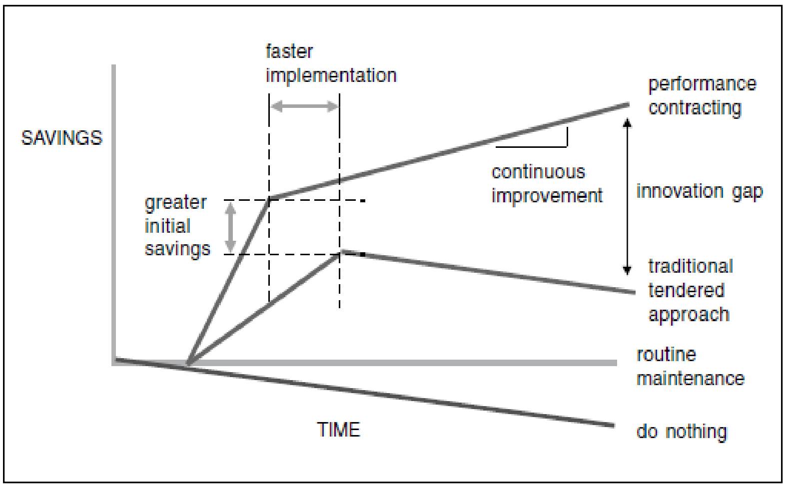


Figure 5.1: potential of EPC (Energy Charter Secretariat, 2003)

5.6 Municipalities & Energy Performance Contracting

As discussed in the introduction, municipal real estate forms an important target group in the implementation of energy efficiency in the built environment. Some barriers are discussed in the previous chapter which refrains municipalities from investing in energy efficiency. Although, the Clinton Climate Initiative suggest that investing in energy efficiency is lucrative. Below some additional issues are pointed out regarding municipalities.

Regulations related to deficit budget national government

Several other financial opportunities are available for municipalities to finance energy efficiency such as ‘groen hypotheken’, revolving funds, own equity, and regular loans. Although the economic crisis resulted in a new regulation called HOF (Houdbare overheids financiën). The total deficit of the national government constitutes 16,7 billion euro. This deficit have to be decreased seriously the common years. The municipalities are responsible for a deficit of 3,2 billion euro. Municipalities are not be able to attract new debts anymore. This disenables the municipalities to invest in large scale energy efficiency projects.

Risks on the municipal balance

Investing in energy reduction measures can be profitable, but cannot be done without taking investment risks. Investing in energy reduction measures have payback times of several years, in some cases more than 10 years. Several risks have to be taken into account in achieving energy efficiency. Municipalities should avoid these risks on their balance. Private parties have better instruments and knowledge in constraining these risks.

5.7 Conclusion

The concept of energy performance contracting is rather simple. Investing in energy efficiency will decrease the energy bill. The energy service company have the incentive to perform well, because the reward is dependent to the performance of the ESCo. Energy efficiency barriers and regulation constitute the basis for the current development of energy performance contracting.

6. Financing options & contract types

'Are there different contract structures in the world of energy performance contracting?'

'What are the pros and cons of collaboration in energy performance contracts?'

6.1 Introduction

In general, there are three broad financing options for energy efficiency projects regarding an ESCO; customer financing, ESCo financing, and third-party financing (Mora Associates, 2010; CE Delft, 2005). First, these three options are described in this chapter. Second, the different contracts are described briefly. Finally some remarks and the conclusion is given.

6.2 Financing options

Customer financing

Customer financing implies that the customer (the energy user) finances the initial investment by them self and the ESCo guarantees a certain performance. The customer pays the ESCO a fixed amount of money in return for this guarantee. However, all benefits from the achieved energy savings credit the customer. The investments of the customer are on-balance, which is one of the reasons for customers to choose one of the other contract types (Boer, 2011).

ESCo financing

When the ESCO finances the initial investment by them self for the energy efficiency, in the literature ESCo financing is used in the literature. In this construction, both the customer and the ESCO profit from the energy savings because both parties depend on the achieved energy reduction (Boer, 2011).

Third party financing

Third-Party Financing is a contractual arrangement where a third party finances the initial investment for the energy efficiency. This option allows investing in energy efficiency if both parties are not be able or willing to invest in energy efficiency. In addition, several parties are interested in energy efficiency financing. Financial institutions as the Triodos bank or ASN bank give attention and enable investments in energy efficiency. Obviously, this is only possible if the internal rate of return is greater than the interest rate.

However, there is always the possibility to bring in 'own' equity in the project. If the internal rate of return will be higher than the interest rate (not known in advance), financial leverage can occur.

6.3 Contract types – Third party financing

'Shared saving' contract

The 'Shared saving' contract is comparable to the ESCo financing option but in this case the ESCo provides the financial resources necessary for the investment. The ESCo and the customer share the savings resulting from the project in proportions as specified in the shared-savings contract. The ESCo makes debt service payments from its share of the savings: if the ESCo's share of the actual savings is less than the debt-service payments, the ESCO covers the difference. The ESCo's reward is thus fully dependant on the level of energy savings. Figure 7.1 gives a schematic overview of the 'Shared saving' contract.

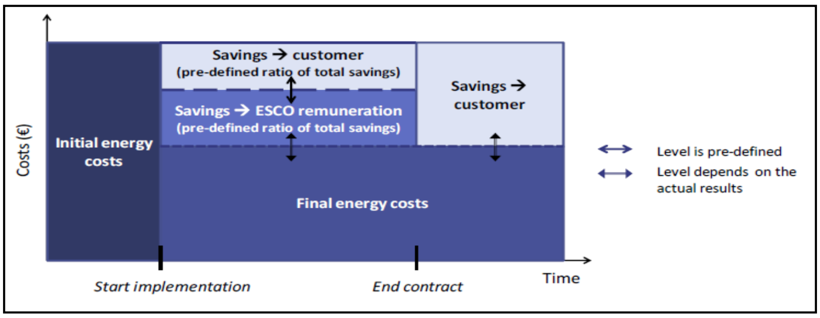


Figure 6.1: SWOT analysis 'shared saving' contract (De Boer, 2011)

'Guaranteed saving' contract

The 'guaranteed saving' contract is comparable to customer financing with the difference that the customer does not use its own capital but borrows money from a third-party. In this structure, the arrangement between the customer and the financial institution is being backed by an energy savings guarantee, issued by the ESCO, with the purpose to demonstrate the financial institute that the project for which the customer borrows money will generate a positive cash flow (Mora Associates, 2010). If the guaranteed will not be achieved, the ESCo will pay the difference plus a penalty. If the reduction is higher, the surplus will be divided. Figure 7.2 gives a schematic overview of the 'guaranteed saving' contract.

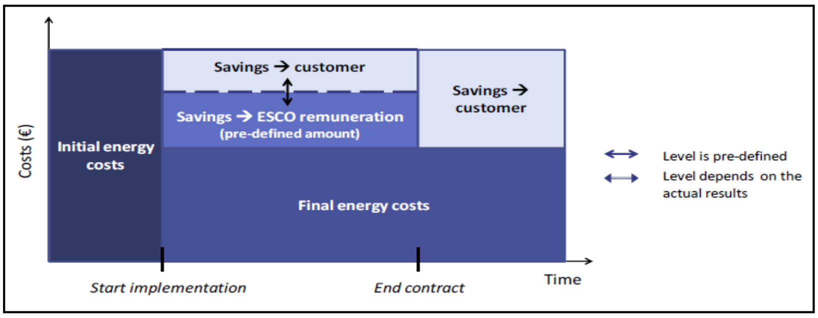


Figure 6.2: SWOT analysis 'guaranteed saving' contract (De Boer, 2011)

'Variable saving' contract

The 'variable saving' contract is comparable to the 'guaranteed saving' contract. However, the ESCo borrows the financial resources necessary for the investment. The financial structure of the different contract types are pointed out in the chapter 'Model design'.

6.4 Conclusion

Third party financing in combination with own equity will be the situation in most projects. The debt money can be provided by financial institutions as Triodos and the ASN bank. The three contract types fit in the concept of third party financing. The different variables within the three contract types are discussed in the next chapter.

7. Dependant variable analysis / Methodology

7.1 Introduction

The model is designed for the implementation of energy performance contacts in Dutch swimming accommodations. The benefits out of the efficiency measures are influenced by some factors. This chapter gives an overview and analysis of the dependant variables. The two main used methods to analyze the dependant variables are the 'Morris' and 'Monte Carlo' analysis which are briefly explained in this chapter.

7.2 Contract as leading document

The energy performance contract is the leading document in the collaboration between the provider (ESCo) and the customer (consumer). All the relevant factors which may influence the rewards for both parties have to be investigated and secured in the contract. Knowing the risk will give you the opportunity to constraint them.

Human behavior

In many literature and talks with experts, the aspect of human behavior is essential to be successful. A lot of current contracts between owner and operator are remarkable. The operator is renting the swimming accommodation for a fixed amount of money from the owner (Interview: Infomil, Rullens, 2012). The energy bill is paid by the owner (in many cases by the municipality) and the operator has no incentive to use their energy in a responsible way. If the owner decides to invest as well as confirm an energy performance contract, there has to be an incentive to the 'real' energy user to become more aware of their energy consumption. Besides the energy performance contracts, the exploitation contract between owner and operator of swimming accommodations are very important. To ensure that the project will be successful, it is crucial that all the relevant stakeholders changes their contract and attitude. For example the customer must have an incentive to be responsible in their energy consumption.

Dividing risks

The parameter analysis, which is explained in this chapter, gives the provider and customer a clear projection of the variables which influences the 'new' energy bill. On the basis of the variable analysis, the different 'risks' can be divided between both parties. The 'Morris' analysis gives the influence of each separate variable. The 'Monte Carlo' analysis gives the influence of multiple variables. First an overview of the different dependant variables is given.

7.3 Dependant parameters

The rewards are determined on the basis of the difference between the 'old' and 'new' energy bill, the structure of the energy bill is explained in appendix 1. The dependant variables, which are part of the energy bill, influences the cash flow streams (rewards) for both parties. The different dependant variables will not assume the same values during the time horizon. The uncertainty in the different values are reviewed on the basis of data from the past. However, the opening hours and the number of visitors (which have a direct mutual connection) cannot be substantiated. Table 8,1 gives an overview of the different variables along with the baseline values and uncertainty ranges. Appendix 2 gives an extensive analysis and substantiation of each variable.

Dependant variable	*Unit*	*Affects the…*	*Baseline Value'12*	*Uncertainty range*
Electricity tariff	€	'new' energy bill	0,100	0,082 – 0,118
Gas Tariff	€	'new' energy bill	0,348	0,284 – 0,412
Water tariff	€	'new' energy bill	0,840	0,760 – 0,920
Tax level electricity	€	'new' energy bill	0,0111	0,0091 – 0,0131
Tax level gas (low demand)	€	'new' energy bill	0,1443	0,1131 – 0,1755
Tax level gas (high demand)	€	'new' energy bill	0,0400	0,0330 – 0,0480
Outside temperature	Degree days	Demand gas	2671	2455 – 2887
Opening hours	Hours	Demand electricity	2912	scenario
Number of visitors	Number	Demand gas and water	constant	scenario
Inflation rate	%	Net present value	2,30	1,76 – 2,84
Risk free interest rate	%	Net present value	2,98	2,21 – 3,75

Table 7.1: Overview dependant variables

7.4 Dependant parameter analysis

'Morris' analysis

The Morris analysis is an example of an 'one-at-a-time' method. The 'one-at-a-time' reviews the corresponding of each parameter regarding to the random variable (net present value). The different parameters will be varied one by one, the result will be evaluated. The objective is to investigate the influence of each parameter and which parameters should be constrained. The analysis is dependent to the consumption of the particular swimming accommodation. The range of each variable will be investigated, the range is expressed in the net present value. The range of each variable will be rescaled to values between [0,1]. The minimum value (of all the dependant variables) is 0 and the maximum value (of all the dependant variables) is 1. The 'Morris' analysis will be applied in the spreadsheet program excel. A total and clear overview of the influence of all the different dependant parameters can be given by placing the parameters in the same box plot. The formulas (3,1) and (3,2) in appendix 3 are used for these calculations.

'Monte Carlo' analysis

The 'Monte Carlo' method is based on the generation of multiple trials to determine the expected value of the random variable (net present value). The dependant parameters determine the random variable (net present value of the reduction). The range (boundary) of each variable is specified in previous chapter. The 'Monte Carlo' simulation produces distributions of possible outcome values. Removing some parameters out of the 'Monte Carlo' simulation (removing fluctuation risks out of the model) will influence the net present value.

7.5 Conclusion

The contract has been seen as the leading document in investing in energy efficiency by energy service companies. The linear regression method is used to create the most reliable scenario. The 'Morris' analysis investigate the influence of each dependant parameters. The 'Monte Carlo' analysis use multiple trials. Some dependant parameters can be extracted from the model. Thus the 'Morris' analysis determines the scenario's which are taken into account in the decision model. The purpose is to achieve a decision table in which the 'best' option for both option can be chosen. In the next chapter, the model is pointed out. The case studies shows the model in practice.

8. Model design

8.1 Introduction

The objective of the research is to design a risk management decision model which should give more insights in energy performance contracting. The model should improve the collaboration between customer and provider in order to create a reliable business case for both parties. In this chapter, the risk management decision model will be elaborated.

8.2 Model structure

The start position of the model consist of the baseline value (data availability of the most recent year). Each contract will use the baseline values and will achieve the same net present value. This can be achieved by composing the reward variables; these variables will become clear in the elaboration of the different contracts. The three contracts have different rewards, this results in a dissimilar sensibility. The dependant variables are analyzed and modeled in order to discover the differences. Figures 8.1 & 8.2 give a schematic overview of the model design.

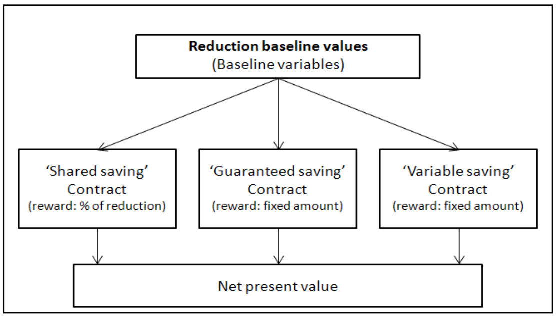


Figure 8.1: Reduction baseline values

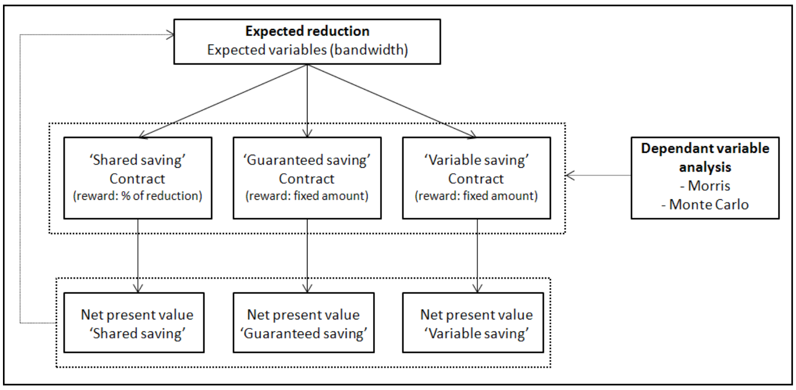


Figure 8.2: expected reduction over a certain time horizon

Reduction baseline values (Baseline variables)

The baseline year is the starting position of the calculations. In the baseline year, the energy reduction measures will be implemented and will result in a reduction of the energy bill. It is important that the values used in the baseline calculations are reliable. On the basis of these baseline values, the net present value of the reduction measures calculated. Formula (1.1) is used for the calculation of the baseline values. The term forms the baseline energy bill. The formula (1,1) is elaborated in appendix 1.

$$B_b = (C_g * P_g) + (C_e * P_e) + (C_w * P_w) + Tax + R_m \quad (1,1)$$

Contract types elaborated (cash flow streams)

Below the different contract types are elaborated, the different ways of rewarding the energy service company will be highlighted. The money bags are not a reflection of the proportion of the total reduction, it is just to represent the cash flow stream.

'Shared saving' contract

A fixed percentage of the reduction of the energy (maintenance) bill is the reward for the energy service company regarding a 'shared saving' contract. The advantage for the customer is the difference between the 'old' and 'new' bill. Figure 8.3 gives a schematic overview of the cash flow stream of the 'shared saving' contract. The formulas (1,2) & (1,3) are used to calculate the reward for the ESCo and the advantage for the customer (colored bags). The formulas are elaborated in appendix 1.

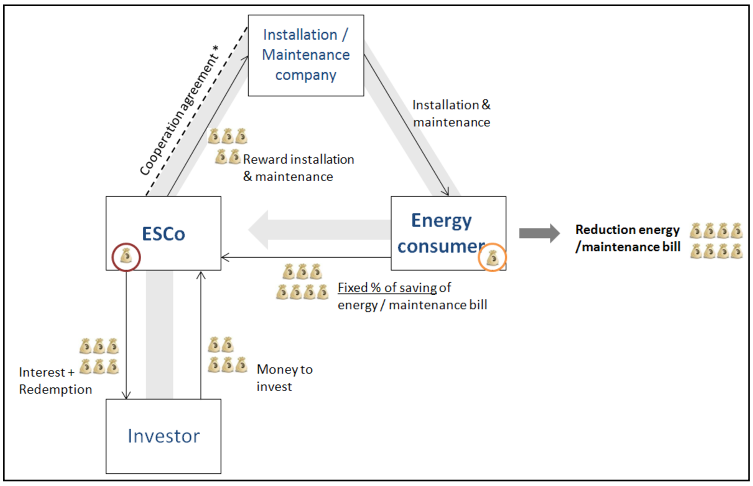


Figure 8.3: Schematic cash flow stream of the 'Shared saving' contract

* An energy service company is usually part of the installation and maintenance company. A good relationship (confidence) is necessary in succeeding a project.

Reward customer

$$NPV = \sum_{i=1}^{n} R_{total} - Reward_{Customer} \tag{1,2}$$

Reward ESCo

$$NPV = -Investment + \sum_{i=1}^{n} \frac{savings}{(1+i)^n} \tag{1,3}$$

<u>'Guaranteed saving' contract</u>

In this contract type, the energy service company will provide the capital for the investment in energy efficiency. The reward for the energy service company consists of a fixed amount of money which will be paid every year. Although, a reduction penalty as well as a bonus can be imposed of the reduction is lower of higher than the guaranteed reduction. Figure 9.4 gives a schematic overview of the cash flow stream of the 'guaranteed saving' contract. The formulas (1,2) & (1,4) are used to calculate the reward for the ESCo and the advantage for the customer (colored bags). The formula (1,4) is elaborated in appendix 1.

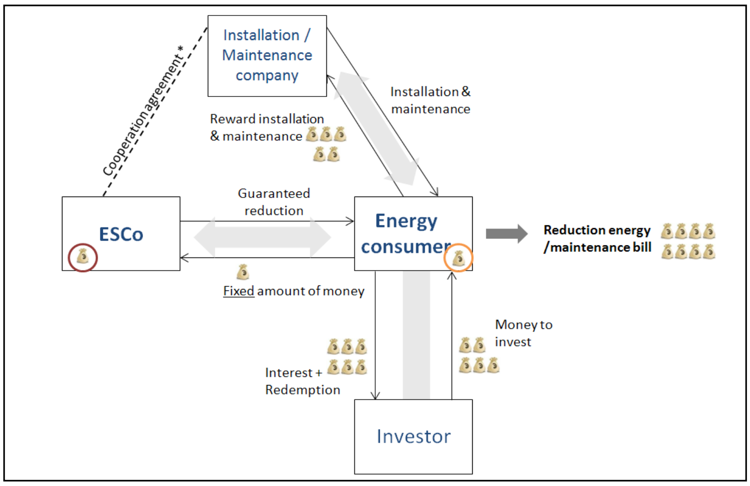


Figure 8.4: Schematic cash flow stream of the 'Guaranteed saving' contract

Reward ESCo

$$NPV = \sum_{i=1}^{n} Fixed\ reward - RP + RB \tag{1,4}$$

<u>'Variable saving' contract</u>

In this contract type, the customer instead of the ESCo will provides the capital. The reward for the energy service company consists of a fixed amount of money which will be paid every year. Although, a reduction penalty as well as a bonus can be imposed if the reduction is lower or higher than the guaranteed reduction. Figure 8.5 gives a schematic overview of the cash flow stream of the 'variable saving' contract. The formulas (1,2) & (1,5) are used to calculate the reward for the ESCo and the advantage for the customer (colored bags). The formula (1,5) is elaborated in appendix 1.

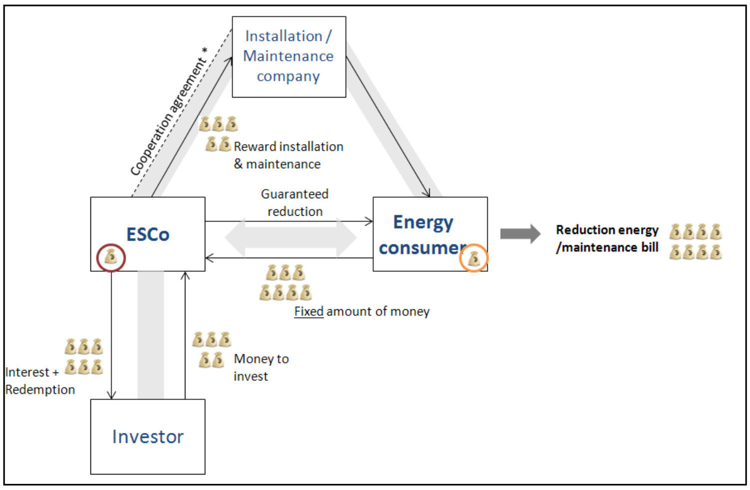


Figure 8.5: Schematic cash flow stream of the 'Variable saving' contract

Reward ESCo

$$NPV = -Investment + \sum_{i=1}^{n} \frac{fixed\ reward - RP + RB}{(1+i)^n} \qquad (1,5)$$

8.3 Risk management decision model

The risk management decision model is designed in the computer program Excel. Below the model is elaborated.

Dashboard 'front'

The first 'tab' of the model is a 'dashboard'. The 'dashboard' gives the energy performance contractor or the customer an analysis of both net present values i.e. how the 'win-win' situation is divided between both parties regarding different circumstances. The different variables, which are explained in previous chapters, along with their boundaries can be used to investigate the affect of variable changes to the 'win-win' (NPV) situation. Figure below shows a print screen of the 'front' dashboard.

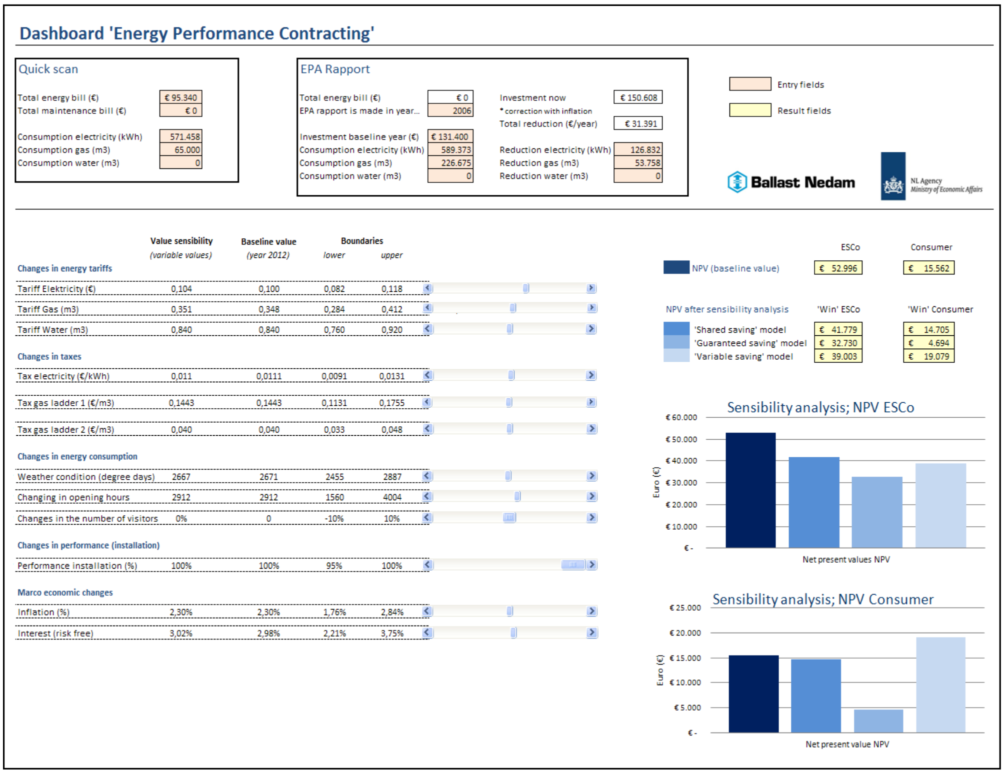


Figure 8.6: Print screen dashboard; risk management decision tool

EPA report

Specialized companies can perform an ‘Energie Prestatie Advies’. They analyze a particular building and investigate the possibilities to reduce the energy demand. In this rapport, the applicable measures, the expected investment costs, and the expected reduction are determined. These data forms the input for the reduction (reward) calculations.

EPA Rapport

Total energy bill (€)	€ 0	Investment now	€ 150.608
EPA rapport is made in year...	2006	* correction with inflation	
		Total reduction (€/year)	€ 31.391
Investment baseline year (€)	€ 131.400		
Consumption electricity (kWh)	589.373	Reduction electricity (kWh)	126.832
Consumption gas (m3)	226.675	Reduction gas (m3)	53.758
Consumption water (m3)	0	Reduction water (m3)	0

Figure 8.7: Print screen EPA rapport (Case study ‘Overschie’)

Quick scan [2]

If no EPA rapport is available, the model have the alternative to perform a quick scan. The current quick scan constitutes the result of 9 swimming accommodations. A complement to this method, in order to achieve a more reliable result, is to set up a database of realized projects (measures, investment, result). Infomil, a Dutch advisory board of the public sector, have tried to develop a certain database. The process of this project is hard but still in progress, municipalities are reticent in providing data (Interview: Infomil, Rullens, 2012). A database can approximate which investments have to be made in order to achieve a reduction of electricity, gas, and water. In addition, such a database can function as a quick scan. After the quick scan, there can still be decided to perform a ‘Energie Prestatie Advies’. The quick scan can may function as the first step in the process of energy efficiency. Appendix 5 gives an overview of the calculations which are used to determine the expected reduction and investment value.

Quick scan

Total energy bill (€/year)	€ 95.488
Total maintenance bill (€/year)	€ 0
Consumption electricity (kWh)	571.458
Consumption gas (m3)	65.000
Consumption water (m3)	0

Figure 8.8: Print screen Quick scan (Case study ‘De Smagtenbocht’)

Baseline values

As described in the model design, the start position is determined on the baseline values of year 2012. Three different contract types are included in the model. The different dependant variables react mutually different to the contract types. Figure 8.4 shows the ‘win’s’ for the customer as well as the ESCo.

	ESCo	Consumer
NPV (baseline value)	€ 32.259	€ 11.008
NPV after sensibility analysis	'Win' ESCo	'Win' Consumer
'Shared saving' model	€ 32.259	€ 11.008
'Guaranteed saving' model	€ 32.259	€ 11.008
'Variable saving' model	€ 32.259	€ 11.008

Figure 8.9: Print screen start position (Case study ‘De Smagtenbocht’)

[2] This way of calculating the investment value in order to achieve a certain reduction is very rough. Although, the ‘database’ can serve as a beginning of a well functioning and more reliable database. Putting more results (data) in the database gives you a better approximation of the investment and reduction. Also the size of the swimming accommodation, construction year, and other criteria could be taken into account.

Dashboard 'elaborated'

The second tab of the excel model constitutes of a elaborated dashboard. Some variables/ assumptions can be adjusted before the analysis. Figure below shows the print screen of the elaborated dashboard.

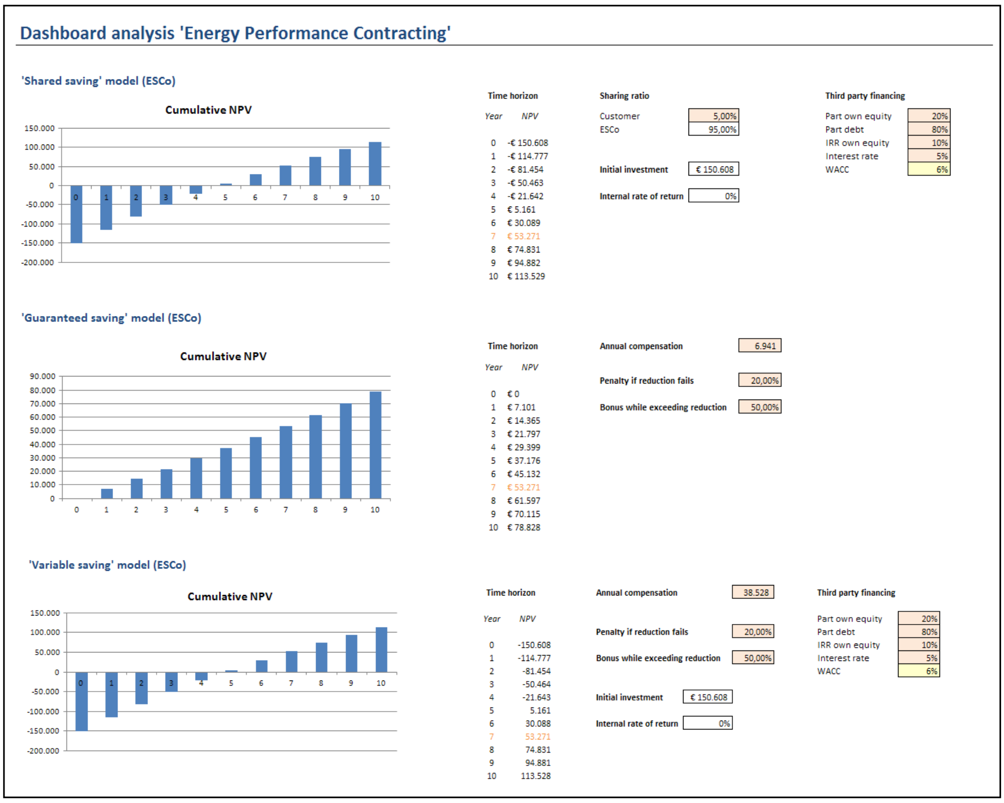


Figure 8.10: Print screen dashboard (elaborated); risk management decision tool (Case study 'Overschie')

<u>Time horizon</u>

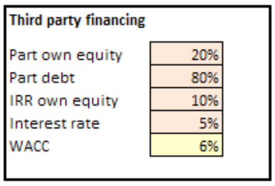
The time horizon is a parameter which will be fixed in the contract. This parameter can be adjusted before the analysis has been done. The average time horizon of the energy efficiency measures is 15 years (Lawrence Berkeley National Lab, 2005). The time horizon can be adjusted in order to achieve a feasible business case.

Time horizon	
Year	*NPV*
0	-€ 150.608
1	-€ 114.777
2	-€ 81.454
3	-€ 50.463
4	-€ 21.642
5	€ 5.161
6	€ 30.089
7	€ 53.271
8	€ 74.831
9	€ 94.882
10	€ 113.529

Figure 8.11: Print screen time horizon (Case study 'Overschie')

Third party financing – own equity versus debt financing

As discussed in chapter 7, third party financing is an important manner of financing the investment in energy efficiency measures. Although, participating with own equity could be a condition of the financial institution. However, participating with own equity can also function as financial leverage for the investment. This effect is only applicable if the yields are higher than the interest rate.



Third party financing	
Part own equity	20%
Part debt	80%
IRR own equity	10%
Interest rate	5%
WACC	6%

Figure 8.12: Print screen TPF (Case study 'Overschie')

Guaranteed reduction

The guaranteed reduction is determined on the basis of the baseline values in year 2012. The expected reduction is in this case the guaranteed reduction. However, the guaranteed reduction can be adjusted whereupon the 'Morris' and 'Monte Carlo' analysis can run again.

Reward variables

The reward variables are different in the three contract. The 'shared saving' contract assumes the percentage of the achieved reduction. The other contract assumes fixed rewards concerning a guaranteed reduction in accordance with reduction penalties or bonuses. The reward variables are used to synchronize the start position which is pointed out in previous paragraph.

Decision model

After determining the variable values on the dashboards of the model, the 'Morris and 'Monte Carlo' analysis can be done. A combination of both model techniques will create a decision table in which the revenues and risks are divided. The first step is choosing a contract type which fit the best between both parties. The second step analyzes the variables and put them in a table where the risks and rewards for both parties can be weighed. A combination between the risks and contract type answers the question; *'How will the 'win' of the achieved energy efficiency be divided by the customer and provider'?* Figure 9.12 gives a schematic overview of the risk management decision table.

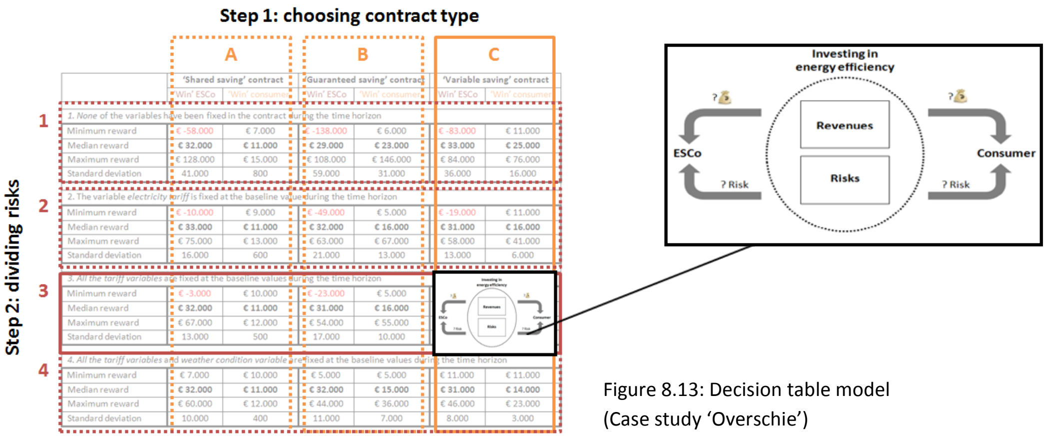


Figure 8.13: Decision table model (Case study 'Overschie')

8.4 Proactive attitude changes required

Behavior and attitude have an important position concerning an energy performance contract between provider (ESCo) and customer (consumer). The traditional way of contracting (tendering) does not assume mutual respect. The Customer is interested in a (financial) product to become more sustainable. The provider makes an offer to sell the product to the customer. The position of the customer (parent) towards the provider (child) is not equal and could lead to a natural reaction between both parties. The provider is (feels themselves) under the position of the customer, although the provider will use every moment to turn around this position. Energy performance contracts usually have a long time horizon, a parent-child relationship is therefore not desirable. Figures 9.14 structures the traditional way of collaboration between provider and customer (consumer). Nearby, the actuality gives also attention to new ways of collaboration (appendix 5).

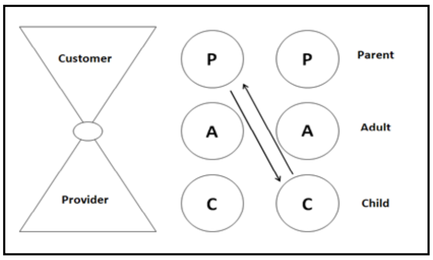


Figure 8.14a: Traditional way of collaboration (Maas & Eekelen,2004)

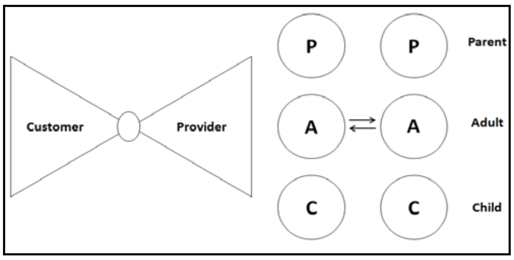


Figure 8.14b: Collaboration by equity (Maas & Eekelen, 2004)

8.5 Conclusion

The risk management decision model contains several parameters which have been determined in order to analyze the affect of the dependant variables. However, the values of the parameters can be adjusted after the dependant parameter analysis. The purpose of the model is to support the choices which have to be made in order to collaborate in the process of energy efficiency. The way of collaborating have an important position in achieving a 'sustainable' collaboration. Collaborating is part of the process, collaborating by equity have serious preference. The model has been applied to two existing swimming accommodations in the next chapters.

9. The model in practice - Case studies

9.1 Introduction

The risk management model will be applied to two existing swimming accommodations in the Netherlands. One swimming accommodation is privately owned, the other one public. The input values for the model are discussed first. Then the results (decision model) is described briefly.

9.2 Case study 'De Smagtenbocht'

Swimming accommodation (SA) 'De Smagtenbocht' is an existing SA in Bladel (Province Noord-Brabant, Netherlands). This SA is involved in an area development of the construction company 'Ballast Nedam Gebiedsontwikkeling'. The area development concerns a 'green' recreation area of eight acres. The purpose is, within this area development, to transform the SA into a (more) sustainable SA by adding energy efficiency. This case could be an example of collaboration between both private parties.

Input values

The energy bill constitutes the essential input to use the risk management decision model. The current tariffs which are paid by the owner of swimming accommodation 'De Smagtenbocht' are unknown. The energy bill is calculated on the basis of the current tariffs baseline year 2012 (Cbs, 2012). The consumption of water is unknown and thus not taken into account in this calculation. Tables below overview the input values.

Input values quick scan

Consumption electricity (kWh)	571.458
Consumption Gas (m^3)	65.000
Consumption water (m^3)	Unknown
Tariff electricity	Tariff 2012
Tariff gas	Tariff 2012
Tariff water	Tariff 2012
Energy bill (€)	95.488
Maintenance bill (€)	Unknown

Table 9.1: Input values SA 'De Smagtenbocht'

Input values dashboard 'elaborated'

	'Shared saving'	'Guaranteed saving'	'Variable saving'
Investment value (ESCo)	€ 227.000,-	€ 0,-	€ 227.000,-
Investment value (customer)	€ 0,-	€ 227.000,-	€ 0,-
Baseline Intern rate of return	10 %	10 %	10 %
Guaranteed reduction	-	30,4%	30,4%
Time horizon (years)	10,0	10,0	10,0
Reward (ESCO)	**97,50 %** of total savings	Fixed amount of € **2840**,- / year	Fixed amount of € **37.800**,- / year
Reward (customer)	**2,5 %** of total savings	Total savings /year € **36.760**,- / year	Total savings /year € **990**,- / year
Penalty if reduction is lower	-	20% + difference	20% + difference
Bonus when reduction is higher	-	50% of the exceeding	50% of the exceeding

Table 9.2: Input values dashboard 'elaborated'

'Morris' analysis

Swimming accommodation 'De Smagtenbocht' uses a remarkable high kWh of electricity and low m^{3}of gas. The 'Morris' analysis therefore shows that the tariff of electricity is the most sensible factors. However, most of the swimming accommodations show a sensible character regarding the variable 'tariff of gas'. The 'tax on electricity' is less more capricious than the 'tax on gas', the analysis shows therefore a relatively less sensibility to tax variables. Besides the tariff and tax on electricity, the 'weather condition' and 'tax on gas' variables are also important factors to look at in the 'Monte Carlo' analysis. Figure below shows the result of the 'Morris' analysis. The results are used to determine several scenario's in the decision

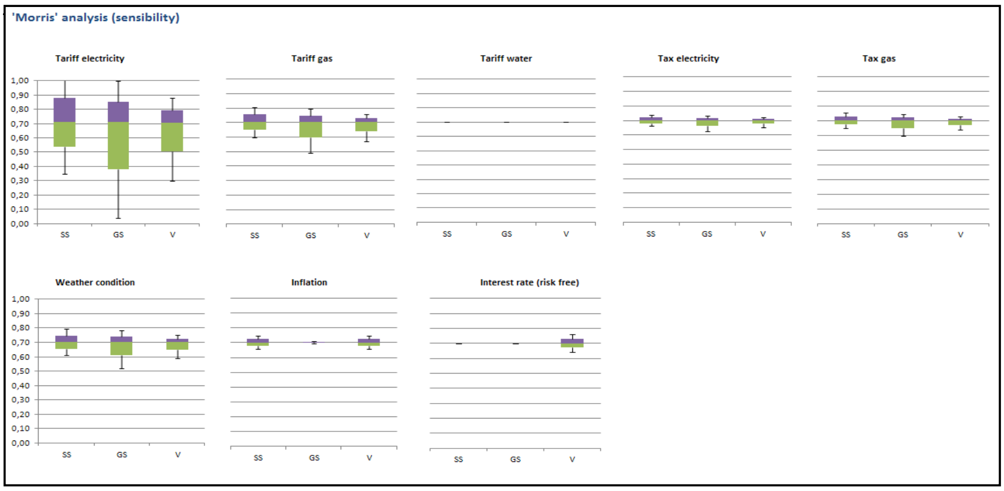


Figure 9.1: Print screen result 'Morris' analysis

Decision table; 'Monte Carlo' analysis

The 'Monte Carlo' analysis calculates the net present value on the basis of multiple trials (of the dependant variables). The first step is determining the contract type, which are presented as A, B and C. The factors which influence the contract choice are discussed in chapter 7. The party who is going to invest and has the willingness to give a guarantee are issues which have to be analyzed. The second step is analyzing the different contract options, which variables will be taken into account in the contract. The standard deviation indicates the risk of the reward, the minimum and maximum rewards are connected to this value. The combination between a letter and a number (black square) constitutes the business case for both parties. Which square will be chosen emanate from the negotiation between provider and customer. The output (histogram) of the 'Monte Carlo' (both business cases) analysis is pointed out in appendix 6.

		A		B		C	
		'Shared saving' contract		'Guaranteed saving' contract		'Variable saving' contract	
		'Win' ESCo	'Win' Customer	'Win' ESCo	'Win' Customer	'Win' ESCo	'Win' Customer
	1. *None* of the variables have been fixed in the contract during the time horizon						
1	Minimum reward	€ -58.000	€ 7.000	€ -138.000	€ 6.000	€ -83.000	€ 11.000
	Median reward	**€ 32.000**	**€ 11.000**	**€ 29.000**	**€ 23.000**	**€ 33.000**	**€ 25.000**
	Maximum reward	€ 128.000	€ 15.000	€ 108.000	€ 146.000	€ 84.000	€ 76.000
	Standard deviation	41.000	800	59.000	31.000	36.000	16.000
	2. The variable *electricity tariff* is fixed at the baseline value during the time horizon						
2	Minimum reward	€ -10.000	€ 9.000	€ -49.000	€ 5.000	€ -19.000	€ 11.000
	Median reward	**€ 33.000**	**€ 11.000**	**€ 32.000**	**€ 16.000**	**€ 31.000**	**€ 16.000**
	Maximum reward	€ 75.000	€ 13.000	€ 63.000	€ 67.000	€ 58.000	€ 41.000
	Standard deviation	16.000	600	21.000	13.000	13.000	6.000
	3. *All the tariff variables* are fixed at the baseline values during the time horizon						
3	Minimum reward	€ -3.000	€ 10.000	€ -23.000	€ 5.000	€ -4.000	€ 11.000
	Median reward	**€ 32.000**	**€ 11.000**	**€ 31.000**	**€ 16.000**	**€ 31.000**	**€ 15.000**
	Maximum reward	€ 67.000	€ 12.000	€ 54.000	€ 55.000	€ 51.000	€ 33.000
	Standard deviation	13.000	500	17.000	10.000	11.000	5.000
	4. *All the tariff variables* and *weather condition variable* are fixed at the baseline values during the time horizon						
4	Minimum reward	€ 7.000	€ 10.000	€ 5.000	€ 5.000	€ 11.000	€ 11.000
	Median reward	**€ 32.000**	**€ 11.000**	**€ 32.000**	**€ 15.000**	**€ 31.000**	**€ 14.000**
	Maximum reward	€ 60.000	€ 12.000	€ 44.000	€ 36.000	€ 46.000	€ 23.000
	Standard deviation	10.000	400	11.000	7.000	8.000	3.000

Table 9.3: Decision table 'Monte Carlo' analysis (Case study 'De Smagtenbocht')

9.3 Case study 'Overschie'

Swimming accommodation (SA) 'Overschie' is an existing SA in Zuid-Holland (Province South-Netherlands, Netherlands). The building is built in 1971 and is located in a living area. SA 'Overschie' has been used as calculation example for the EPA rapport. Meanwhile, the swimming accommodation is renovated and provided with many energy efficiency measures.

Input values EPA rapport

The 'Energie prestatie rapport' give a more reliable[2] overview of the saving potential of energy efficiency. The tariffs of the baseline year 2012 has been taken into account for calculating the reduction in money. The reduction of the water consumption was not included in the report and is thus not taken into account. Tables below overview the input values.

Consumption electricity (kWh)	589.373
Consumption Gas (m^3)	226.675
Consumption water (m^3)	Unknown
Investment reduction measures (€)	131.400
Expected reduction electricity (kWh)	126.832
Expected reduction gas (m^3)	53.758
Expected reduction water (m^3)	Unknown

Table 9.4: Input values SA 'Overschie'

Input values dashboard 'elaborated'

	'Shared saving'	'Guaranteed saving'	'Variable saving'
Investment value (ESCo)	€ 151.000,-	€ 0,-	€ 151.000,-
Investment value (Consumer)	€ 0,-	€ 151.000,-	€ 0,-
Baseline Intern rate of return	10 %	10 %	10 %
Guaranteed reduction	-	22,9%	22,9%
Time horizon (years)	7,0	7,0	7,0
Reward (ESCO)	**95,00 %** of total savings	Fixed amount of € **6940**,- / year	Fixed amount of € **35.500**,- / year
Reward (customer)	**5,0 %** of total savings	Total savings /year € **34.400**,- / year	Total savings /year € **2080**,- / year
Penalty if reduction is lower	-	20% + difference	20% + difference
Bonus when reduction is higher	-	50% of the exceeding	50% of the exceeding

Table 9.5: Input values dashboard 'elaborated'

'Morris' analysis

Swimming accommodation the 'Overschie' uses high amounts of gas and electricity. The tariff variables 'tariff of gas' and 'tax on gas' are sensible. The weather conditions influences the gas consumption, this is also an important factor to look at. Figure below shows the result of the 'Morris' analysis. The results are used to determine several scenario's in the decision table.

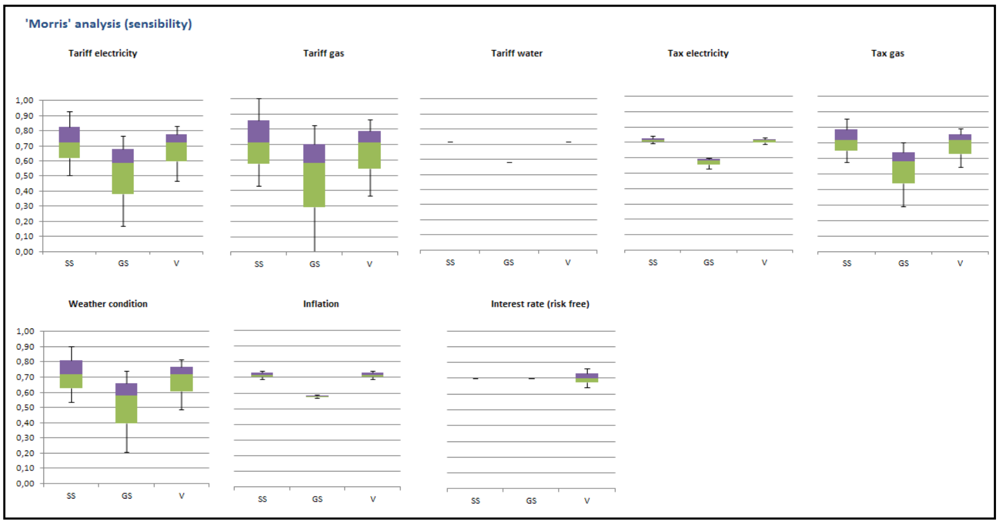


Figure 9.2: Print screen result 'Morris' analysis

Decision table; 'Monte Carlo' analysis

The 'Monte Carlo' analysis calculates the net present value on the basis of multiple trials (of the dependant variables). The first step is determining the contracts, which are presented as A, B and C. The factors which influence the contract choice are discussed in chapter 7. The party who is going to invest and has the willingness to give a guarantee regarding the height of the reduction are issues which have to be analyzed. The second step is analyzing the different contract options. The standard deviation indicated the risk of the reward, the minimum and maximum rewards are connected to this value. The combination between a letter and a number (black square) constitutes the business case for both parties. Which square will be chosen emanate from the negotiation between provider and consumer. The output (<u>histogram</u>) of the 'Monte Carlo' analysis is pointed out in appendix 6.

	A 'Shared saving' contract		B 'Guaranteed saving' contract		C 'Variable saving' contract	
	'Win' ESCo	'Win' Customer	'Win' ESCo	'Win' Customer	'Win' ESCo	'Win' Customer
1. *None* of the variables have been fixed in the contract during the time horizon						
Minimum reward	€ -114.000	€ 3.000	€ -222.000	€ -140.000	€ -147.000	€ 16.000
Median reward	**€ 55.000**	**€ 15.000**	**€ 44.000**	**€ 18.000**	**€ 52.000**	**€ 26.000**
Maximum reward	€ 214.000	€ 26.000	€ 160.000	€ 56.000	€ 132.000	€ 128.000
Standard deviation	63.000	5000	82.000	62.000	59.000	23.000
2. The variable *weather condition* is fixed and will be corrected during the time horizon						
Minimum reward	€ -75.000	€ 6.000	€ -171.000	€ -105.000	€ -147.000	€ 15.000
Median reward	**€ 48.000**	**€ 15.000**	**€ 43.000**	**€ 58.000**	**€ 55.000**	**€ 36.000**
Maximum reward	€ 186.000	€ 25.000	€ 144.000	€ 141.000	€ 124.000	€ 109.000
Standard deviation	58.000	4000	75.000	58.000	54.000	21.000
3. *All the tariff variables* are fixed at the baseline values during the time horizon						
Minimum reward	€ -14.000	€ 11.000	€ -68.000	€ -54.000	€ -30.000	€ 15.000
Median reward	**€ 54.000**	**€ 16.000**	**€ 54.000**	**€ 16.000**	**€ 53.000**	**€ 25.000**
Maximum reward	€ 120.000	€ 21.000	€ 101.000	€ 78.000	€ 90.000	€ 65.000
Standard deviation	27.000	1000	37.000	28.000	25.000	11.000
4.						
Minimum reward	€ 16.000	€ 13.000	€ -4.000	€ -18.000	€ 9.000	€ 15.000
Median reward	**€ 54.000**	**€ 16.000**	**€ 53.000**	**€ 15.000**	**€ 52.000**	**€ 22.000**
Maximum reward	€ 93.000	€ 18.000	€ 79.000	€ 50.000	€ 77.000	€ 40.000
Standard deviation	19.000	1000	24.000	18.000	17.000	6.000

Table 12.3: Decision table 'Monte Carlo' analysis (Case study 'Overschie')

9.4 Conclusion

The decision table which is created by the 'Morris' and 'Monte Carlo' analysis can be used to analyze both business cases regarding energy efficiency in the swimming accommodation 'De Smagtenbocht' and 'Overschie'. The quick scan gives you a rough estimation of the reduction and investment. To have a more reliable view, an EPA rapport have to be made. The decision tool support both parties in analyzing and dividing the benefits and risks.

10. Conclusions & Recommendations

Conclusions

- Energy efficiency in swimming accommodation have great potential

One of the greatest energy consumers in the built environment are swimming accommodations. Investing in energy efficiency can achieve 30% reduction of the energy bill. The total energy bill of municipal swimming accommodation is 400 million euro. A rather rough calculation gives a reduction of more than 100 million euro's. Great opportunities for swimming accommodations to reduce their energy bill.

- New business models regarding energy efficiency are required

An important Dutch expression is; 'onbekend maakt onbemind'. Many parties are unknown and have less knowledge regarding the possibilities of energy efficiency. Energy efficiency could save much money by the direct decrease of the energy bill. Besides the lack of knowledge concerning energy efficient, energy service companies are even unknown by many parties. If energy service companies are known, many parties are distrustful in collaboration with them. These distrustful is mainly caused by the information gap. Research and insights in new business models increase the awareness concerning energy efficiency.

- Energy performance contracting vehicle for energy efficiency

Energy performance contracting is an important vehicle in promoting energy efficiency within the built environment. Private parties are looking for new business opportunities to sell their products in the current 'difficult' market. Energy Customers become aware of the rising energy costs and the problem of global warming. Different barriers such as information and financial barriers refraining (in particular public) parties from investing in energy efficiency. Energy performance contracting could use some of these barriers for a feasible business model. Other barriers, such as the information barrier, should be solved either by other parties for instance governmental research agencies.

- Proactive attitude changes required at all relevant stakeholders

The way of collaborating has an important position in the implementation of energy efficiency in the built environment. Many parties are used to collaborate in the traditional way, this lead to collaboration structures such as turnkey' and 'brochure plan'. The traditional way of collaborating could contribute to the distrustful towards energy service companies. A consensus model (adult – adult) may increase the transparency which probably increase the trustfulness and efficiency of the collaboration.

Discussion
The model is a simplified reproduction of the reality. In the process of energy performance contracting, many stakeholders are involved. A very important stakeholder, which is not discussed so far, is the energy consumer. The energy consumer plays a crucial role in the success of energy efficiency in a particular building. The consumer will actually manage and influence the energy consumption of the building. Giving the consumer an incentive to perform well regarding energy efficiency is an important issue.

In addition, the model calculates the financial benefits and risks for both parties. Although, the comfort level for the customer is also a very important factor. Comfort agreements have to be made in the contractual document. The energy service company have to be excited to perform well concerning these comfort levels. Even if the comfort levels will be exceeded, the energy service company have to be rewarded or punished if the level will not be reached. Besides the implementation of energy efficiency on building level, it is interesting to look on larger scale. The production of renewable energy and the implementation of energy efficiency can only be successful on a larger scale. The development of 'Smart' cities plays a crucial role in this process. Other businesses such as 'smart' mobility is part of the concept of 'smart' cities.

Research question
The research question forms the basis for this thesis, finally a concise answer is given below.

> *'Is there an opportunity to create a risk management decision tool which can be used by the customer as well as the ESCo to get insights in the benefits and risk regarding energy performance contracting?'*

Energy performance contracting can definitely be a vehicle for energy efficiency in Dutch swimming accommodations. The barriers have to be removed in order to stimulate the implementation of the measures. The models do have a contribution in the gap energy efficiency in Dutch swimming accommodations by energy performance contracting. The purpose of the thesis is therefore achieved. Although, further research concerning this model and the subject of energy performance contracting is needed.

Future research model

The model gives you also the opportunity to 'play' with other variables. 8 variables are taken into account in the 'Morris' and 'Monte Carlo' analysis. Perhaps could other assumptions, such as the reduction penalty or bonus, be adjusted to achieve a better result. Adjusting these variables may lead to greater incentives to reduce. Many other variables can be modeled in order to achieve an 'optimal' result. Therefore the 'database' of realized projects could be extended. Besides the extension, other characteristics can be added to the quick scan in order to achieve a more precise result. This model can be a beginning in the promoting, distributing the (extended) model in the market might be the next step.

Glossary

<u>Energy service company</u>:	An energy service company (ESCo) is an external organization which is engaged in developing, installing, maintaining and possibly financing performance-based energy reduction projects during a fixed time horizon. The payment for the service company is based on the achievement of the energy efficiency improvement i.e. the decrease of the energy bill.
<u>Energy performance contracting</u>:	Energy performance contracting has been seen as the collaboration vehicle between the ESCo and Customer
<u>'Smart' Cities</u>:	Developed urban area which creates sustainable economic development and high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living, and government.
<u>Split incentive</u>:	The investor invests in energy efficiency, although cashes not direct the money from the reduction.
<u>Gross domestic product</u>:	Is the market value of all officially recognized final goods and services produced within a country in a given period of time.
<u>Net Present Value (NPV)</u>:	Is the sum of the present values (PVs) of the individual cash flows of the same entity.
<u>BAR</u>:	Method which is used in the real estate branch to calculate the investment worth on the basis of revenues.

NAR: Method which is used in the real estate branch to calculate the investment worth on the basis of revenues including the exploitation costs.

Std: The standard deviation shows how much variation of dispersion exists from the average.

Mean: Mean is in the statistics used as the average of the data points.

Median: The numerical value separating the higher half of a sample, a population, or a probability distribution, from the lower half.

SWOT analysis: A SWOT analysis or matrix is a structured planning method used to evaluate Strengths, Weaknesses, Opportunities, and Threats involved in a project or in a business venture.

Time horizon: The time horizon is the period when (mostly in years) when an agreement is arranged.

Histogram: A histogram is a graphical representation showing a visual impression of the distribution of data. It is an estimate of the probability distribution of a continuous variable

R square: The multiple correlation coefficient describes how well a regression line fits a set of data.

Green Deal: A national government agreement which support energy efficiency initiatives.

Management summary (English)

A RISK MANAGEMENT DECISION MODEL FOR PROMOTING ENERGY EFFICIENCY BY USING MONTE CARLO SIMULATION

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ABSTRACT
Many experts characterize the 21 century as an urban century. In light of the global population growth, that is expected to rise to more than 9 billion people in 2050, our planet faces huge challenges. A growing population will increase the global demand for energy. However, energy prices are expected to grow in the coming years. Hereby the awareness of global warming becomes more and more important, highlighting the relevance of investing in energy efficiency for the environment. However, many involved parties face an awareness, information and financial gap. Hence, business model innovation is required to overcome those problems. Transferring to an energy performance contracting business model can stimulate the promotion of energy efficiency. Changing attitude between customer and provider is important in the process of energy performance contracting. A risk management decision model has been developed in order to support the collaboration between customer and provider in the case of energy performance contracting. The model should fill in the awareness and information. The 'Morris' analysis is used to determine different scenario's. Additionally, 'Monte Carlo' analysis is used for modeling the risks and benefits for each contract. The only viable route to achieve a sustainable and livable society is the swift and massive scaling up of clean technologies combined with a fundamental shift to sustainable production and consumption patterns.

Keywords: energy efficiency, energy performance contracting, risk management, decision model, 'Morris' analysis, 'Monte Carlo' simulation.

INTRODUCTION

The increasing number of people on our planet, which will probably rise to more than 9 billion people in 2050, create huge challenges for global economies . The growing population will lead to an increase in the global energy demand (Climate Neutral Group, 2011). Besides the growing number of people, the awareness for climate changes becomes more and more important. The promotion of energy efficiency has different motives which are briefly pointed out below.

Demographical changes and global warming

Research showed that the global population will grow to more than 9 billion people in 2050 (Climate Neutral Group, 2011). This increase will mainly occur in urban areas; besides the increasing number of people, the expectation is that these people are mainly going to live in urban areas. Kenber stated that cities will be the main drivers in the worldwide energy transition.

'Cities are going to be in the forefront of driven the clean revolution forward' (Kenber, 2011).

Oil based economies

Nowadays, countries which own natural resources such as crude oil or gas are very wealthy and powerful. These resources are seen as the drivers behind our current economies, it can be stated that our current economies are oil based economies. The increase in energy prices is also based on the supply and demand balance of oil. A change from oil based to low carbon and oil independent cities and economies is the ideal situation. Scaling up the implementation of energy reduction measures can contribute to these situation. Thereby, many violent frictions in the world are partly based on oil dependency and interests of countries. Energy efficiency could also contribute to the relations between countries. Gandhi, the man who lead the Indian people to independency from British rule in 1947, wrote down some fundamentals for changing the world. One of his famous fundamentals is the following metaphor; *'You must be the change you want to see in the world'*.

Current economic situation Netherlands

The energy bill usually forms a small part of the total cost structure of companies. The priority to reduce the energy costs had been very low last years. The current economic situation has ensured the awareness for energy reduction. Many parties such as municipalities have the willingness to become more sustainable but have a lack of financial resources. Besides the financial aspect, there are other aspects such as knowledge and regulation which retain parties from investing in energy efficiency. Business model innovation contributes to these barriers for energy efficiency. Energy performance contracting is a rather unknown concept in the Netherlands but regularly used abroad. In this study, a risk management decision model is developed to support the collaboration between parties in the process of energy performance contracting.

BARRIERS ENERGY EFFICIENCY

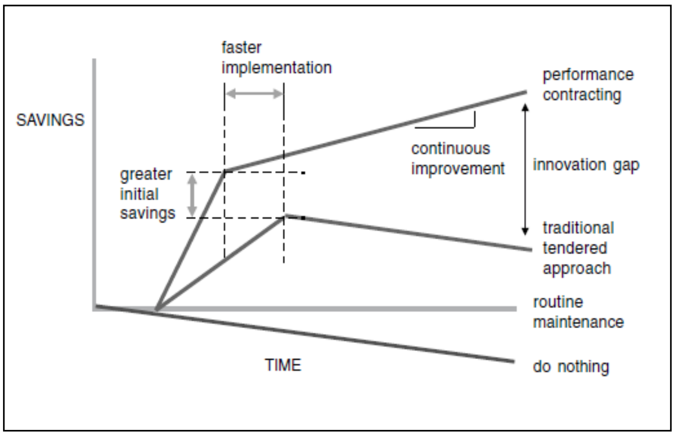
The current Dutch market has several barriers regarding the implementation of energy efficiency. The only viable route to achieve a 'sustainable' and 'livable' society is the swift and massive scaling up of clean technologies combined with a fundamental shift to sustainable production and consumption patterns. The current barriers in the Dutch market can be divided in four main groups; market and social barriers, information failures, regulatory barriers, and financial barriers. In the current weak economical situation, financial barriers restrain parties from investing in energy efficiency projects. The awareness for energy efficiency is growing these days, although the lack of resources creates some problem (ECN, 2012). The different barriers, which can be divided in the 4 main groups, are put in a SWOT matrix (strengths, weaknesses, opportunities, and threats).

Strengths - Reducing energy costs - Increasing comfort level - Opportunity financial benefits	***Weaknesses*** - Lack of awareness - Lack of financing options - Access to the capital market - The 'hassle' factor - Price distortion - Regulatory barriers
Opportunities - Hatch to price increases - Benefit opportunities - Contribution global issues	***Threats*** - Increasing exploitation costs (increasing price energy commodities

The weaknesses and threats regarding energy efficiency forms an opportunity or strength for energy service companies. Energy service companies create business models by using the weaknesses and threats concerning energy efficiency by the customer. Therefore, energy performance contracting can function as an important driver for energy efficiency.

CONCEPT OF ENERGY PERFORMANCE CONTRACTING

An energy service company (ESCo) is an external organization which is engaged in developing, installing, maintaining and possibly financing performance-based energy reduction projects during a fixed time horizon. The payments for the service company is based on the achievement of the energy efficiency improvement i.e. the decrease of the energy bill. Energy performance contracting is the contractual instrument which is provided by energy service companies. Energy performance contracting includes not just the implementation of measures but also the management and performance of the installation during a certain time horizon. Figure 1 provides a schematic overview of the concept of energy performance contracting.



Different contract types regarding Energy Performance Contracting

Energy performance contracting is a business model concept which can be set up in several ways. The two main contract types are the ‘shared saving’ contract and the ‘guaranteed saving’ contract. Besides these two main contract types, several variants are conceivable. Although, the main difference is the concept of dividing the benefits out of the contract. The ‘shared saving’, contract assumes a pre-fixed percentages of the result. The guaranteed saving contract assumes a guaranteed reduction, and a penalty and bonus malus scale.

MODEL DESIGN

The risk management decision model has the objective to get more insights in the benefits and risk regarding energy performance contracting. The baseline benefits for both parties are calculated based on the baseline values. The baseline values determine the customers energy bill for each year and thus represent the benefits for the energy service company as well as the customer. However, energy performance contracting contains a time horizon of several years. The baseline variables are certainly going to change during the contractual period. These variables affects the energy bill en thus the benefits (business models) for both parties. The reduction of the bill which can be achieved by energy performance can be calculated by using formula (1). The formula consists of the consumption and price component of gas, electricity, and gas. Also the governmental tax component and the reduction of the maintenance bill can be taken into account.

$$R_b = \left(C_g * P_g\right) + \left(C_e * P_e\right) + \left(C_w * P_w\right) + Tax + R_m \quad (1)$$

Changes in the dependant variables, which are part of formula 1 or influence the variables of formula 1, are the risks regarding energy performance contracting. These variables (risks) have to be taken into account in the contractual document. The benefits (expressed as the net present value) of the different contract are expressed by the formulas (2), (3), (4) and (5). Figures 1 and 2 gives a schematic overview of the structure of the model.

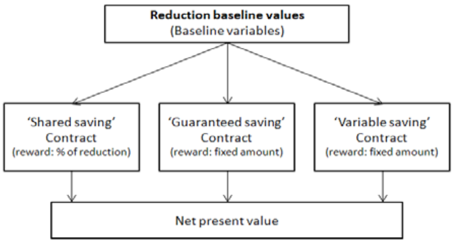


Figure 2a: baseline situation

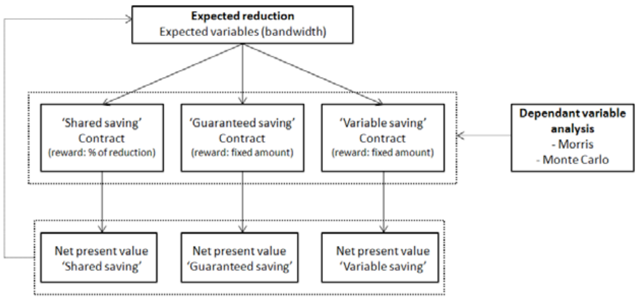


Figure 2b: concept of changing benefits

The formulas calculate the net present value (NPV) for the customer as well as the energy service company. The expresses the total reduction achieved by the investment in energy efficiency. The expresses the reduction penalty if the reduction is smaller than the guaranteed reduction. The expresses the bonus malus if the reduction is greater than the guaranteed reduction.

Formula: Benefit customer all contract types

$$NPV = \sum_{i=1}^{n} R_{total} - Reward_{ESCo} \quad (2)$$

Formula: Benefit 'Shared saving' contract (ESCo)

$$NPV = -Investment + \sum_{i=1}^{n} \frac{savings}{(1+i)^n} \tag{3}$$

Formula: Benefit 'Guaranteed saving' contract (ESCo)

$$NPV = \sum_{i=1}^{n} Fixed\ reward - RP + RB \tag{4}$$

Formula: Benefit 'Variable' contract (ESCo)

$$NPV = -Investment + \sum_{i=1}^{n} \frac{fixed\ reward - RP + RB}{(1+i)^n} \tag{5}$$

'Morris' analysis

The 'Morris' analysis is an example of an 'one-at-a-time' method. The 'one-at-a-time' method reviews the contribution of each variable in the benefits of each contract. The different variables will be varied one by one. The 'Morris' analysis indicates the sensitivity of different factors regarding energy efficiency projects. Constraining the most sensible factors in the contract will decrease the risks and the benefits, in addition for the energy service company. The different scenario's in the model are based on the 'Morris' analysis. Formula 6 is used for the 'Morris' analysis. The is the difference between the minimum and maximum value.

$$d_i(\underline{x}) = \frac{Y(x_1,\ldots,x_i + \Delta,\ldots x_k) - y(\underline{x})}{\Delta} \tag{6}$$

(Saltelli et al., 1999)

'Monte Carlo' analysis

The 'Monte Carlo' analysis is based on the generation of multiple trials (of the dependant variables) to determine the expected benefits for both parties. Nine different parameters are taken into account. The different parameters are; electricity tariff, gas tariff, water tariff, tax level electricity, tax level gas, outside temperature, inflation rate, and interest rate. A lower and upper boundary to these parameters are determined by a statistical analysis on the basis of existing data. Nine parameters including their boundaries form the input of the 'Monte Carlo' simulation. The simulation is used to determine the expected benefits (net present value) in the risk management decision model.

RISK MANAGEMENT DECISION MODEL

The risk management decision model is constructed in order to support the customer as well as the energy service company in dividing the risks and benefits regarding energy efficiency. In the process of energy performance contracting, different contracts types are used. In the most cases, the contract types are determined based on either the available resources or the preferences of the customer. Choosing the right contract type forms the first step in the management decision model. Although, the contract can also be chosen on the basis of the outcomes of 'Monte Carlo' analysis.

In general, energy commodities such as gas and electricity have a capricious price development. The price fluctuation affects the energy bill of real estate owners and users. An increasing trend is expected the coming years in energy prices (CBS, 2012). Furthermore, price (increase) and demand changes (caused by for instance the outside temperature) affect energy demand too. These changes will affect the benefits of energy efficiency during the agreed time horizon. Figure 3 shows the output of a case study, the case study is executed for a swimming accommodation in Den Hague, the Netherlands. In this case study, the 'variable saving' contract is used as example. The first scenario, expressed in the model by '1', is to put all the parameters (including the unpredictably of the variables) in the 'Monte Carlo' simulation. The simulation generates multiple trials and a simple statistical analysis calculates the expected benefits for both parties. Besides the expected benefits, the deviation represents the risk component. The second scenario, expressed in the model by '2', is determined on the basis of the 'Morris' analysis. The most sensible factor is constrained (in the contract) and the 'Monte Carlo' simulation generates again the expected benefits and risks. Repeating this process should lead to feasible business cases for both parties.

Step 1: choosing contract type

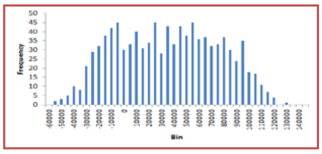
Step 2: dividing risks

		A		B		C	
		'Shared saving' contract		'Guaranteed saving' contract		'Variable saving' contract	
		'Win' ESCo	'Win' consumer	'Win' ESCo	'Win' consumer	'Win' ESCo	'Win' consumer
1	1. *None* of the variables have been fixed in the contract during the time horizon						
	Minimum reward	€ -58.000	€ 7.000	€ -138.000	€ 6.000	€ -83.000	€ 11.000
	Median reward	**€ 32.000**	**€ 11.000**	**€ 29.000**	**€ 23.000**	**€ 33.000**	**€ 25.000**
	Maximum reward	€ 128.000	€ 15.000	€ 108.000	€ 146.000	€ 84.000	€ 76.000
	Standard deviation	41.000	800	59.000	31.000	36.000	16.000
2	2. The variable *electricity tariff* is fixed at the baseline value during the time horizon						
	Minimum reward	€ -10.000	€ 9.000	€ -49.000	€ 5.000	€ -19.000	€ 11.000
	Median reward	**€ 33.000**	**€ 11.000**	**€ 32.000**	**€ 16.000**	**€ 31.000**	**€ 16.000**
	Maximum reward	€ 75.000	€ 13.000	€ 63.000	€ 67.000	€ 58.000	€ 41.000
	Standard deviation	16.000	600	21.000	13.000	13.000	6.000
3	3. *All the tariff variables* are fixed at the baseline values during the time horizon						
	Minimum reward	€ -3.000	€ 10.000	€ -23.000	€ 5.000	€ -4.000	€ 11.000
	Median reward	**€ 32.000**	**€ 11.000**	**€ 31.000**	**€ 16.000**	**€ 31.000**	**€ 15.000**
	Maximum reward	€ 67.000	€ 12.000	€ 54.000	€ 55.000	€ 51.000	€ 33.000
	Standard deviation	13.000	500	17.000	10.000	11.000	5.000
4	4. *All the tariff variables* and *weather condition variable* are fixed at the baseline values during the time horizon						
	Minimum reward	€ 7.000	€ 10.000	€ 5.000	€ 5.000	€ 11.000	€ 11.000
	Median reward	**€ 32.000**	**€ 11.000**	**€ 32.000**	**€ 15.000**	**€ 31.000**	**€ 14.000**
	Maximum reward	€ 60.000	€ 12.000	€ 44.000	€ 36.000	€ 46.000	€ 23.000
	Standard deviation	10.000	400	11.000	7.000	8.000	3.000

Figure 3: Output; risk management decision model

Contract and risk combination

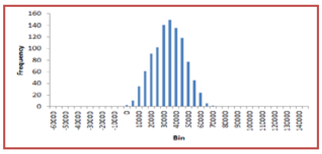
Model output; combination C1



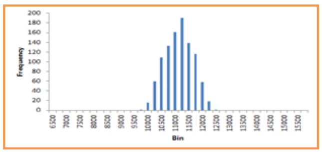
Benefits/risks ESCo

Benefits/risks Customer

Model output; combination C3



Benefits/risks ESCo



Benefits/risks Customer

The model generated for the 'Variable saving' contract illustrates the expected benefits for energy service company as well as for the customer. The risks concerns the probability of the deviation towards the mean of the multiple trials. The purpose is to find the optimal balance for both parties by constraining some variables in the model/contract. The model output C1 shows the expected benefits without constraining any variable in the contract. The model output C3 constrains the tariff variables. The vertical axis shows the trials, the horizontal axes shows the expected net present value of the contract.

CHANGING STAKEHOLDERS ATTITUDE

Only a theoretical model which calculates the business opportunities for investing in energy efficiency is not sufficient. Energy performance contracting is not just an agreement. Energy performance contracting connects involved stakeholders for several years. The mutual relationship between both parties is very important. Traditional tendering does not assume mutual relationship, the position of the customer and energy service company is not equal (Maas & Eekelen,2004). Natural reaction such as position changes during the process is not desirable. Changes stakeholder's attitude is a condition in the process of energy performance contracting.

CONLUSIONS

The only viable route to achieve a 'sustainable' and livable society is the swift and massive scaling up of clean technologies combined with a fundamental shift to sustainable production and consumption patterns. The introduction and implementation of 'smart' technology business model innovation is required within this process. Energy performance contracting is seen as an important vehicle in the promotion of energy efficiency. Energy performance contracting converts barriers into feasible business cases. The risk management decision model supports the customer as well as the energy service company in the process of energy performance contracting. However, proactive attitude of the stakeholders is crucial.

DISCUSSION

The model is a simplified reproduction of the reality. In the process of energy performance contracting, many stakeholders are involved. A very important stakeholder, which is not discussed so far, is the energy consumer. The energy consumer plays a crucial role in the success of energy efficiency in a particular building. The consumer will actually manage and influence the energy consumption of the building. Giving the consumer an incentive to perform well regarding energy efficiency is an important issue.

In addition, the model calculates the financial benefits and risks for both parties. Although, the comfort level for the customer is also a very important factor. Comfort agreements have to be made in the contractual document. The energy service company has to be excited to perform well concerning these comfort levels. Even if the comfort levels will be exceeded, the energy service company has to be rewarded or punished if the level is not reached. Besides the implementation of energy efficiency on building level, it is interesting to look on larger scale. The production of renewable energy and the implementation of energy efficiency can only be successful on a larger scale. The development of 'smart' cities plays a crucial role in this process. Other businesses such as 'smart' mobility is part of the concept of 'smart' cities.

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EEN RISICOMANAGEMENT BESLISMODEL VOOR DE PROMOTIE VAN ENERGIEBESPARENDE MAATREGLEN DOOR GEBRUIK TE MAKEN VAN MONTE CARLO SIMULATIE

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Afstudeer programma:

Construction Management & Engineering, 2012-2013

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INTRODUCTIE

De 21^{e} eeuw wordt door vele experts gezien als de eeuw van de urbanisatie. De wereldbevolking zal de komende decennia fors gaan toenemen, de verwachting is dat deze stijgt tot 9 miljard mensen in het jaar 2050 (Climate Neutral Group, 2011). Daarnaast zal er ook een toenemende trek ontstaan naar steden. Grote uitdagingen op verschillende vlakken liggen in het verschiet voor deze steden. Een van deze uitdaging ligt op het gebied van energiemanagement. De energievraag zal mede door de groeiende populatie gaan toenemen. Kenber schreef dan ook in zijn rapport; *'Cities are going to be in the forefront of driven the clean revolution forward'.*

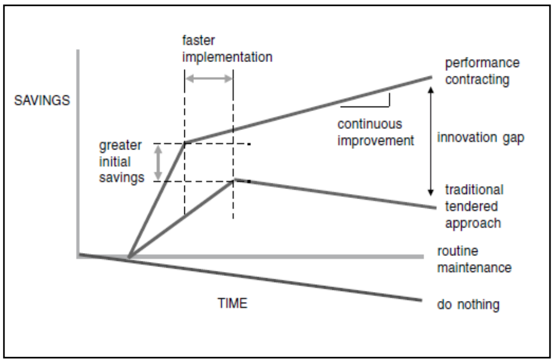
Een andere mondiale uitdaging is de opwarming van de aarde. Door verbranding van fossiele brandstoffen stijgt de concentratie van broeikasgassen in de atmosfeer. Ten gevolge van de stijging wordt de aarde langzaam opgewarmd wat grote gevolgen heeft voor mens en milieu. De belangrijkste energiebron op dit moment wordt gevormd door fossiele brandstoffen. Het verminderen van het energiegebruik en de implementatie van duurzame energiebronnen vormt de komende decennia een belangrijk doel de komende decennia. Investeren in duurzame energie is belangrijk voor een duurzame en leefbare samenleving de komende jaren.

BARRIERES NEDERLANDSE MARKT VOOR ENERGIE BESPARING

De bewustwording van de transitie naar duurzame energiebronnen begint zijn intrede te doen in de Nederlandse samenleving. Echter zijn er nog verschillende barrières in de markt die voor vele partijen de weg naar deze transitie moeilijk of onmogelijk maken. Het investerend vermogen is door de economische crisis afgenomen waardoor veel partijen niet de financiële middelen hebben. Echter de bewustwording van met name kostenbesparing door energiebesparende maatregelen is wel toegenomen. De verschillende barrières omtrent de implementatie van energiebesparende maatregelen kunnen worden verdeeld in 4 verschillende groepen; sociale & markt barrières, informatie barrières (gap), beleid barrières en als laatste de financiële barrière (ECN,2012). Innovatie in business modellen kan hierin een rol spelen. 'Energy Performance Contracting' is één van die innovaties die verscheidene barrières invult. Deze contractvorm (business model) is nog erg onbekend in Nederland, echter al wel op grote schaal toegepast in het buitenland. Een model dat inzicht geeft in de opbrengsten en risico voor de klant en aanbieder kan bijdragen aan de ontwikkeling van dit business model in Nederland.

ENERGY SERVICE COMPANIE (ESCO)

Een organisatie die voor partijen het gehele energiemanagement uit handen neemt wordt Energy Service Companies genoemd. Dit betekent dat de ontwikkeling van het energie management concept, de installatie, het onderhoud en vaak ook de financiering voor een bepaalde tijdsperiode wordt overgenomen. De initiële investering wordt vaak gedaan door de ESCo. Het terugverdienmodel van de ESCo is gekoppeld aan de prestaties die vervolgens worden geleverd. De verlaging van de energierekening vormt hierin het speerpunt. Het business model kan op verschillende manieren worden vormgegeven. Vele contractvormen worden wereldwijd gebruikt. In het model zijn de twee voornaamste contractvormen geïntegreerd; 'shared saving' & 'guaranteed saving' contract. De derde vorm is een combinatie van beide; 'variable saving' contract. Het 'shared saving' model gaat uit van een vergoeding op basis van een vast percentage van de reductie van de rekening. Het 'guaranteed saving' en 'variable saving' model gaat uit van een vooraf afgegeven garantie. Het voornaamste verschil tussen deze twee laatste contracten is wie de beste toegang heeft tot de kapitaalmarkt.



Figuur 1: Concept Energy Performance Contracting
(Energy Charter Secretariat, 2003)

MODEL DESIGN

Het ontwikkelde model heeft als doel meer inzicht te geven in de opbrengsten en risico's met betrekking tot energiebesparende maatregelen in de vorm van prestatiecontracten. De opbrengsten per contractvorm hebben dezelfde uitgangssituatie. Formule 1 geeft een overzicht hoe de energierekening is opgebouwd. De formule is opgebouwd uit een prijs en consumptieparameter van elektriciteit, gas en water. Daarnaast een belastingparameter en een onderhoudcomponent ten behoeve van de installaties.

$$R_b = (C_g * P_g) + (C_e * P_e) + (C_w * P_w) + Tax + R_m \qquad (1)$$

Omdat met energie prestatie contracten voor een lange tijd een overeenkomst wordt aangegaan, zullen de verschillende parameters zich niet constant gaan gedragen gedurende die periode. Deze prijsfluctuaties zullen invloed hebben op het business model van beide partijen (klant en ESCo). Het analyseren van de afhankelijke parameters met betrekking tot de formule 1 is daarom belangrijk. De 'Morris' analyse is gebruikt om gevoeligheid van verschillende variabelen te analyseren. Deze analyse wordt gebruikt om bepaalde scenario's te maken die vervolgens worden doorgerekend in de 'Monte Carlo' simulatie. De output van het model is de netto contante waarde (NCW) die voor beide partijen bereikt wordt door te investeren in energiebesparende maatregelen. De formules 2, 3, 4 en 5 vormen de basis voor de contractvormen.

Opbrengsten klant; alle contracttypes

$$NPV = \sum_{i=1}^{n} R_{total} - Reward_{ESCo} \qquad (2)$$

Opbrengsten ESCo 'Shared saving' contract

$$NPV = -Investment + \sum_{i=1}^{n} \frac{savings}{(1+i)^n} \qquad (3)$$

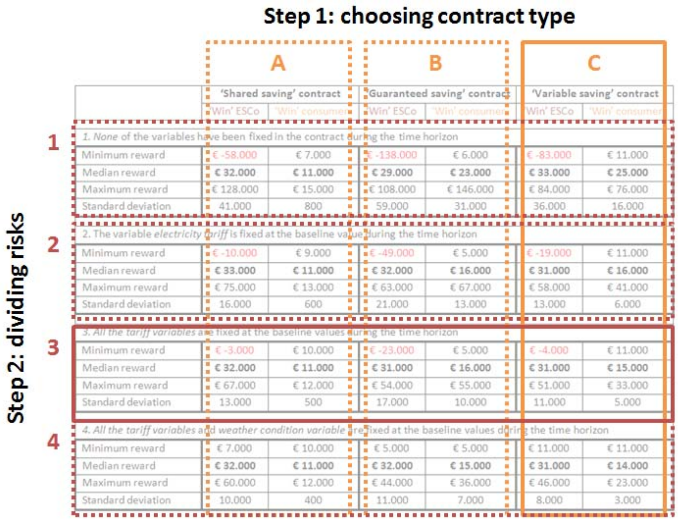
Opbrengsten ESCo 'Guaranteed saving' contract

$$NPV = \sum_{i=1}^{n} Fixed\ reward - RP + RB \qquad (4)$$

Opbrengsten ESCo 'Variable saving' contract

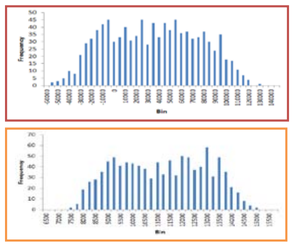
$$NPV = -Investment + \sum_{i=1}^{n} \frac{fixed\ reward - RP + RB}{(1+i)^n} \qquad (5)$$

BESLISMODEL
Het model dat zowel de klant als ESCo inzicht geeft in de opbrengsten en risico is gemaakt in het computerprogramma Excel. 9 verschillende parameters zijn meegenomen en worden geanalyseerd aan de hand van bovengenoemde methode. Zoals al eerder genoemd zijn er 3 verschillende contractvormen opgenomen in het model. Deze contractvormen worden aangegeven met de letters A, B en C. Het kiezen van de juiste contractvorm bij de bestaande situatie is dan ook vaak de eerste stap. De partij die de beste toegang heeft tot de kapitaalmarkten, behoefte tot gehele ontzorging zijn vragen die de contractvorm doen beïnvloeden. De tweede stap is het analyseren van de verschillende scenario's die worden geïnitieerd door de 'Morris' analyse. Beide partijen zullen streven naar twee haalbare business cases met de voorwaarde die mede aan de hand van het model wordt vastgesteld. Figuur 2 geeft een weergave van het beslissingsmodel. Hierin is een zwembad in Den Haag als rekenvoorbeeld genomen.

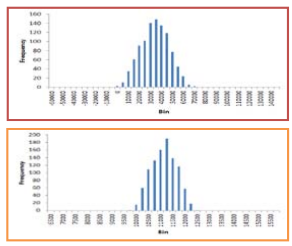


	A: 'Shared saving' contract		B: 'Guaranteed saving' contract		C: 'Variable saving' contract	
	'Win' ESCo	'Win' consumer	'Win' ESCo	'Win' consumer	'Win' ESCo	'Win' consumer
1. None of the variables have been fixed in the contract during the time horizon						
Minimum reward	€ -58.000	€ 7.000	€ -138.000	€ 6.000	€ -83.000	€ 11.000
Median reward	**€ 32.000**	**€ 11.000**	**€ 29.000**	**€ 23.000**	**€ 33.000**	**€ 25.000**
Maximum reward	€ 128.000	€ 15.000	€ 108.000	€ 146.000	€ 84.000	€ 76.000
Standard deviation	41.000	800	59.000	31.000	36.000	16.000
2. The variable *electricity tariff* is fixed at the baseline value during the time horizon						
Minimum reward	€ -10.000	€ 9.000	€ -49.000	€ 5.000	€ -19.000	€ 11.000
Median reward	**€ 33.000**	**€ 11.000**	**€ 32.000**	**€ 16.000**	**€ 31.000**	**€ 16.000**
Maximum reward	€ 75.000	€ 13.000	€ 63.000	€ 67.000	€ 58.000	€ 41.000
Standard deviation	16.000	600	21.000	13.000	13.000	6.000
3. All the tariff variables are fixed at the baseline values during the time horizon						
Minimum reward	€ -3.000	€ 10.000	€ -23.000	€ 5.000	€ -4.000	€ 11.000
Median reward	**€ 32.000**	**€ 11.000**	**€ 31.000**	**€ 16.000**	**€ 31.000**	**€ 15.000**
Maximum reward	€ 67.000	€ 12.000	€ 54.000	€ 55.000	€ 51.000	€ 33.000
Standard deviation	13.000	500	17.000	10.000	11.000	5.000
4. All the tariff variables and weather condition variable are fixed at the baseline values during the time horizon						
Minimum reward	€ 7.000	€ 10.000	€ 5.000	€ 5.000	€ 11.000	€ 11.000
Median reward	**€ 32.000**	**€ 11.000**	**€ 32.000**	**€ 15.000**	**€ 31.000**	**€ 14.000**
Maximum reward	€ 60.000	€ 12.000	€ 44.000	€ 36.000	€ 46.000	€ 23.000
Standard deviation	10.000	400	11.000	7.000	8.000	3.000

Figuur 2: Output; risk management beslismodel



Opbrengsten/risico ESCo – klant combinatie C1



Opbrengsten/risico ESCo – klant combinatie C3

In de output combinaties is goed te zien dat de spreiding en dus het risico van de opbrengsten afneemt. In de combinatie C1 worden alle fluctuaties van de variabelen meegenomen, vandaar de grote spreiding in de opbrengsten. In combinatie C3 zijn de prijzen voor elektriciteit en gas vastgelegd. Het risico van prijsfluctuaties op beide business cases is hierdoor weg. Opbrengst versus risico is voor beide partijen een belangrijk aspect. Nieuwe business modellen zullen ook de manier van samenwerken gaan veranderen. Het uitschrijven van tenders op de traditionele manier gaat niet meer werken. Het begrip samen aan een project werken voor langere tijd krijgt een nieuwe betekenis.

CONCLUSIE

De enige weg naar een duurzame samenleving is het op grote school implementeren van energie besparende maatregelen in combinatie met duurzame opwekking. Verschillende barrières omtrent de implementatie van energiebesparende maatregelen bevorderen de innovatie in nieuwe business modellen. Deze innovatie is wenselijk om tot het gewenste resultaat te komen. Energie prestatie contracten is een nieuw business model met betrekking tot energiebesparing dat zich aan het ontwikkelen is in de Nederlandse markt. Een risico management model geeft inzicht in de opbrengsten en risico's omtrent investeren in energiebesparende maatregelen. Echter zal het begrip samenwerken wel opnieuw gedefinieerd moeten worden om het tot een succes te maken.

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Sep – 2012;’ESCo’s en Energiebesparings bv’s’

Nov -2012; ‘De toekomst van het installatie bedrijf in de bouw’

Dec – 2012; discussion day concerning energy performance contracting, Organized by NSWV Helix and Johnson Controls

Appendix

Appendix 1: Model design

Reduction baseline value:

$$B_b = (C_g * P_g) + (C_e * P_e) + (C_w * P_w) + Tax + R_m{}^{A1} \tag{1.1}$$

B_b = energy bill baseline year 20XX (€)
C_g = consumption of gas in baseline year X (m^3)
P_g = price of gas baseline year X (€)
C_e = consumption of electricity baseline year X
P_e = price of electricity baseline year X (€)
C_w = consumption of water baseline year X
P_w = price of water baseline year X (€)
Tax = paid energy tax baseline year X
R_m [A1] = Reduction maintenance bill (€)

$$Tax = (C_g * T_g) + (C_e * T_e) + (C_w * P_w)$$

Tax = total amount of tax baseline year 20XX (€)
C_g = consumption of gas in year X
T_g = percentage x of tax over gas consumption (%)
C_e = consumption of electricity in year X
T_e = percentage x of tax over electricity consumption (%)
C_w = consumption of water in year X
T_w = percentage x of tax over water consumption (%)

$$R_m = (M_b * F_m)$$

R_m [A1] = The reduction of the maintenance bill of the swimming accommodation X (€)
M_b = Maintenance bill baseline year 20XX (€)
F_m = Reduction factor maintenance bill (%)

[A1] The reduction of the maintenance bill is in the most cases not taken into account. If the reduction of the maintenance bill by incurring an ESCo is included, the reduction can be used in the model.

Structure energy bill:

The revenues in the different contracts will be determined by the reduction of the energy (maintenance bill). The reduction of the energy bill (achieved reduction) is calculated by the difference between the 'old' and 'new' energy bill. The 'new' energy bill (achieved reduction) is the energy bill achieved during the agreed time horizon, this bill will be compared to 'old' bill (the baseline). The figure below shows a schematic overview of the reduction calculation.

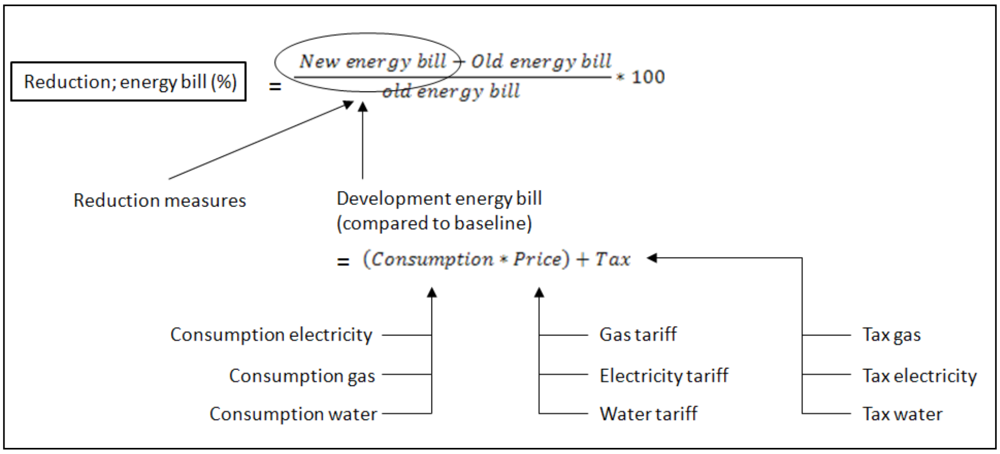


Figure A1.1: Structure energy bill

The uncertainties of the variables related to the energy reduction ('new' energy bill) can be divided into 4 main groups: changes in energy tariffs, changes in taxes, changes in energy consumption and changes in the performance of the reduction measures (installation). Besides the variables connected to the energy bill, macro economic variables also affect the rewards. The maintenance bill will only be corrected by the inflation (macro-economic variable). Other influences on the maintenance costs are not taken into account.

All contract types

Advantage energy Customer:

$$NPV = \sum_{i=1}^{n} R_{total} - Reward_{Customer} \qquad (1.2)$$

NPV = net present value for the energy Customer (€)
R_{total} = total reduction (€)
$Reward_{customer}$ = reward paid to the energy service company (€)

'Shared saving' contract

Reward energy service company:

$$NPV = -Investment + \sum_{i=1}^{n} \frac{savings}{(1+i)^n} \qquad (1.3)$$

NPV = net present value for the energy service company (€)
$-Investment$ = amount of money which is (will be) invested in energy reduction measures (€)
$Savings$ [A2] = amount of money which is (will be) saved from the energy and maintenance bill (€)
i = internal rate of return (%)
n = time horizon of contract (years)

$$savings = x_1((a_1 * C_g) + (b_1 * C_e) + (c_1 * C_w))$$

x_1 = pre-fixed reward percentage of the initial savings (%)
a_1 = gas reduction (%)
C_g = consumption of gas in year x
b_1 = electricity reduction (%)
C_e = consumption of electricity in year x
c_1 = water reduction (%)
C_w = consumption of water in year x

[A2] The savings will be corrected with an inflation factor of X (%)

<u>'Guaranteed saving' contract</u>

Reward energy service company:

$$\text{NPV} = \sum_{i=1}^{n} \text{Fixed reward} - \text{RP} + \text{RB} \qquad (1.4)$$

NPV = net present value (€)
Fixed reward[A3] = fixed amount of money as reward for the performance guarantee of x % of the energy & maintenance bill (€)
RP = reduction penalty (€)
RB = reduction bonus (€)
n = time horizon of contract (years)

Reduction penalty ESCo:

$$RP = If\ (AR < GR)\ than;\ fixed\ reward - (x_1(GR - AR))$$

RP = reduction penalty in (%)
AR = achieved reduction (%)
GR = guaranteed reduction (€)
Fixed reward[A3] = fixed amount of money as reward for the performance guarantee of x % of the energy & maintenance bill (€)
x_1 = penalty coefficient

Reduction bonus ESC:

$$RB = If\ (AR > GR)\ than;\ fixed\ reward + (x_2(AR - GR))$$

RB = reduction bonus (€)
AR = achieved reduction (%)
GR = guaranteed reduction (%)
Fixed reward[A3] = fixed amount of money as reward for the performance guarantee of x % of the energy & maintenance bill (€)
x_2 = bonus coefficient

[A3] The savings will be corrected with an inflation factor of X (%)

'Variable saving' contract

Reward energy service company:

$$NPV = -Investment + \sum_{i=1}^{n} \frac{fixed\,reward - RP + RB}{(1+i)^n} \tag{1.5}$$

NPV = net present value (€)
$-Investment$ = amount of money which is (will be) invested in energy reduction measures (€)
Fixed reward[A4] = fixed amount of money as reward for the performance guarantee of x % of the energy & maintenance bill (€)
i = internal rate of return (%)
n = time horizon of contract (years)

Reduction penalty ESCo

$$RP = If\ (AR < GR)\ than;\ fixed\,reward - (x_1(GR - AR))$$

RP = Reduction penalty (%)
AR = Achieved reduction (%)
GR = Guaranteed reduction (€)
Fixed reward[A4] = fixed amount of money as reward for the performance guarantee of x % of the energy & maintenance bill (€)
x_1 = penalty coefficient

Reduction bonus ESCo

$$RP = If\ (AR < GR)\ than;\ fixed\,reward - (x_1(GR - AR))$$

RP = Reduction penalty (%)
AR = Achieved reduction (%)
GR = Guaranteed reduction (€)
Fixed reward[A4] = fixed amount of money as reward for the performance guarantee of x % of the energy & maintenance bill (€)
x_1 = penalty coefficient

Reduction bonus ESCo

$$RB = If\ (AR > GR) than;\ fixed\,reward + (x_2(AR - GR))$$

RB = reduction bonus (€)
AR = Achieved reduction (%)
GR = Guaranteed reduction (%)
Fixed reward[A4] = fixed amount of money as reward for the performance guarantee of x % of the energy & maintenance bill (€)
x_2 = bonus coefficient

[A4] The savings will be corrected with an inflation factor of X (%)

Appendix 2: Model design

Dependant variables

Tariff electricity

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Index electricity (CBS, 2012)	84,9	90,4	88	100	128,8	134,7	150,7	138,2	132,1	132,9	132,2
Index to **baseline** year	61,43	65,41	63,68	72,36	93,20	97,47	109,04	100	95,59	96,16	95,66
Tariff electricity €/kWh	0,064	0,068	0,066	0,075	0,097	0,101	0,113	0,104	0,099	0,100	0,100

Table A2.1: Fluctuations electricity tariff (CBS, 2012)

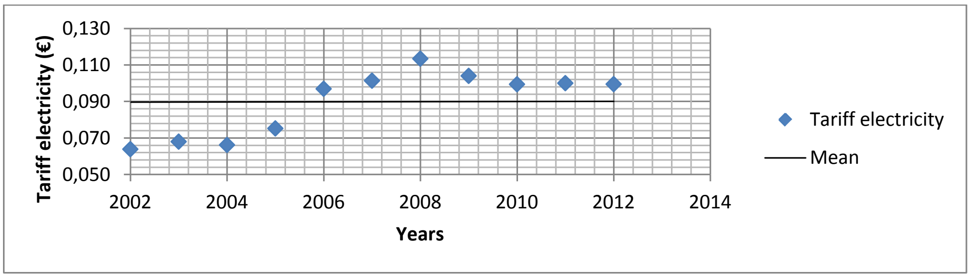


Figure A2.1: Scatter plot electricity tariff

Mean electricity (µ)	0,090
Standard deviation (ծ)	0,018
Lower boundary	**0,082**
Upper boundary	**0,118**

Table A2.2: Variable information electricity

Tariff gas

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Index gas (CBS, 2012)	75,8	82	79,9	100	126,1	127,9	154,9	118,3	111,1	132,3	146,6
Index to **baseline** year	64,07	69,32	67,54	84,53	106,59	108,11	130,94	100,00	93,91	111,83	123,92
Tariff gas €/m^3	0,1800	0,1948	0,1898	0,2375	0,2995	0,3038	0,3679	0,2810	0,2639	0,3143	0,3482

Table A2.2: Fluctuations gas tariff (CBS, 2012)

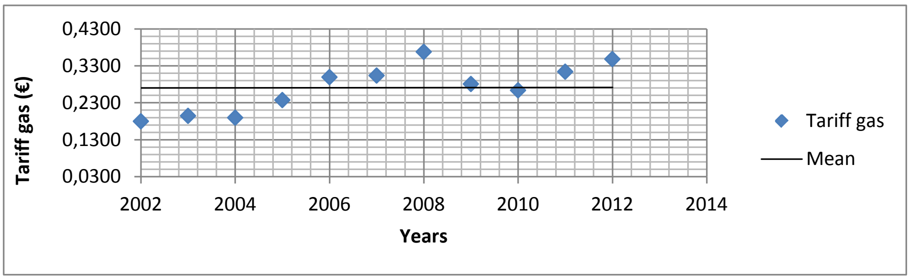


Figure A2.2: Scatter plot gas tariff

Mean electricity (µ)	0,271
Standard deviation(ð)	0,064
Lower boundary	**0,284**
Upper boundary	**0,412**

Table A2.3: Variable information gas

Tariff water

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Tariff water €/m^3 (CBS,2012)	1	1,07	1,13	1,13	1,11	1,08	1,05	1,06	1,07	1,05	0,84

Table A2.4: Fluctuations water tariff (CBS, 2012)

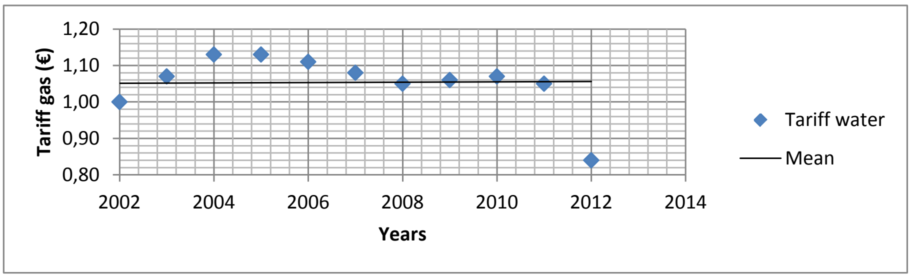


Figure A2.3: Scatter plot water tariff

Mean electricity (µ)	1,054
Standard deviation (ð)	0,080
Lower boundary	**0,760**
Upper boundary	**0,920**

Table A2.5: Variable information water

Tax on electricity

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Tax electricity €/kWh (CBS,2012)	0,0061	0,0063	0,0065	0,0086	0,0094	0,0102	0,0104	0,0106	0,0108	0,0109	0,0111

Table A2.6: Fluctuations electricity tax (CBS, 2012)

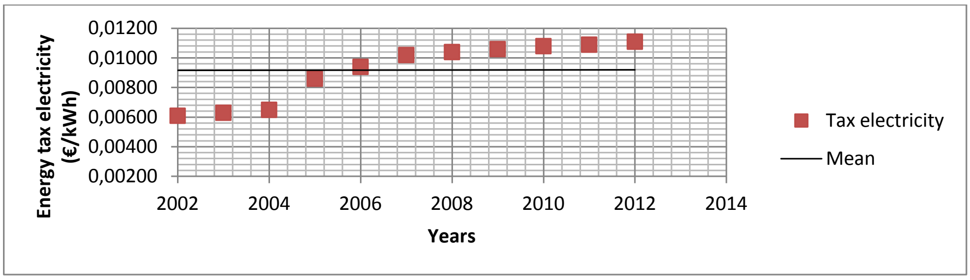


Figure A2.4: Scatter plot tax on electricity

Mean electricity (μ)	0,00917
Standard deviation (ð)	0,00198
Lower boundary	**0,0091**
Upper boundary	**0,0131**

Table A2.7: Variable information tax electricity

Tax on gas

Ladders energy tax 2009	
Electricity (kWh)	Tariff (€)
0 - 10.000 kWh	0,1140
10.000 - 50.000 kWh	0,0415
50.000 - 10.000.000 kWh	0,0111
Gas (m³)	Tariff (€)
0 - 5.000 m³	0,1667
5.000 - 170.000 m³	0,0400
> 170.000 m³	0,0083

Table A2.8: Tax ladder (Rijksoverheid, 2012)

Tax on gas(low and high consumption)

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Consumption 5.000 – 170.000 €/m3	0,0685	0,0710	0,0727	0,1019	0,1238	0,1342	0,1362	0,1385	0,1411	0,1419	0,1443
Consumption 170.000 – 1.000.000 €/m3	0,0213	0,0221	0,0227	0,0311	0,0340	0,0372	0,0378	0,0384	0,0391	0,0393	0,0400

Table A2.9: Fluctuations gas tax (CBS, 2012)

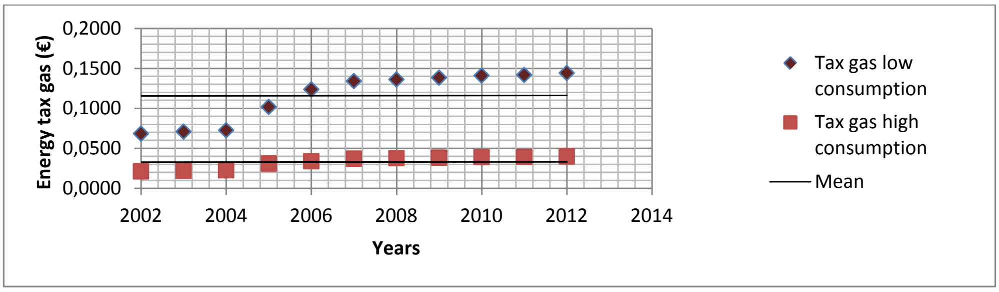


Figure A2.5: Scatter plot tax on gas

Consumption 5.000 - 170.000 €/m3	
Mean electricity (µ)	0,1158
Standard deviation(ð)	0,0312
Lower boundary	**0,1131**
Upper boundary	**0,1755**

Table A2.10: Variable information tax gas (low

Consumption 170.000 - 1.000.000 €/m3	
Mean electricity (µ)	0,0330
Standard deviation (ð)	0,0075
Lower boundary	**0,033**
Upper boundary	**0,048**

Table A2.11: Variable information tax gas (high consumption)

Tax on water and the purify charge

The project of Rotterdam (benchmark) shows that the amount of money paid for water tax and purify charge are negligible. These two variables will not been taken into account in the analysis.

Changes in energy consumption

Degree days

Year	Degree days
2002	2710
2003	2913
2004	2871
2005	2765
2006	2671
2007	2530
2008	2785
2009	2804
2010	3321
2011	2622

Table A2.12: Degree days, the Bilt (Netherlands) (KNMI, 2012)

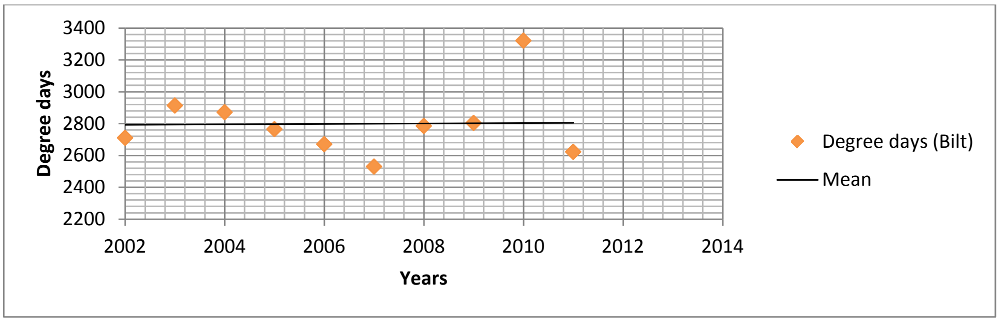


Figure A2.6: Scatter plot degree days

Mean Degree days (µ)	2799
Standard deviation (ð)	216
Lower boundary	**2455**
Upper boundary	**2887**

Table A2.13: Variable information degree days

The changes in gas consumption can be calculated with the following formula:

$$Change_{cg} = (0{,}8 * C_g) * (\frac{Degree\ days\ boundary}{Degree\ days\ baseline}) \qquad (2{,}1)$$

$Change_{ce}$	= Change of gas consumption by change of the weather conditions
C_g	= Total gas consumption baseline year
$Degree\ days\ boundary$	= Degree days of the lower and upper boundary
$Degree\ days\ baseline$	= Degree days of the baseline year
Opening hours	

$$Change_{ce} = (0{,}7 * C_e) * \left(\frac{Openinghours\ adjusted}{Opening\ hours\ baseline}\right) \quad (2,2)$$

$Change_{ce}$	= Change electricity consumption by changing the opening hours
C_e	= Total electricity consumption baseline year
$Openinghours\ adjusted$	= Average amount of opening hours over n years after baseline year
$Opening\ hours\ baseline$	= Total amount of opening hours in the baseline year

Number of visitors

$$Change_{cg} = (0{,}2 * C_g) * \left(\frac{Number\ of\ visitors\ adjusted}{Numer\ of\ visitors\ baseline}\right) \quad (2,3a)$$

$Change_{cg}$	= Change gas consumption by change in number of visitors
C_g	= Total gas consumption
$Number\ of\ visitors\ adjusted$	= Average number of visitors over n years after baseline year
$Numer\ of\ visitors\ baseline$	= Total number of visitors in the baseline year

$$Change_{cw} = (0{,}8 * C_w) * \left(\frac{Number\ of\ visitors\ adjusted}{Numer\ of\ visitors\ baseline}\right) \quad (2,3b)$$

$Change_{cw}$	= Change water consumption by change in number of visitors
C_w	= Total water consumption
$Number\ of\ visitors\ adjusted$	= Average number of visitors over n years after baseline year
$Numer\ of\ visitors\ baseline$	= Total number of visitors in the baseline year

Marco economic changes

Inflation

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Inflation (CBS, 2012)	2,40%	2,10%	1,20%	1,70%	1,10%	1,60%	2,50%	1,20%	1,30%	2,30%	2,30%

Table A2.14: Fluctuations inflation (CBS, 2012)

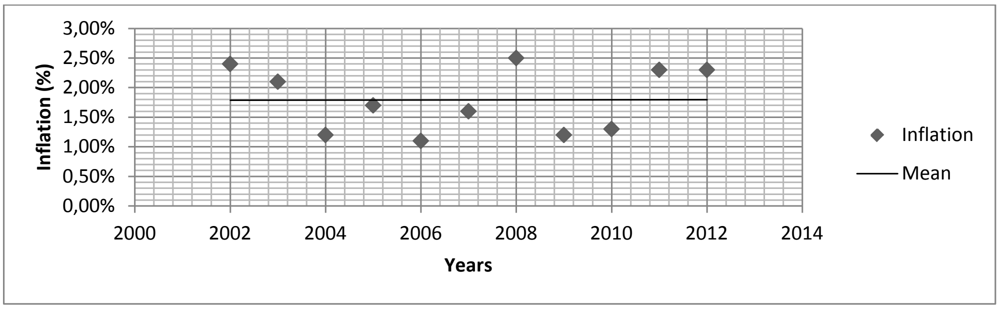


Figure A2.7: Scatter plot inflation

Mean inflation (μ)	1,79%
Standard deviation (ð)	0,54%
Lower boundary	**1,76%**
Upper boundary	**2,84%**

Table A2.15: Variable information inflation

Interest rate

$$IRR = i_{rf} + R_i + R_r \quad (2,4)$$

(Hordijk, 2009)

IRR = internal rate of return of the project
i_{rf} = risk free interest rate (Dutch bonds)
R_i = inflation rate
R_r = risk rate (general, category, specific)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Risk free interest rate (DNB, 2012)	5,41	4,96	4,89	4,12	4,09	3,37	3,78	4,29	4,23	3,68	2,98	2,98

Table A2.16: Fluctuations Dutch bonds interest rate (DNB, 2012)

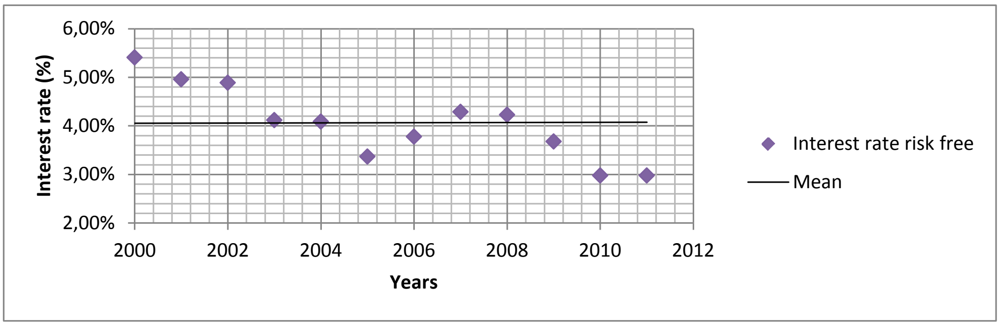


Figure A2.8: Scatter plot interest rate risk

Mean electricity (µ)	4,07
Standard deviation (ð)	0,77
Lower boundary	**2,21%**
Upper boundary	**3,75%**

Table A2.17: Variable information risk free interest rate

Appendix 3: Model design

'Morris' analysis

$$\Delta = \frac{1}{p-1} \tag{3.1}$$

(Saltelli et al., 1999)

Δ = Difference between the minimum and maximum value
p = Dimension of the range

If the different values are rescaled, the range of each variable can be calculated with the following equation.

$$d_i(\underline{x}) = \frac{Y(x_1, \dots, x_i + \Delta, \dots x_k) - y(\underline{x})}{\Delta} \tag{3.2}$$

(Saltelli et al., 1999)

$d_i(\underline{x})$ = Value of range; between [0,1]
Y = Random variable; net present value of the reduction
x_1 = Dependant variables
Δ = Difference between the minimum and maximum value

'Monte Carlo' analysis

The 'Monte Carlo' analysis will be applied in the spreadsheet program excel. The random trials will be calculated with the following equation.

$$Random\ Trial = Random\ (\ ) * (B_u - B_l) + B_l \tag{3.3}$$

B_u = Upper boundary each dependant variable
B_l = Lower boundary each dependant variable

The Morris analysis does not pay attention to the interaction (correlation) between the variables, the Monte Carlo analysis does. In the variable analysis, the correlation between the variables has been investigated. In the Monte Carlo analysis, these correlation will be included.

Appendix 4: Dependant variable analysis / methodology

Drie energiereuzen verlagen hun prijzen

ARTIKEL | REACTIES | BEWAAR

Door: redactie
18-10-12 - 08:15 bron: AD

'Dat gaat echt euro's schelen'

© ANP.

UPDATE De grote energiebedrijven verlagen hun prijzen per 1 januari 2013. Bij Eneco levert dit een gemiddeld gezin een besparing op van zo'n 80 euro per jaar. De meevaller zit hem met name in een lagere gasprijs. De andere twee energiereuzen, Nuon en Essent, zullen hun prijzen ook verlagen. Dat meldt het AD.

Nuon komt pas volgende week met definitieve tarieven voor 2013, maar zegt dat de gasprijs net als bij Eneco behoorlijk omlaag gaat. Bovendien verlaagt Nuon de stroomprijs. Ook Essent zegt uit te gaan van een daling van de energienota.

Figure A4.1: Article decrease energy prices
(Algemeen Nederlands Persbureau, 2012)

Appendix 5: Risk management decision tool

Quick scan [A5]*:*

9 swimming accommodations in Rotterdam have been become more sustainable with the aim to achieve the sustainability objectives. The construction company, who won the tender, started in 2009 with the proceedings. The data below is available and can be used to approximate the investment and reduction of a swimming accommodation X.

- Total energy consumption before reduction of 1.19 mln €/year
- Investment in reduction measures of 1.60 mln € in baseline year

- Average achieved reduction: gas 43%/year, electricity 24%/year, water 9%/year
- Reduction of the energy bill with 32,75%
- Reduction of the maintenance bill with 15,0% a year

(Strukton, 2012) (Gemeente Rotterdam, 2010)

The following assumption is made regarding to the investment in energy reduction measures (database realized projects):

$$Ratio_I = \frac{C_X}{Cb} \qquad (5.1)$$

$Ratio_I$ = Investment ratio
C_X = Total energy consumption (€)
Cb = Total energy consumption database (€)

$$I_x = Ratio_I * I_b \qquad (5.2)$$

I_x = Investment swimming accommodation X to achieve the energy reduction (€)
$Ratio_I$ = Investment ratio
I_b = Investment value database (€)

[A5] This way of calculating the investment value in order to achieve a certain reduction is very rough. Although, the 'database' can serve as a beginning of a well functioning and more reliable database. Putting more results (data) in the database gives you a better approximation of the investment and reduction. Also the size of the swimming accommodation, construction year, and other criteria could be taken into account.

Model in practice

zaterdag 2 februari 2013 **Eindhovens Dagblad**

Economie | 21

TECHNOLOGIE Overheden gaan onvoldoende mee in nieuwe servicemodellen voor verlichting

Philips wil andere aanbestedingen

Verouderde inkoopregels bij overheden zijn een sta-in-de-weg voor nieuwe, duurzame exploitatie van openbare verlichting. Philips-topman bepleit modernisering.

door **Henk van Weert**
e-mail: **h.vanweert@ed.nl**

EINDHOVEN - Overheden houden de snelle ontwikkeling van technologie niet bij. Ze werken met verouderde inkoopregels en exploitatievormen. Die gaan nog te veel uit van een vaste aanschafprijs, waarna de kosten van exploitatie voor rekening van de nieuwe eigenaar komen. Ook de Europese aanbestedingsregels sluiten niet aan bij de moderne businessmodellen die de industrie aan het invoeren is. Dat houdt verduurzaming tegen, vindt Philips.

Philips-topman Frans van Houten pleit daarom voor aanpassing van aanbestedingen en inkoopregels bij de overheden. Hij deed dit onlangs op het World Economic Forum in Davos.

Een goed voorbeeld is vernieuwing van stadsverlichting. Overheden gaan er nog te veel vanuit dat die nieuwe verlichting tegen een zo laag mogelijke, vaste prijs aangekocht wordt. Dat betekent dat ze met piekinvesteringen te maken krijgen. In deze tijd is dat voor veel gemeenten moeilijk.

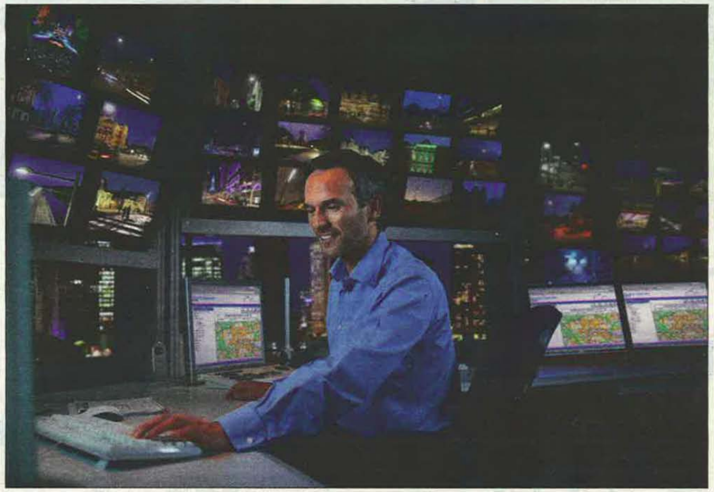
Het is volgens Philips helemaal niet nodig om zo'n flink bedrag ineens op tafel te leggen. Voor stadsverlichting ontwikkelde Philips Lighting vorig jaar City Touch, een benadering waarin stadsverlichting niet langer een product is, maar een service. Philips installeert de nieuwe led-verlichting, controleert en regelt die vanuit een Philips-centrale en onderhoudt het systeem. Alles verloopt via internet. De gemeente wordt geen eigenaar, maar betaalt periodiek een vast bedrag voor de service.

Deze benadering vergt wel een andere manier van denken, vindt Van Houten. Overheden moeten grenzen slechten om mee te gaan in zulke innovatieve exploitatiemodellen. Maar ze laten zich nog te veel leiden door angst voor het onbekende. „En verouderde inkoopregels die zijn gericht op zo laag mogelijke initiële aankoopkosten."

Volgens Philips kunnen overheden snel besparingen realiseren op de kosten van openbare verlichting, als ze meegaan in de nieuwe aanpak.

Led-stadsverlichting vergt veel minder elektriciteit dan conventionele straatverlichting. Uit die besparingen kan al een flink deel van de servicekosten betaald worden, redeneert Philips. „Als je samen aan tafel gaat zitten blijkt vaak dat er heel veel mogelijk is", zegt Van Houten.

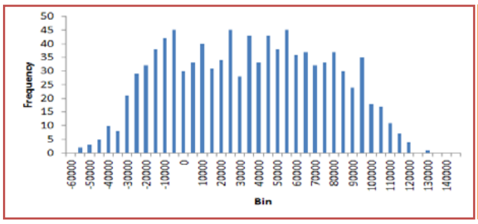
Overigens is hij niet de enige die met dit pleidooi gekomen is. Burgemeester Rob van Gijzel van Eindhoven kaartte dit onlangs ook aan bij Eurocommissaris Johannes Hahn van regionaal beleid. Hij pleitte voor een aanpassing van de Brusselse aanbestedingsregels aan de nieuwe mogelijkheden die de technologie biedt.

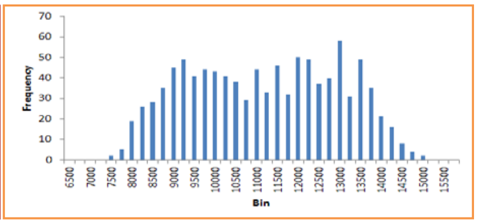


Vanuit een controlekamer van Philips wordt straatverlichting bediend. foto **Rens van Mierlo**

Appendix 6: Case study 'De Smagtenbocht' *'shared saving' model*

A1





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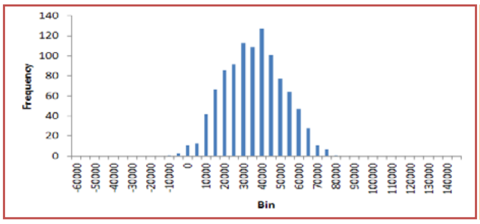

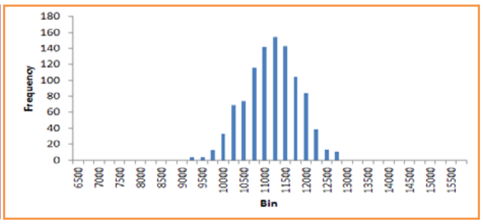

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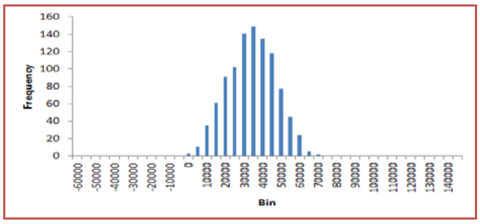

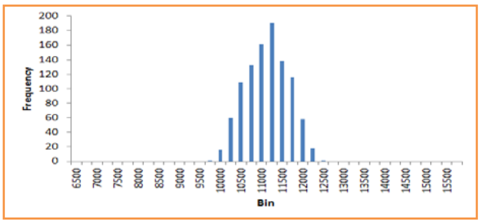

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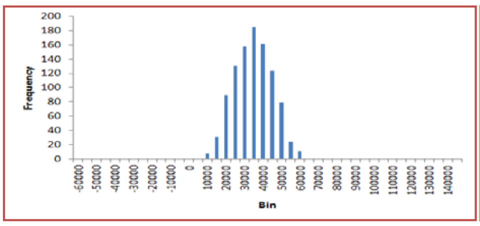

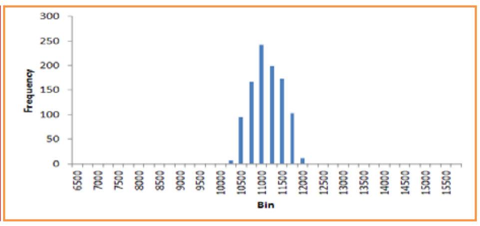

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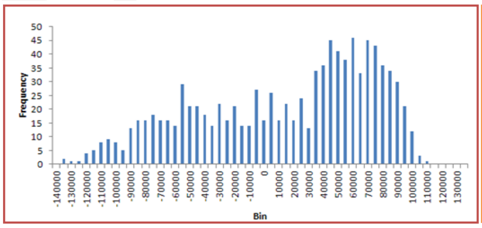
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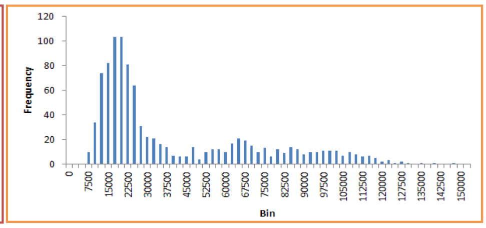
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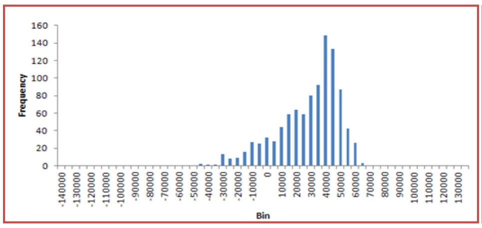
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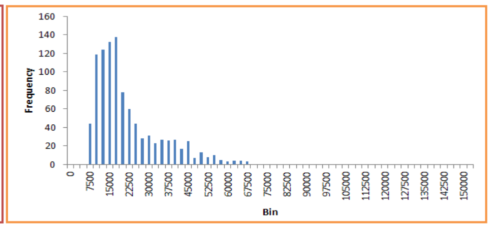
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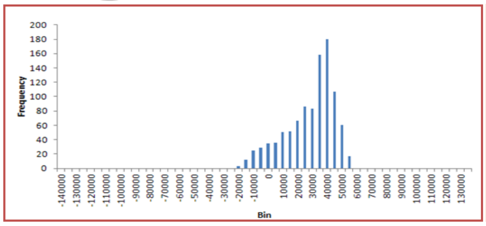
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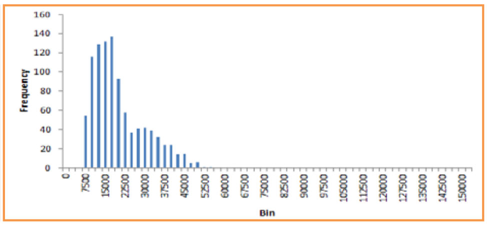
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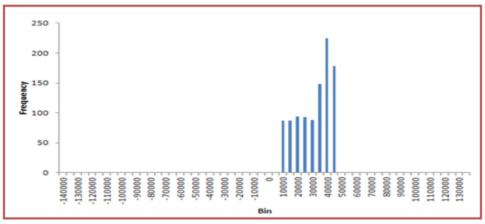
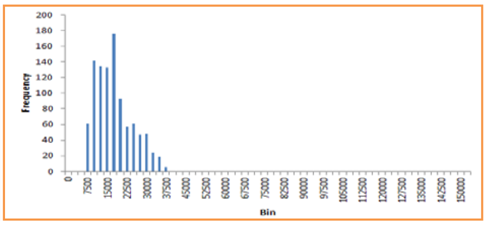

Frequency
Bin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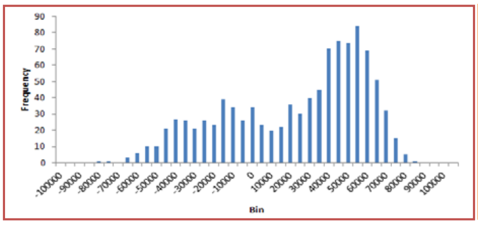
C1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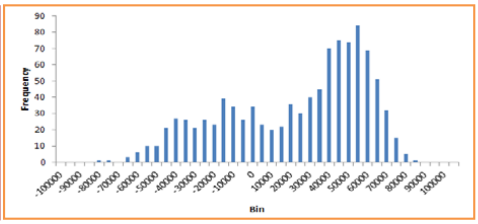
Frequency
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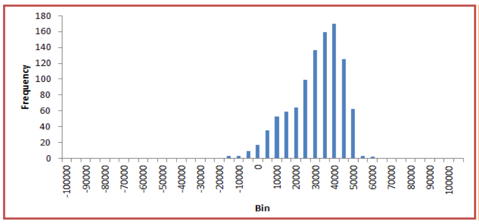
C2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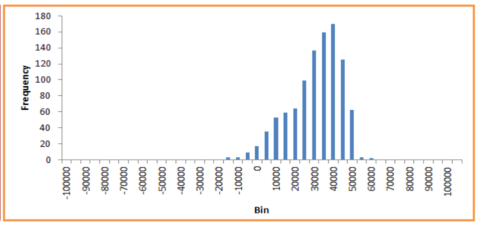
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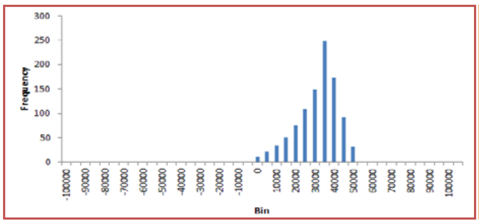
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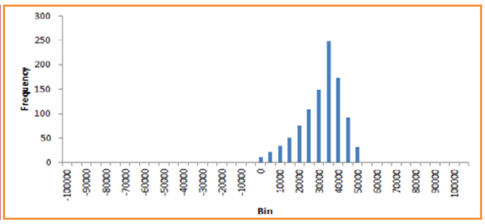
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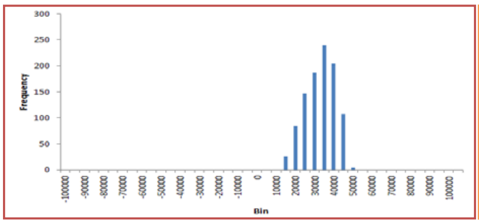
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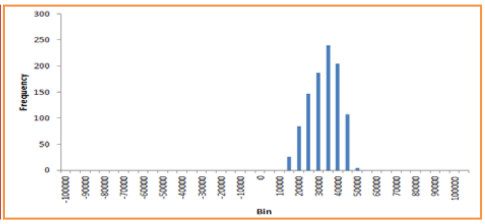
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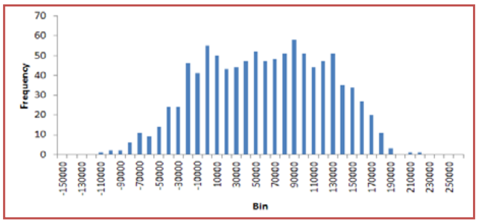
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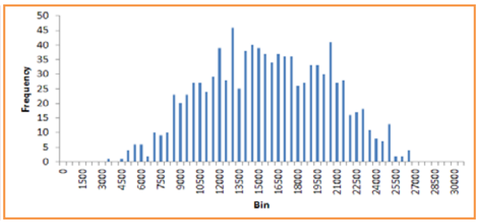
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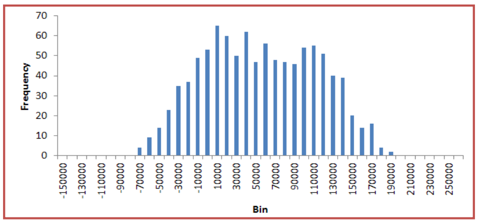
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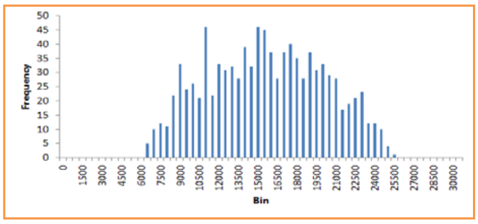
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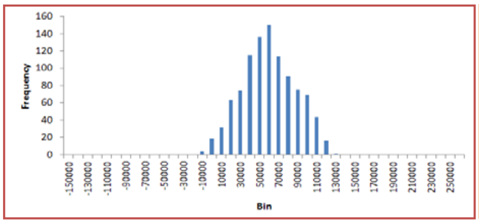
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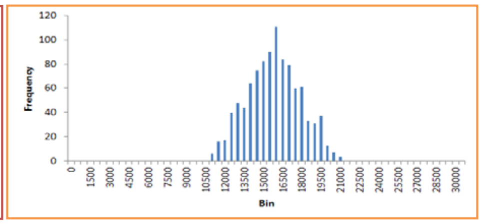
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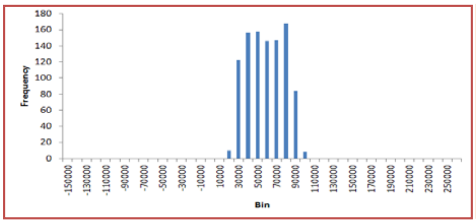
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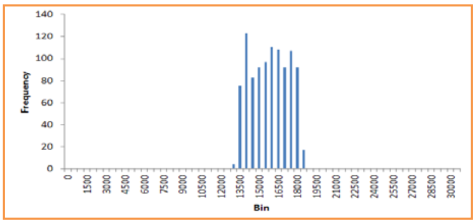
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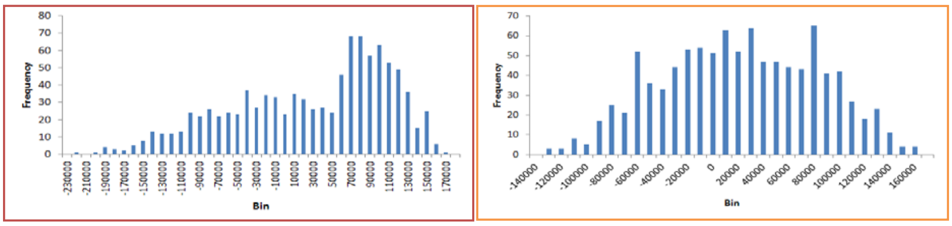
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Frequency
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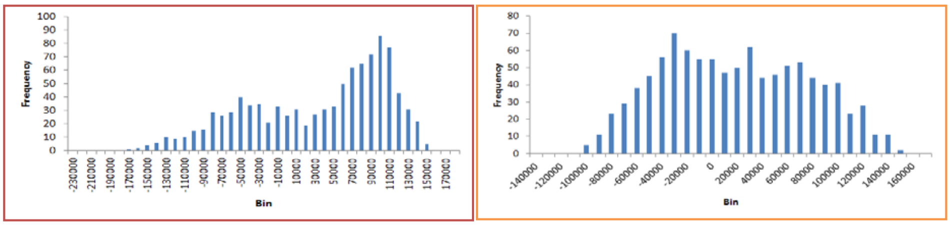
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Frequency
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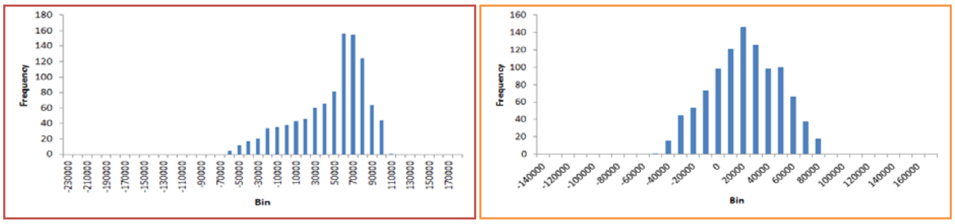
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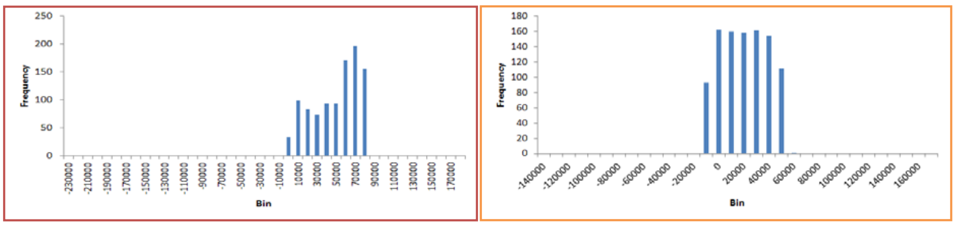
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Frequency
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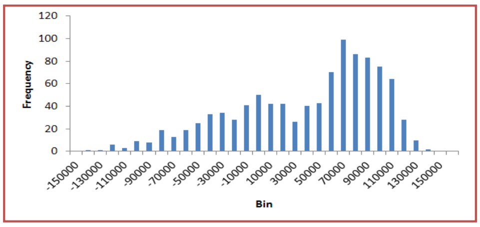
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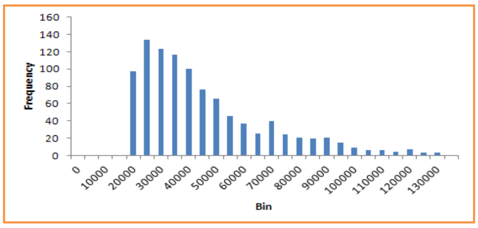
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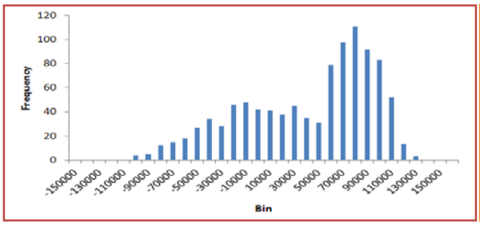
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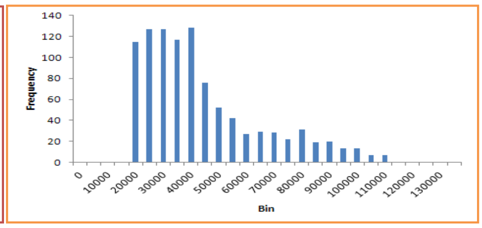
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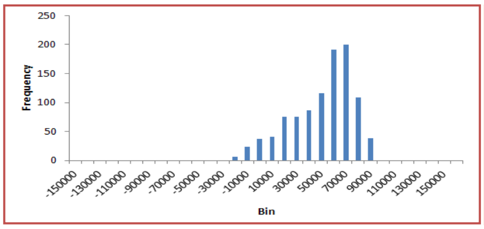
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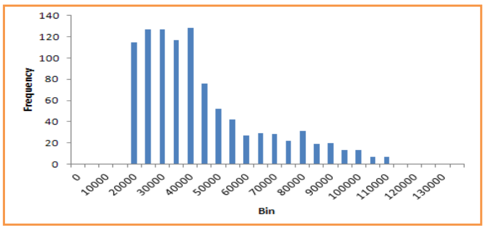
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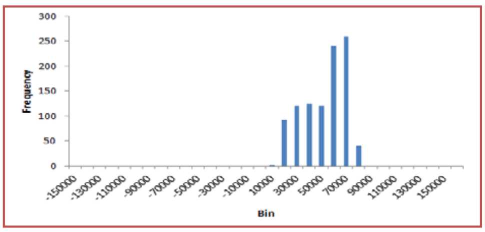
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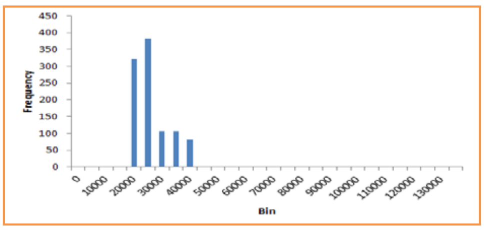
Frequency
Bin

Appendix 8: Additional used formulas

Standard deviation (Std)

$$Sd = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n_x}}$$

Sd = Standard deviation of the included variables
x_i = Variable x
$\bar{x}$ = Average of the included variables
n_x = x number of variables which are included

Mean

$$\bar{x} = \frac{\sum X_i}{n}$$

$\bar{x}$ = Average of the included variables
x_i = Variable x
n = Number of variables