Exploring energy neutral development

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EXPLORING ENERGY NEUTRAL DEVELOPMENT
Part 3

TU/e
2012/2013

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Contents

INTRODUCTION

KenW^{2}iB$_{rabant}$ is based upon cooperation between governmental organizations, university and entrepreneurial companies. The program started in September 2009 as the KENWIB project and with just a slightly different name in terms of **KenW^{2}iB$_{rabant}$** the program has been re-established in 2012 and financial supported for a period of two years by the Province of Noord Brabant and by the 'Smart Energy Regions – Brabant' program of the EEI at Eindhoven University of Technology.

During the period of September 2012 till August 2013, 31 Master of Science graduation students in the interdisciplinary field of building - and management sciences worked on assignments, relevant for sustainable and energy neutral (re-)development urban districts. Basically their projects were all dealing with implementation of innovative technology into complex urban environments. Business cases, scenario's and decision support modeling are features of these studies. The individual students were connected to a wide variety of stakeholders and as final graduates they have not only developed knowledge and understanding of this subject, but they also have become a group of 'ambassadors' representing the ideas of sustainable and energy neutral developments.

The summaries of each of these graduation project reports are presented in this book. Already this is the third summary book. The first and second summary books contain respectively the report summaries of the periods of 2010 – 2011 and 2011 – 2012. The reports are also all free to download from the site www.kenwib.nl and are grouped according to the following keywords: dwellings, buildings, mobility, city models and 'special items'.

The societal relevance of these studies has not been changed during the last couple of years: Parallel to the ongoing climate discussions, the need for the establishment of a sustainable economy becomes emphatic recognizable. The idea for a circular economy is widely supported, but the puzzles related to this 'policy' are hard to solve. The setting up of a regional, national sustainable economy, which is in substance no more or no less dependent on consumptive use of raw materials and fossil fuels, will directly contribute to achieving global peace and security situations.

Even the still ongoing financial crises and the perception of shrinkage are challenging us: A world wide economy model, based upon growth, growing consumption and growing financial wealth is questioned. To that end, there are constantly debates conducting in different sectors of society, business circles and public institutions such as schools and universities. The topics include issues such as recycling of materials, and sustainable energy and sustainable water use.

The Appendix holds the report of an international study trip to England. Also two workshops were organized by the **KenW^{2}iB$_{rabant}$** program during this period. November 1st, 2012, the workshop 'The Future the Building Services Branches' was realized and February 28th, 2013, 'the Future of Sustainable Development of Eindhoven'.

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SUMMARIES

PRESERVATION OF THE EXISTING HOUSING STOCK OF HOUSING ASSOCIATIONS

A case study for Woonbedrijf about organization models for implementation

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ABSTRACT:

In the next fifteen years, some major changes will take place in the global energy field driven by increasing energy demand and declining stocks of fossil fuels. These developments will lead to further increasing energy prices causing a new situation called energy poverty where households are no longer able to pay their energy costs. Housing associations feel more and more responsible for the total housing expenses of their tenants, but are subject to a complex legal framework. The aim of this paper is to formulate an advice on which housing association Woonbedrijf from Eindhoven can practically implement an energy preservation concept in their pilot project the Airey neighbourhood. A literature study combined with a financial model and AHP analysis are used to select the best organization model. The results showed that the organization structure where the tenants collectively participate in an energy cooperative is the most preferred alternative.

Keywords: preservation, housing association, PV, organization models, AHP, financial model

INTRODUCTION

In the next fifteen years, some major changes will take place in the global energy field driven by two major developments. First, worldwide energy demand continues to rise especially because of the economical growth in the (former) developing countries. And second, the stocks of fossil fuels are declining rapidly whereby a large part of the remaining stock is located in politically unstable countries (Weevers, 2012).

These developments will lead to further increasing energy prices since an increase in demand from emerging economies and simultaneously decreasing stocks stimulate a market driven rise of prices. In the past years, the energy costs for households have risen considerably. Only electricity prices already rose annually with an average of 5,2% over the past 10 years (Agentschap NL, 2012). The rising energy prices are mainly responsible for the increasing housing costs (rent/mortgage + energy expenses) of households where especially low-income households suffer from it. This triggers a new situation called *energy poverty* where households are no longer able to pay their energy costs. According to NIBUD (2009)

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one particular group of the population is most at risk namely, households with a disposable income in the bottom 20% of incomes in the Netherlands and less educated people.

These types of households form the target group of housing associations in the Netherlands. The main task of housing associations is to build, manage and rent social housing and social real estate. In the view of the rising energy costs, housing associations feel more and more responsible for the total housing expenses of their tenants. A possible strategy to fight these rising energy costs is to generate energy from renewable sources in order to create immunity for the constantly rising prices. This is not easy for housing associations because investments in renewable energy are often expensive and the constantly changing legal framework raises more questions than answers. Housing associations are therefore searching for organization structures that can be applied for investments in renewable energy within their specific discipline and legal framework.

One of these housing associations is Woonbedrijf from Eindhoven (NL). With an ownership of more than 30.000 rental units is Woonbedrijf by far the largest housing association in Eindhoven. Given their significant size and progressive sustainable policy, Woonbedrijf aims to play a leading role in the preservation of Eindhoven towards their goal to be energy neutral in 2045. Woonbedrijf makes their sustainable policy operational with the use of pilot projects in which they assess the usability, applicability and affordability of renewable techniques before they are applied to all their possessions. As a starting point, they have defined one neighbourhood as a pilot project, namely the Airey neighbourhood in Gestel (Eindhoven). Based on former research conducted by Victor de Vrede (Vrede de, 2012), Woonbedrijf already has a clear picture of sustainable techniques that can be applied for the preservation of the Airey Neighbourhood. However, the way of organizing and financing this kind of projects raises a lot of questions.

PROBLEM DEFINITION
Based on this context, the following problem has been defined for this research:
A lot of research has been conducted about techniques for the preservation of existing dwellings, but it is not clear to housing associations how the implementation of these techniques can be organized and financed!

Research objective
Formulating an advice on which Woonbedrijf can practically implement an energy preservation concept in the Airey neighbourhood in Genderdal.

Research boundaries
Given the limited timeframe of the research, the following research boundaries have been formulated:
- The research will focus on the existing housing stocks of housing associations;
- The Airey neighbourhood will be used as a case study;
- Only investments in renewable electricity in the form of PV panels will be taken into account according to Woonbedrijf's investment strategy;
- The research focuses on land-based dwellings.

METHOD
The research has been structured into two parts. First a literature study has been conducted in order to get an overview of the most important aspects and developments regarding sustainability and housing associations. Here, a set of alternatives is generated that will be tested against the Airey neighbourhood case study in part two of the research. The second part of the research consists of a two-step research structure wherein firstly the financial consequences for the tenants (client value) and the investor (company value) are determined and secondly the best alternative will be selected with the use of the Analytic Hierarchy Process (AHP).

GENERATING ALTERNATIVES BASED ON A LITERATURE STUDY
In order to get an overview of the possibilities to organize the preservation of existing housing stocks, a literature study has been conducted based on the following key subjects 1) the legal framework will be described to create a solution space, 2) the financing possibilities will be elaborated followed by 3) the organization structures. These three subjects will be combined in order to generate a set of alternatives that can be assessed against the case study.

Legal framework
Acts are important subjects to study because these form the context in which solutions can be sought. There are two key acts regarding sustainable electrical measures for housing associations, namely the Housing Act and the Electricity Act. The Housing Act is in the middle of a renewal process and is important in terms of organization structures. The new Housing Act, which is expected to be introduced in 2014, does not exclude alternatives, but provides specific regulations for some structures like connections with external entities.

The Electricity act regulates the prices and taxes that have to be paid for electricity usage. This is important for the development of renewable electricity based business cases because the exemption of energy taxes can make the difference between a viable and a non-viable business case.

Financing possibilities
Since the market for sustainable energy is emerging, more and more parties are entering the market offering a broad spectrum of services ranging from single services like financing or customer support up to full package services including financing and exploitation. When financing options are considered it is important to know which party is going to invest in the project. According to Atrive (2012), the following parties could play the role of investor in the implementation of sustainable measures in the social housing sector, namely the housing association (Woonbedrijf), the tenants and external companies. Table 1 shows the available financing possibilities for these three groups.

Financing type	Housing Association	External Company	Tenant(s)
Equity capital	□	□	□
Secured loan	□		
Commercial loan	□	□	□
Green loan	□	□	□
Lease construction	□	□	□
Revolving fund			□

Table 1: Available financing possibilities for different investors

Organization models
Choosing the right organization structure is an important step in the preservation of the existing housing stock. Questions like: "*Who invests in the project? Who bears the risks? Who takes care of the exploitation? Outsourcing or do it yourself? What are the benefits for the housing association, external companies and the tenants?*" come together within the organization structure. The organization structures are a combination of financing possibilities and payback options within the legal framework whereby a distinction has been made based on which party is going to invest in the project. Organization structures can be divided into the following groups:
- Housing association invests
- External company invests
- Tenant invests
- Hybrid organization structures

The financing possibilities combined with the organization models within the legal framework generate a lot of possible combinations. In order to keep things organized, an overview has been created (figure 1) in which all possibilities are summarized.

Set of alternatives
The legal framework, financing possibilities and organization models are combined in order to generate a set of alternatives. Figure 1 gives an overview of the alternatives that will be tested against the case study. In total there are 15 alternatives divided over three main groups (housing association, external company, tenants) and five subgroups based on the type of organization structure.
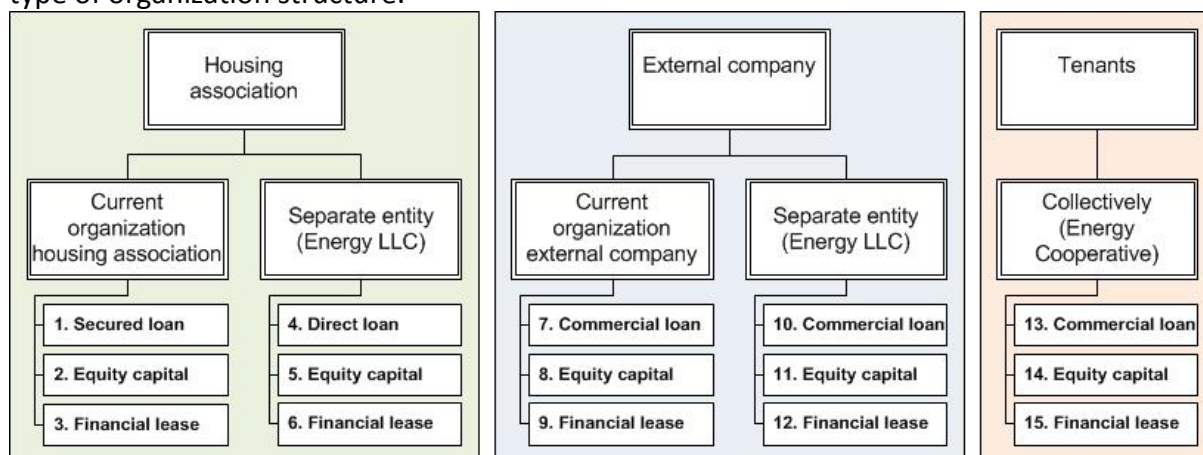
Figure 1: Set of alternatives for further research
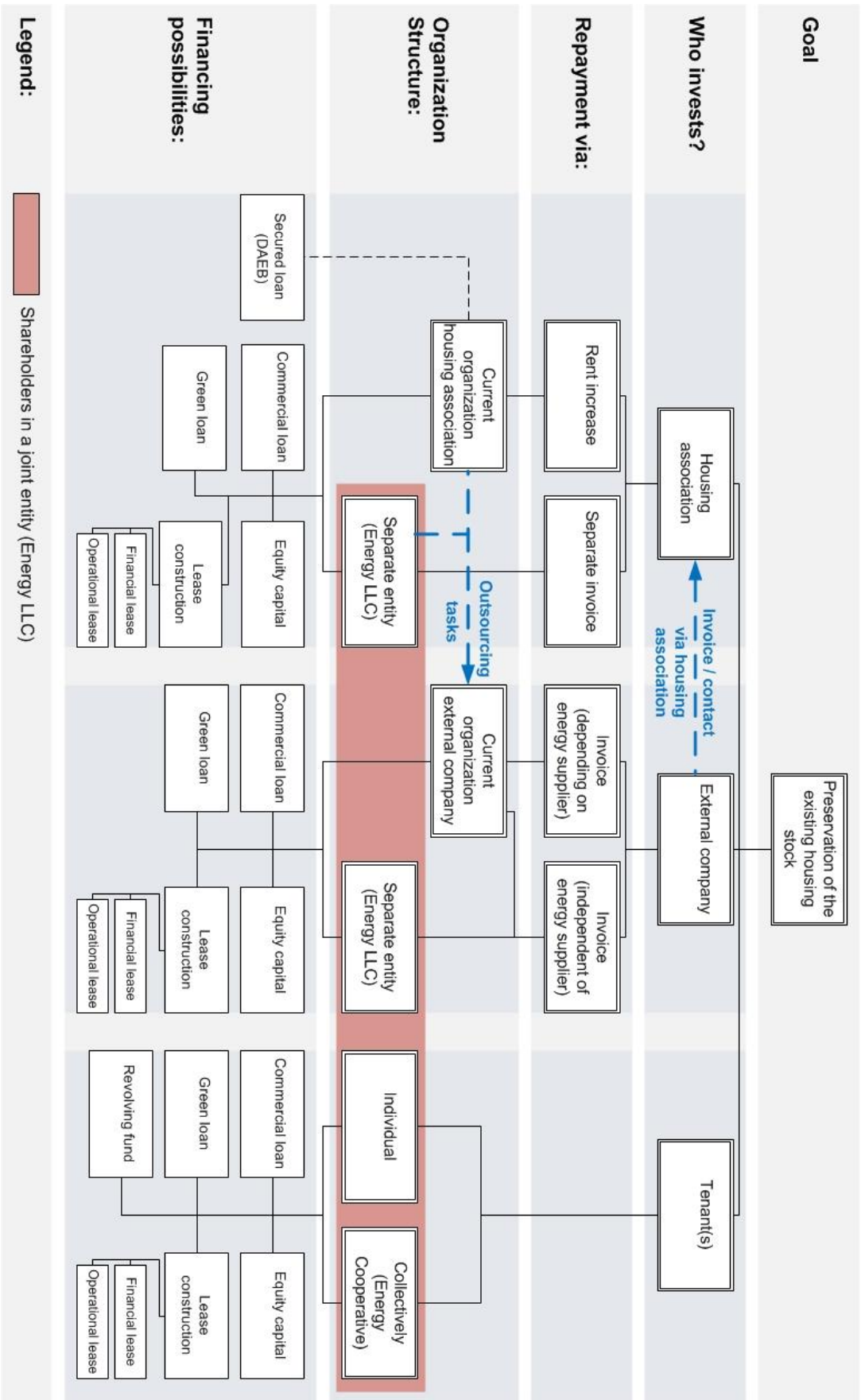
Figure 2: Overview of the financing possibilities and organization structures

CASE STUDY: THE AIREY NEIGHBOURHOOD

Genderdal is a residential area in the district Gestel in the south of Eindhoven (NL). A neighbourhood of 226 dwellings so called Airey houses in Genderdal (built in 1958) is assigned as pilot project for sustainable measures and techniques in Eindhoven. Woonbedrijf wants to try out different sustainable measures and techniques in this neighbourhood (Vrede de, 2012). The households in the Airey neighbourhood have an average energy consumption of 1.250 m³ gas and 2.500 kWh electricity per year. This energy consumption results in an energy bill of approximately € 1.745 per year or € 145 per month. The average rental price is € 375 per month. This results in average total housing costs of € 520 where energy costs cover about 30% of the housing costs.

FINANCIAL MODEL

The first part of the case study consists of a financial model in which the financial consequences for the tenants (client value) and the investor (company value) are determined.

Decision criteria

A customer survey conducted by Woonbedrijf showed that 79% of the tenants does not accept an increase in housing costs (rent + energy). When cost savings exceed the increase in rent, the tenants will benefit from lower housing costs. A decrease in housing costs will be indicated as a *positive client value*. In the context of this research, only alternatives with *positive client values* will be considered for further research since at least 70% of the tenants has to approve the increase in rent before the project starts.

Results

The 15 alternatives generated in chapter 2 are all imported in the previously described calculation model. For each of the alternatives, the *client value* and the *company value* have been calculated. Table 2 shows the results of the financial model for all the alternatives. According to the preconditions, alternatives with a negative client value will be rejected for further research. Table 2 shows that only alternative 8 and 11 generate negative client values. This is a positive result because this proves that investments in PV are viable business cases and that renewable energy is able to compete with conventional energy.

Organizational structure	Financing type	Increase rent (€/month)	Client Value	Company value	Increase rent (€/month)	Client Value	Company value
Housing Corporation (Current organization)	1: DAEB-financing	€ 22,97	€ 7,43	€ -	€ 25,40	€ 5,00	€ 110.966
	2: Equity capital	€ 24,79	€ 5,61	€ -	€ 25,40	€ 5,00	€ 27.798
	3: Financial lease	€ 23,78	€ 6,62	€ -	€ 25,40	€ 5,00	€ 62.602
Housing Corporation (Energy LLC)	4: Direct loan	€ 26,45	€ 3,95	€ -	€ 25,40	€ 5,00	€ 48.138-
	5: Equity capital	€ 27,96	€ 2,44	€ -	€ 25,40	€ 5,00	€ 117.068-
	6: Financial lease	€ 30,10	€ 0,30	€ -	€ 25,40	€ 5,00	€ 181.704-
External company (Current organization)	7: Commercial loan	€ 25,56	€ 4,84	€ -	€ 25,40	€ 5,00	€ 4.520-
	8: Equity capital	€ 32,96	€ 2,56-	€ -	€ 25,40	€ 5,00	€ 211.536-
	9: Financial lease	€ 29,75	€ 0,65	€ -	€ 25,40	€ 5,00	€ 114.808-
External company (Energy LLC)	10: Commercial loan	€ 25,67	€ 4,73	€ -	€ 25,40	€ 5,00	€ 7.684-
	11: Equity capital	€ 33,06	€ 2,66-	€ -	€ 25,40	€ 5,00	€ 214.474-
	12: Financial lease	€ 29,87	€ 0,53	€ -	€ 25,40	€ 5,00	€ 117.746-
Tenants (Collectively)	13: Commercial loan	€ 23,13	€ 7,27	€ -	€ 25,40	€ 5,00	€ 105.994
	14: Equity capital	€ 23,13	€ 7,27	€ -	€ 25,40	€ 5,00	€ 105.994
	15: Financial lease	€ 24,30	€ 6,10	€ -	€ 25,40	€ 5,00	€ 47.912
		Fixed company value (NPV=0)			Fixed client value (CV=5)		

Table 2: Results financial model

AHP ANALYSIS
In the second part of the case study, the analytic hierarchy process (AHP) has been applied in order to select the best organization structure for the preservation of the Airey neighbourhood.

Method
The analytic hierarchy process (AHP) was developed by Thomas Saaty (Saaty, 2008) at the Wharton School of Business. It is broadly used around the world in decision situations and especially in group decision-making processes. AHP allows decision makers to model a complex problem into a hierarchical structure. It engages decision makers in breaking down a decision into smaller parts, proceeding from the goal to criteria to subcriteria and so on down to the alternatives of action (Arentze en Borgers, 2004). The AHP analysis has been executed with the help of a software package called Expert Choice 2000.

The AHP model
Figure 3 shows the four level hierarchies for this research. The goal is a statement of the overall objective. The goal for this research is to choose an organization structure for Woonbedrijf for the preservation of the Airey neighbourhood. The factors that influence the problem are called criteria or objectives. They are located in the level immediately below the goal. The subcriteria are directly related to the criteria because they represent various properties of the criteria. The alternatives are located in the bottom level of the hierarchy. The alternatives for this model are coming from the financial model. The 13 alternatives with a positive client value serve as an input for the AHP model.
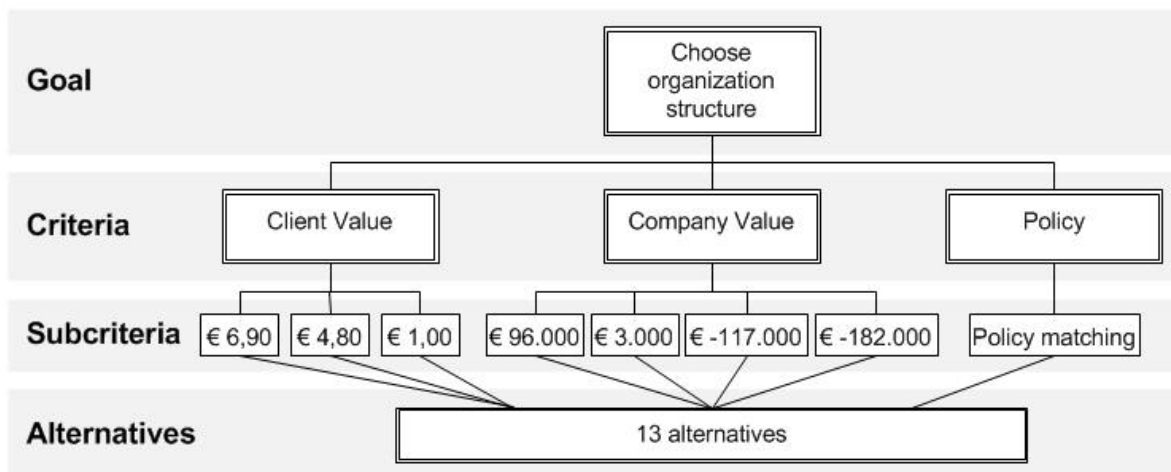
Figure 3: AHP model

Data collection
The data needed for the AHP analysis has been collected with the use of a questionnaire. This questionnaire has been sent to a selection of employees from Woonbedrijf. At the same time, short interviews of 30 minutes where planned with these employees.

RESULTS
Based on the results of the AHP and sensitivity analysis, a substantiated decision for the best organization structure for the preservation of the Airey neighbourhood can be made. The results in figure 4 show that the organization structure where the tenants collectively participate in an energy cooperative is the most preferred alternative by the respondents.

These are alternatives 13 and 14 where the energy cooperative finances the project with a commercial loan or equity capital.

Goal: Choose organization structure

Overall Inconsistency = ,29

1. Woonbedrijf / Current organization / DAEB	,092
2. Woonbedrijf / Current organization / Equity capital	,086
3. Woonbedrijf / Current organization / Finacial lease	,079
4. Woonbedrijf / Energy LLC / Direct loan	,059
5. Woonbedrijf / Energy LLC / Equity capital	,052
6. Woonbedrijf / Energy LLC / Financial lease	,029
7. External company / Current organization / Commercial	,095
9. External company / Current organization / Financial lease	,045
10. External comany / Energy LLC / Commercial loan	,093
12. External comany / Energy LLC / Financial lease	,047
13: Tenants / Collectively / Commercial loan	,110
14: Tenants / Collectively / Equity capital	,110
15: Tenants / Collectively / Financial lease	,103

Figure 4: Priorities of the different alternatives with respect to the goal

The first criterion, *client value*, appeared to be the most important criterion with a weight of 53% related to the goal. Within the *client value*, the subcriterion with the highest *client value* (€ 6,90) is the most preferred value with a weight of 61%. Alternative 13 and 14 share the second-highest priority (0,111) related to the client value with a monthly saving of € 7,27 per household just behind alternative 1 which has a monthly saving of € 7,43 and a priority of 0,119.

The *client value* is followed by the *company value* in descending order of importance. The *company value* has an overall weight of 29% related to the goal whereby the positive *company values* are strongly preferred by the respondents (total weight of 77%). Alternative 13 and 14 are here also in the upper segment of the priorities (0,083) with a *company value* of € 105.994.

The *policy* criterion has with a weight of 18% the smallest amount of importance related to the goal. However, this criterion definitely affects the final outcome. Alternatives 13 and 14 have by far the highest priority (0,148) because the energy cooperative structure fits perfectly to Woonbedrijf's policy.

Figure 5 shows the organization structure of the energy cooperative. The energy cooperative takes care of the investment and exploitation of the PV panels and the members pay the cooperative through an invoice including a membership fee. The tenants will have a vote in the board of the cooperative through their shares.
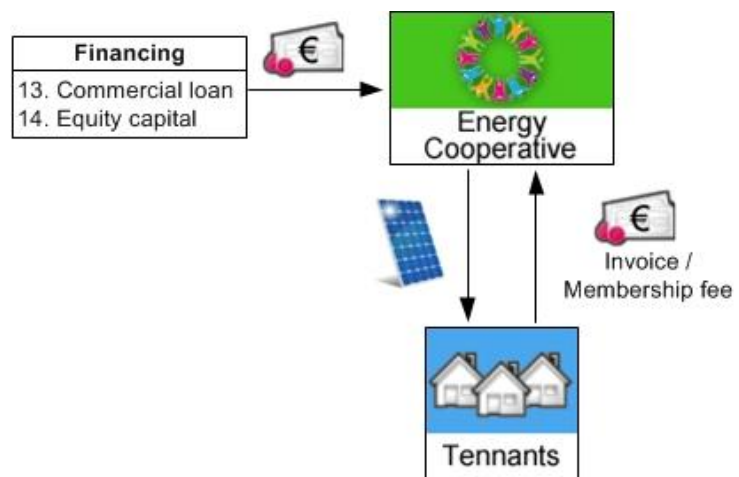
Figure 5: Energy cooperative structure

CONCLUSION
Based on the literature study in the first part of the research, the following conclusions can be made:
- There are two important acts that have to be taken into account, namely the *Housing Act* and the *Electricity Act*;
- When financing options in the social housing sector are considered, the following parties could play the role of investor in sustainable projects: 1) the housing association, 2) the tenants and 3) external companies;
- Organization structures can be divided into three groups based on who is investing. The findings of the first part of this research are all summarized into one scheme (figure 1).

The second part of the research was completely dedicated to the selection of the best organization structure for the Airey neighbourhood. In order to make an objective selection, a two-step research structure has been applied wherein firstly the financial consequences have been determined and secondly the best alternative has been selected with the use of the Analytic Hierarchy Process (AHP).

The organization structure where the tenants collectively participate in an energy cooperative (figure 5) is the most preferred alternative according to the AHP and sensitivity analysis. The energy cooperative structure has high priorities for the three criteria because this structure generates high *client values* (€ 7,27), high *company values* (€ 105.994) and fits perfectly to the policy of Woonbedrijf.

Discussion
When investments in renewable energy are considered, both electricity and heat play an important role. According to Woonbedrijf's investment strategy, this research focuses on electricity where mainly financial parameters are important. This reflects the financial approach for the *client value* and the *company value*. When heat is also taken into account more subjective parameters could play a role like *comfort*. Hereby, the *client value* could have a much broader meaning.

Further research
During the research, some interesting subjects arose that could be interesting for further research:
- Given the electrical and financial focus, further research would be interesting where heat is also included.
- The target group of housing associations is very specific. Further research about influencing behaviour and communication with tenants would be interesting;
- It would be interesting to do research about the possibilities to join the forces of these housing associations like establishing a collective Energy LLC.

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Renewable energy proved to be competitive with conventional energy. It only requires a change in people's mindset.

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AGAINST MATHEMATICS: HOW 2 + 2 CAN EQUAL 5
An application of open business model innovation to create and appropriate synergy in a sustainable business context

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ABSTRACT

The notion that a single firm cannot innovate in isolation serves as starting point for the open innovation paradigm introduced by Chesbrough (2003). In order to improve innovative performance and thereby create value, firms have to engage with other parties to gain access to new ideas or resources (Dahlander and Gann, 2010). The value created and captured by firms opening up their business model should naturally be higher than the sum of the value both parties could have created in isolation. St John and Harrison (1999) describe this phenomenon as 'synergy'. This master thesis dives into this material in order to derive both theory- and practice-based design principles for the creation of synergy through open business model innovation. These principles are applied in a sustainable business context, to see how two firms collaborating could create sustainable innovations that deliver more value to these firms than the combined effort of their work would have been when working individually. As a result, an open business model template to create four types of synergy has been developed and implemented in a sustainable business context.

Keywords: Open Innovation, Business Model Innovation, Open Business Model Canvas, Firm Synergy, Design Principles, Sustainable Business Environment.

INTRODUCTION

The notion that a single firm cannot innovate in isolation serves as starting point for the open innovation paradigm introduced by Chesbrough (2003). In order to improve innovative performance, firms have to engage with other parties to gain access to new ideas or resources (Dahlander and Gann, 2010). So, open innovation is a mean to create and capture value, which in essence is the function of a firm's business model (Osterwalder and Pigneur, 2010). Following from this, Chesbrough (2007) states that firms have to open their *business models* to other parties in order to improve innovative performance, rather than relying at internally generating innovation solely. However, as pointed out by Reed et al. (2012), there is a trade-off between the benefits and risks of open innovation: all parties involved should benefit from open innovation, otherwise firms could better focus on internally generating innovation, thereby avoiding any risks concerned with opening up a firm's boundaries. In other words, the value captured and created by firms opening up their business model should naturally be higher than the sum of the value both parties could have created in isolation. St John and Harrison (1999) describe this phenomenon as *'synergy'.*

RESEARCH QUESTION

Although sounding promising for both managers and scholars, there are two premises that may seem to strike with synergy achievement via open business model innovation. The first premise stems from Chesbrough (2007), who states that the journey towards open business models is challenging. The second premise, following Goold and Campbell (1998), states that although synergy has the potential to create value, it turns out that many synergy efforts end up *destroying* value rather than creating it. So, although desired by managers and receiving increased attention from scholars, creating synergy (via open business models) still has its rough edges. For firms willing to open their business models in their desire for synergy, it is important to gain insights in dealing with these challenges. This thesis contributes to gaining these insights by posing and answering the following research question:

> *"How can open business model innovation help firms establish synergies?"*

Many scholars in the field of economics and management have paid attention to the topic of synergy, but a well-defined theory of synergy and inter-firm networks has yet to emerge (Wei, 2010). This thesis will contribute to the closure of this gap, by developing a synergy typology grounded in literature, which can be linked to an open business model template, to see how open business model innovation could result in firm synergies. Design principles based on both theory and practice are developed in order to show how these different types of synergy can be achieved.

SYNERGY IN OPEN BUSINESS MODELS: LITERATURE REVIEW

A literature review has been conducted, revealing (recent) research on the topics of open innovation, business model innovation and synergy.

OPEN INNOVATION

Reviewing the open innovation paradigm has started with finding a widely accepted definition of the concept. The definition used in this thesis is as follows: "[open innovation is]

the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively" (Chesbrough, Vanhaverbeke and West, 2006, p.1). Following from this definition, the (dis)advantages of open innovation are discussed. Scholars seem to have an imbalanced focus on the advantages of open innovation, thereby neglecting its downside. The main advantages scholars agree upon are *shorter time to market, lower innovation costs* and *increased sales*. Dahlander and Gann (2010) are among the few who describe the *disadvantages* of open innovation: fear of competitors becoming better positioned, increasing transaction costs, lack of absorptive capacity and the possibility of relying too heavily on external resources.

BUSINESS MODEL INNOVATION

Next, in order to see how applying open innovation can create and capture value, the concept of business model innovation is discussed. The business model canvas of Osterwalder and Pigneur (2010) serves as the basis for the theoretical framework. They (ibid, p. 4) state that a business model *"describes the rationale of how an organization creates, delivers and captures value".* Concerning business model *innovation*, Amit and Zott (2010, p.5) describe this as *"designing a new, or modifying a firm's extant activity system".* However, there are some powerful barriers to business model innovation, most importantly the fact that managers have difficulties in recognizing a promising business model timely or that its development is resisted due to conflicts with the prevailing business model (Chesbrough, 2010). Thomke (2002) argues that the way forward is to adopt an experimental stance towards it: companies should develop the ability to experiment with their business models to partake more fully in the benefits of open innovation, coined by Chesbrough (2007) as *open business models*. So, open business models specifically focus on using the firm's environment as key component in the business model in order to create and capture value (Sandulli and Chesbrough, 2009). To see how collaborating firms can capture a *surplus* in value, the thesis continues with elaborating on the concept of synergy.

SYNERGY

Synergy is achieved when the value of a combined entity exceeds the sum of values of the firms in isolation (St John and Harrison, 1999). However, this definition remains rather abstract (cf. Knoll, 2008). Therefore, a synergy typology grounded in literature has been developed consisting of *financial*, *management*, *customer*, *operational* and *knowledge management* synergy. Each synergy type has been defined by synthesizing previous literature. For the *creation* of synergy Wu and Choi (2004) state that firms should exchange and combine resources with business partners to become more competitive and efficient. Based on Goold and Campbell (1998), six processes to achieve synergy are formulated: sharing know-how, coordinating strategies, sharing tangible resources, vertical integration and pooling negotiation power. Although tempting for managers to strive for synergy, four potential biases should be taken into account whilst seeking it: the synergy bias, the parenting bias, the skills bias and the upside bias (ibid).

THEORETICAL FRAMEWORK

These findings have resulted in a theoretical framework and 22 theory-based design principles that show which interventions should take place in order to establish firm synergy (see figure 10).

Business Model Canvas Firm A

- Customer Segments
- Value Proposition
- Channels
- Customer Relationships
- Revenue streams
- Key resources
- Key activities
- Key partners
- Cost structure

Business Model Innovation
- Creation
- Extension
- Revision
- Termination

Implementation in the BM:
- Effectuation
- Experimentation
- Organizational leadership

Synergy preconditions
- Trust & Communication
- Absorptive capacity for sharing resources
- Organizational leadership support

Synergy Creation
- Sharing know-how
- Coordinating strategies
- Share tangible resources
- Vertical integration
- Pooled negotiation power
- Combined business creation

Business Model Canvas Firm B

- Customer Segments
- Value Proposition
- Channels
- Customer Relationships
- Revenue streams
- Key resources
- Key activities
- Key partners
- Cost structure

Resulting Synergies
- Financial Synergy
- Management Synergy
- Customer Synergy
- Knowledge Management Synergy
- Operational Synergy:

Figure 1 - Theoretical framework of this thesis

METHODOLOGY

This thesis adopts a science-based design approach, based on qualitative research. The nature of the research question lends itself readily for such an approach, since it contributes to bridging the gap between researchers' abstract descriptions of synergy and practitioners' search for realizing it (cf. Romme, 2003). More specifically, this thesis follows the reflective cycle of Van Aken et al. (2007), which entails designing a solution for a specific case based on design principles in order to generate design knowledge. To derive the final set of principles, the approach of Van Burg et al. (2008) is followed, which contains designing a final set of principles by combining principles based on practice (by analysing ten case studies using open coding) and principles merely based on research. So, the final set of principles draws on both practitioner- and research knowledge. The principles follow the CIMO logic of Denyer et al. (2008, p.395): *if you want to achieve outcome O in context C, then use intervention type I.* The explanation through which Mechanism the intervention produces the outcome is represented by the 'M' in the CIMO acronym. These principles will be applied to a specific case: Club van 30 (C30). The data collected for the detailed design solution for C30 has been gathered by conducting interviews and via direct observations during the time spent on-site.

DESIGN

The central role of the business environment has extended from being a traditional economic actor, towards being a political and social actor (Li and Toppinen, 2011). Fowler

and Hope (2007) argue that it is possible to achieve win-win scenarios under which a firm can maximize returns while making progress towards the implementation of sustainable business practice. So, sustainable design and practices not only decrease negative impact on the environment, but also could provide benefits to the firm (Gottfried, 2003), making it increasingly impossible for firms to avoid the concept of sustainable development (Dyllick and Hockerts, 2002). However, the concept of sustainability "*has been used to mean different things to different people in different contexts*" (Bebbington, 2003, p.1). As a result, sustainable development constitutes a challenge for firms, since neither the concept, nor the implementation can be properly grasped. To overcome these challenges, Van Kleef and Roome (2007) argue for collaborative innovation through networks and multi-actor forums.

In this context, C30 helps firms overcome these challenges by translating their ambitions into their business models. However, as stated by Gottfried (2003), the solutions that C30 presents to its customers might have more potential value than solely being presented to the customer and decreasing the customer's negative environmental impact. Momentarily, C30 advises customers and helps with the implementation of the solution in the customer's business model, after which the project is finished. However, in view of the open innovation paradigm, combining knowledge and expertise of C30 with daily operations of its customers could result in innovations through collaboration, resulting in a surplus of value for both companies. In other words, collaboration between C30 and its customers has the potential to result in firm synergy, but stagnates at this moment after the project is finished. In a situation of close collaboration, the challenge that firms face while implementing sustainability in their business model can be overcome by using knowledge and expertise of C30, while C30 on its turn could make use of the resources or daily operations of the firms develop and implement sustainable business innovations. The potential benefits for both firms that could arise would be repulsing green-washing, ensuring recurring payments for both firms, implementing innovations market-wide and image building.

A solution for this problem has been designed, in the form of an *open business model template* based on the design principles, to see how the building blocks of the template should be detailed in order to achieve (one of) the different synergy forms. The generic template has been contextualized for the situation of C30. This way, knowledge from C30 can be turned into valuable sustainable business development (knowledge management synergy) by collaborating with external partners, thereby not only creating a surplus in economic benefits (i.e. financial synergy) for both firms, but also decreasing negative impact on the environment, achieving productivity benefits (operational synergy) and enhancing public relations, which include marketing advantages to reach and serve multiple customer segments (customer synergy), cf. Gottfried (2003). Figure 11 on the next page shows the generic open business model template, with the different synergy types. Management and knowledge management synergies reflect on all business model components and therefore these synergies have not been visualized in the figure. The tailored solution to the situation of C30 is described in the thesis.
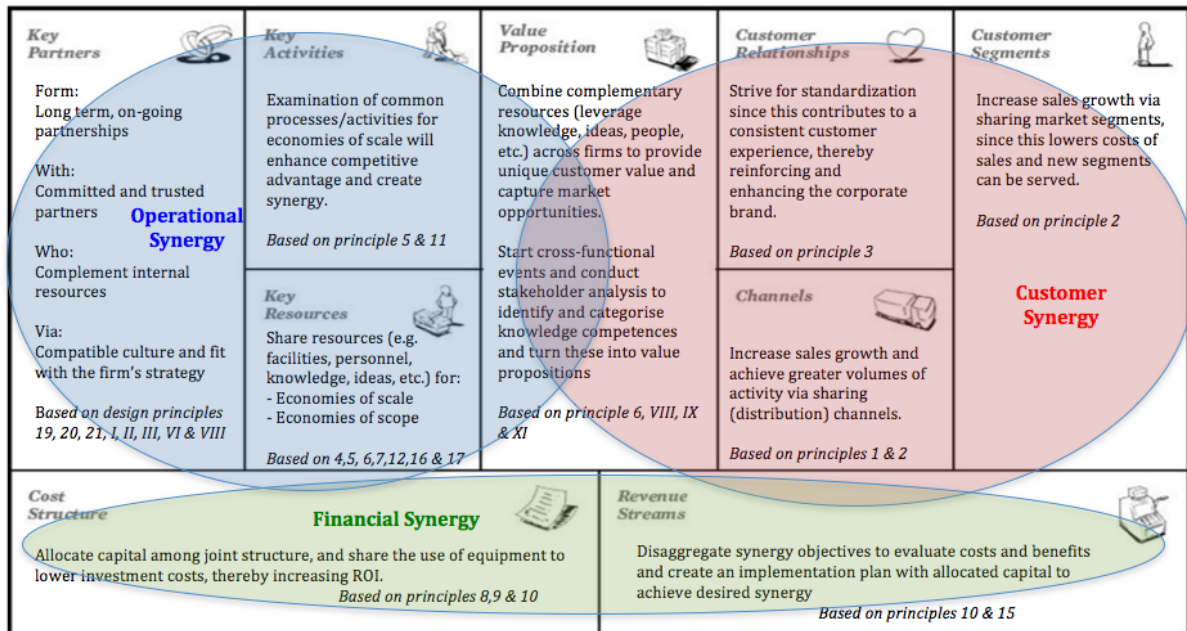
Figure 2 - Design solution

DISCUSSION AND CONCLUSION

This thesis contributes to literature in several ways. First, as pointed out by Wei (2010), a well-defined theory of synergy and firm networks had yet to emerge. This thesis contributes to closing this gap by reflecting on five decades of literature on synergy in order to provide a comprehensive synergy typology with accompanying definitions. Even more important, this thesis aimed at closing the gap between desired synergy outcomes and how to achieve them by combining open business models to the concept of firm synergy. As a result, it shows how synergy can be created and captured by developing an open business model template, based on the work of Osterwalder and Pigneur (2010). Furthermore, a set of over 30 design principles has been developed, building on both theory and practice. The set of principles shows how the different synergy types can be achieved.

For managerial purposes, this thesis is a first step for practitioners in overcoming the problems they face when opening up their business model, by providing concrete guidelines for filling in the business model components, thereby providing a potential pathway to greater innovation activity. Especially when considering Chesbrough's (2003) notion that companies must innovate to survive and the fact that open innovation has been shown to provide opportunities, but simultaneously can be challenging for many firms (Chesbrough, 2010), the open business model template and the accompanying the design principles could be a valuable tool for firms when opening up their borders in an attempt to enhance innovative performance.

LIMITATIONS AND FUTURE RESEARCH

As with any research, this research has been subject to some limitations. First of all, as stated by McGrath (2010), a new business model cannot be fully anticipated in advance, but must be learned over time. In this view, the theoretical framework of this thesis approaches the open business model innovation process perhaps too simplistic, by stating that synergy could be a direct result of changes in a firm's business model. In practice, this process will take time and might involve experimentation to learn from mistakes made and to find out which

business model is appropriate for creating and appropriating synergy. So, although this thesis provides clear and useful linkages between open business model innovation and synergy, future research could address the concept of synergy creation via experimentation, in addition to this study. In doing so, the dynamic and iterative process of experimentation, which is suggested for business model innovation (Thomke, 2002), can be mapped and applied to a case design over a longer period of time, to see if there are any changes compared to the findings of this study.

Next, the choice for the ten case studies on which the practice based design principles are based, has some limitations. Although the case studies show how synergy can be created in practice and the derived principles correspond to theory, the number of cases is rather low. Furthermore, the cases have different sizes, including multi-nationals, while the final design has been applied to a relatively small firm in a specific context (i.c. C30). Future research should address these issues by designing, implementing and evaluating the practice based design principles and the template for multiple case studies in diversified contexts and of different sizes. This way, differences in size and context can be overcome by detailing the design, which could strengthen the robustness of the design.

Third, although the typology of this study is comprehensive, 50 years of literature on synergy makes it virtually impossible to cover all typologies present in literature. Driven by the fact that there is no consensus on the terminology and definition of the concept, many synonyms or concepts related to 'synergy' can be found in literature (e.g. 'strategic fit' or 'strategic alignment'). Although this thesis has covered a large part of these theories, there remain some research streams that focus on the topic of synergy that has not received comprehensive attention in this study. For example, mergers and acquisitions literature dives in the concept of two firms combining their strengths in order to achieve value. However, this thesis has focused on synergy between collaborating firms rather than merging or acquiring firms, since this approaches open innovation practices most directly. Future research could apply the open business model template in the context of mergers and acquisitions, to see if the template can be used in different settings or could be extended to value creation and appropriation in different forms of joint structures, other than open innovation practices.

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THE USE OF WASTE AS FILL MATERIAL IN THE LAND RECLAMATION PROJECTS OF JAKARTA

Evaluating the possibilities of using waste as an interesting substitute of sand within the land reclamation projects of Jakarta

Author: ing. N.F. Barry

ABSTRACT

To coop with urbanization issues and the economic need for expansion, the city of Jakarta is planning to reclaim more land in the Jakarta Bay. More land could discharge the inner city's over-population, enhance its economic growth and solve a lot of environmental and health problems the city is facing. However, the reclamation activities of some islands have barely started and already the developers are facing difficulties in finding sufficient quantities of sand fill material.When addressing the problem of sand scarcity in the case of Jakarta where, an excess of waste production, an inadequate solid waste management system and a lack of dumping ground pose a major problem, it is hard not to think of the use of waste as alternative fill material; the concept of "work with work". This paper evaluates the possibilities of how waste could replace or complement sand within the land reclamation projects of Jakarta considering the governmental, social, environmental and economic context of the city. The research results identify types of waste that could be used, ways or methods of using those types of waste and implementation conditions for the city of Jakarta.

Keywords: Solid Waste Management systems, Land reclamation, artificial islands, Landfills, Multi Criteria Analysis, Scenario planning, Causal loop diagrams

INTRODUCTION

Located on the northwest coast of Java, Jakarta is the capital and largest city of Indonesia and the country's economic, cultural and political center. With a population exceeding 10 million as of November 2011, Jakarta is the most populous city in Southeast Asia, and the seventeenth-largest city in the world. With its population and a land area of 662 km^2, Jakarta has a population density of more than 15,000 people/km^2.

The city is experiencing rapid urbanization, yet its urban development and infrastructure is not ready for such rapid growth in population density; putting huge pressure on the urban environment and leading to problems such as: (1) land subsidence, due to rapid urbanization along with severe over-extraction of groundwater, (2) flood, due to the conversion of half

the city's small lakes into residential or commercial areas, (3) traffic congestion and air pollution, due to smoke and carcinogenic gasses emitted by the innumerable vehicles in the city, (4) waste problems, due to waste open dumping and burning and (5) poor sanitation creating serious health threats.

The Special Capital City District of Jakarta (DKI) has planned to transform Jakarta into a big city in the future by changing its coastal line to about 8 km toward the sea from its existing position. It is planned that Jakarta will become a Water Front City, covering the area of 5 km to the land side and 8 km to the sea side along its coastal line (Levara J.C., 2010).
An overview of the plan area of North-Jakarta is shown below. The orange and yellow colors represent the planned land reclamation Islands (JCDS, 2012).
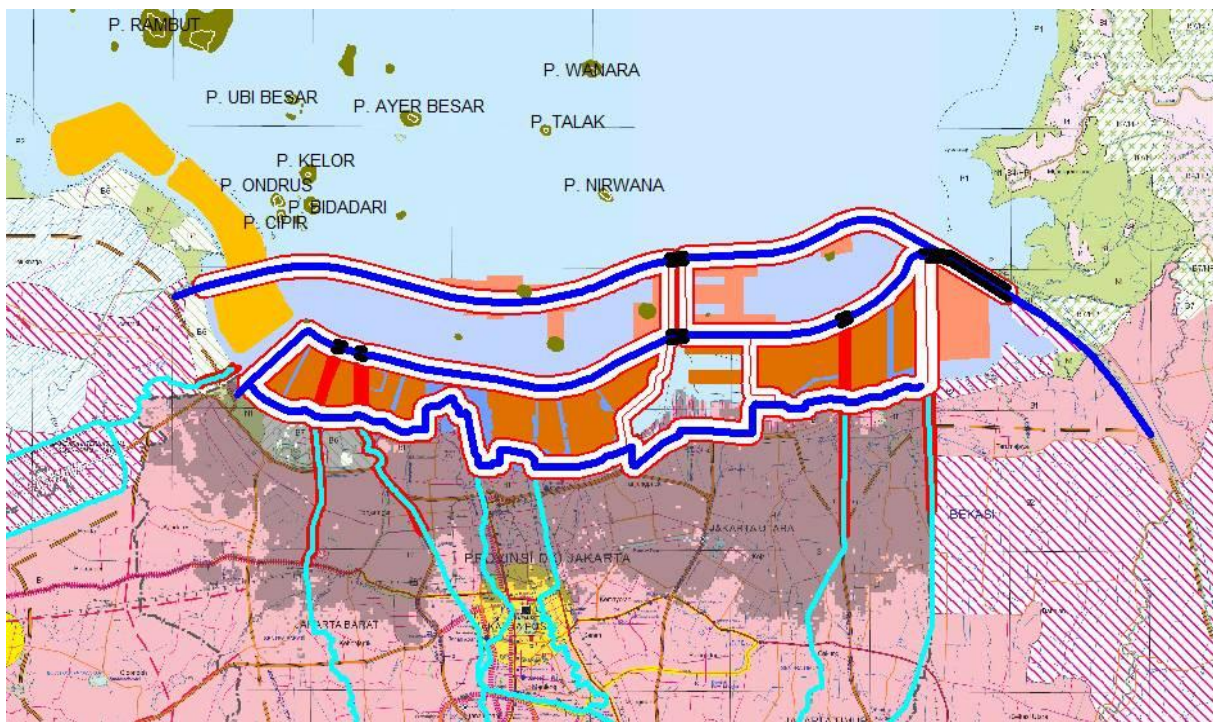
Figure 1: Overview of the planned land reclamation area (JCDS, 2012).

Using waste as fill material within the land reclamation plans of Jakarta could solve most of the urbanization problems the city is facing. Therefore the objective of this research is to find out whether waste can be a good substitute for sand within these land reclamation projects and how to apply it.

Research question and sub-questions:
How could waste be an interesting substitute for sand as fill material in the land reclamation projects of Jakarta?
- o   What alternative (existing or new) ways of using waste as fill material within the land reclamation projects of Jakarta are there?
- o   Which alternative or combination of alternative methods of using waste within land reclamation is more interesting for Jakarta based on the Triple Bottom Line (people planet profit) principle?
- o   How could this more competitive alternative method of using waste within land reclamation be implemented in Jakarta?

Case study

So far, the use of waste within land reclamation is limited. Two existing cases where waste has been used as fill material, although with different purposes and contexts, were studied: the case of Singapore (Pulau Semakau) and the case of Japan (Yumeshima Island).

The purposes of land reclamation within those existing cases differed from the purpose within the case of Jakarta. The following purposes of land reclamation were identified:

1. The purpose of creating waste disposal sites: This refers mostly to offshore waste disposal landfills which are afterwards turned into natural areas (green zones, parks, golf courses etc.). In this case the reclaimed land is not stable and strong enough and therefore cannot be used for other urban development purposes. This is the case of Singapore (Pulau Semakau).

2. The purpose of creating new land for urban development plans: These may range from residential and cultivation purposes to major development projects such as tourism, individual/commercial business ventures, wharfage and other infrastructural improvement. In this case, the use of waste is only chosen when proven to be economically more attractive and able to replace the use of sand within the conventional way of land reclamation.

3. They are also cases where both purposes are urgent. Although the one is always more urgent than the other. In those cases, landfilling is done with the purpose of both securing waste final disposal sites as well as creating new land for urban development after land reclamation. This is the case of Japan (Yumeshima Island).

The case of Jakarta is similar to the second situation, where the purpose is creating new land for urban development. Because of the sand scarcity in the surrounding areas and the abundant availability of waste, the use of waste as fill material becomes interesting to explore.

Analyzing and evaluating the existing cases of Singapore and Japan and using the expertise and technologies from those cases led to the proposition of the first alternative method of using waste as fill material (Alternative 1). In addition the search for alternative new technologies led to two other alternative methods of land reclamation for Jakarta.

RESEARCH METHOD AND DESIGN

The data collection is mostly done through literature study and expert consultations. The conjunctive approach of Multi Criteria Analysis (MCA) is used to evaluate the new and existing land reclamation methods. This approach, based on a risk minimization measures the deficiencies of the different methods determining the safest alternative.

MCA is a structured approach used to determine overall preferences among alternative options, where the options accomplish several objectives. Desirable objectives are specified and corresponding attributes or indicators are identified, allowing to include a full range of social, environmental, technical, economic, and financial criteria.

For the implementation analysis of the chosen alternative land reclamation method, a SWOT analysis is used to evaluate the positive and negative aspects of this alternative method in the context of Jakarta. To help understand the process of the alternative method and the correlation between the process elements, a system dynamics model is used and finally possible future scenarios are simulated using the scenario development approach.

Scenarios are provocative and plausible stories about how the future might unfold. Because scenarios are hypotheses, they are created and used in sets of multiple stories that capture a range of future possibilities (Scearce D., et al., 2004).

In this case, the scenarios are used to deal with the specific system and they involve making explicit assumptions about the future development of the environment of the system using causal loop diagrams. The method for generating scenarios used is based on reasoned judgment and intuition in describing alternative futures by picturing critical uncertainties on axes that frame poles of possible futures; in this case: economy and demography. Two uncertainties, both major drivers for the land reclamation project and alternative fill materials which, when combined, produce believable and useful stories of the future.

The research design is shown below.
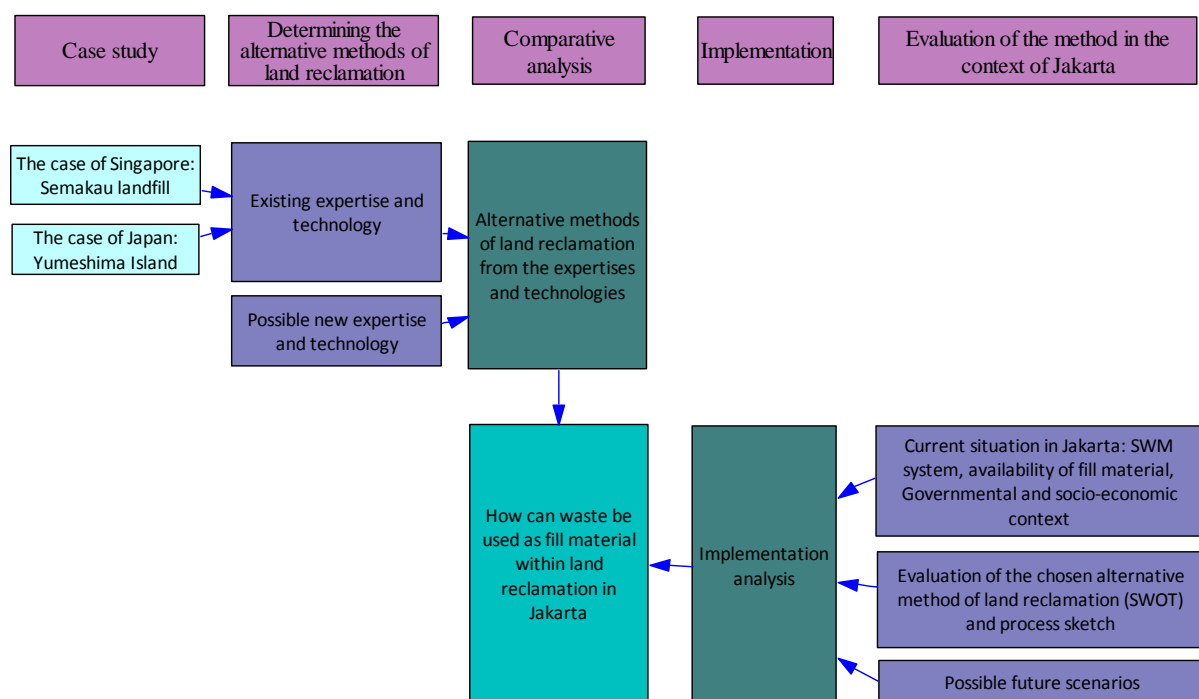
Figure 2: Research design.

RESULTS, DISCUSSION AND RECOMMENDATIONS
Using waste as fill material within land reclamation projects is more complicated than it seems. Waste needs to undergo major changes before it can be dumped into the open sea without significant environmental consequences. In addition to that, when the reclaimed land is meant for an urban area development with its heavy constructions, any alternative fill material needs to be strong and stable enough to carry this new urban area.

Alternative methods of land reclamation with the use of waste as fill material
The search for alternative methods of land reclamation with the use of waste led to the study of existing similar cases (Semakau landfill and Yumeshima Island), and further research on possible new technologies or methods that could be useful. This resulted in the identification of multiple methods of using waste as fill material for the land reclamation projects of Jakarta. Those methods of land reclamation differed from each other through the

types of waste used, the method of waste treatment before use and the way of application. The following alternative methods were further evaluated:

Alternative 1:
The use of compost and incineration ash packed into geotextile to prevent leachate of contaminants. This alternative could only be used for the reclamation area where no heavy structure is to be built on the reclaimed land and was found to be the most unfavorable alternative method based on the TBL framework with 6 major deficiencies, which were scored on the criteria accessibility, affordability, safety, pollution, comfort and health. Most of these deficiencies were caused by the inclusion of incineration. Apart from being very expensive, incineration has also a large negative impact on the environment and public health. Therefore this way of waste treatment was excluded from the recommendations.

Alternative 2:
The use of the plasma gasification technology to transform waste into an inert slag, which could then be directly used for land reclamation. The method was found to be the second most favorable with 3 major deficiencies, scored on the criteria accessibility, affordability and safety. The major setback of this alternative is the availability of the needed amount of slag for the land reclamation which is estimated to be only 13.3% of the sand gained per year so far.
Another setback of this alternative is the affordability. Although a plasma gasification plant generates a net revenue estimated at $32/ton of waste treated (through its energy production), it first needs a large initial investment before it can be productive.

Alternative 3:
The use of the Strengthened Sediment technology, where first, sludge or soft material is dredged or excavated, then strengthened on-site using cement or a specifically selected reactive bottom or fly ash and an initiator (e.g. sodium silicate) and then directly used as fill material. This new technology has not yet been applied for land reclamation but turned out to be the most favorable alternative method with only 1 major deficiency. This major deficiency is scored on the energy criterion, where strengthened sediment uses energy instead of producing it.

This alternative remains very interesting for the land reclamation projects of Jakarta. However, the lack of expertise within this new technology could cause some reservation from the shareholders (the government, developers or other private parties). In addition to that, based on the large amount of fill material needed, it can be assumed that there is not enough sediment available for the whole land reclamation plan. On the other hand the application of the strengthened sediment technology could also be seen as an opportunity because of its benefits in contrast with the conventional way of land reclamation and the other alternatives.

Alternative fill materials
After an analysis based on the TBL framework, the following alternative fill materials were found to be interesting substitute of sand within the land reclamation projects of Jakarta:
   o Compost (directly applicable; gained through composting of organic solid waste);
   o Slag (directly applicable; gained through plasma gasification of non-organic waste);

- o Excavated soil (uncontaminated and directly applicable; gained from construction work sites);
- o Mountain soil (uncontaminated and directly applicable; gained from mining);
- o Sludge (directly applicable through the Strengthened Sediment technology; gained from the city's channels and the seabed).

Within the comparison of those alternative fill materials, the social, environmental and economic characteristics were evaluated based on the conjunctive approach.

Compost, slag, excavated soil, mountain soil and channel sludge were all found to be socially, environmentally and economically more favorable than dredged sand. Seabed sludge having the similar major deficiencies within the social and environmental aspects as dredged sand was however economically more favorable than dredged sand. This makes all fill materials interesting substitutes of sand within the land reclamation projects of Jakarta.

The chosen method of land reclamation

Because the availability of landfill material is limited for each alternative or scenario, the best option was found to be a combination of favorable elements from the different alternative methods in a new alternative; The chosen method of land reclamation. This chosen method is composed of a combination of A1 and A2, where incineration is replaced by plasma gasification and A3.

Within this chosen method, an island could be compartmented into three sections:
- o Section 1, expected to provide a site for heavy constructions will be reclaimed using dredged soil from rivers, harbors and seabed with the strengthened sediment technology (A3);
- o Section 2, expected to provide a site for the construction of an urban area (residential and business area) will be reclaimed using normal mountain soil, surplus soil from construction work sites and plasma gasification slag.
- o Section 3, expected to provide a site for golf courses, light recreational activities and park functions will be reclaimed using compost and excavated soil from civil engineering and construction work sites.

However, the availability of sufficient alternative fill material for the land reclamation is still unpredictable at this point. The quantity of Municipal Solid Waste (MSW) that can be used for the land reclamation is estimated and clear, but the quantities of available excavated earth from construction work sites, construction and demolition waste, mountain soil and dredged sludge are unclear at this point and unpredictable for the future.

It is to assume that when the available alternative fill material is not sufficient, one could always use sand as complement.

An overview of the material flow within the chosen method is shown below.
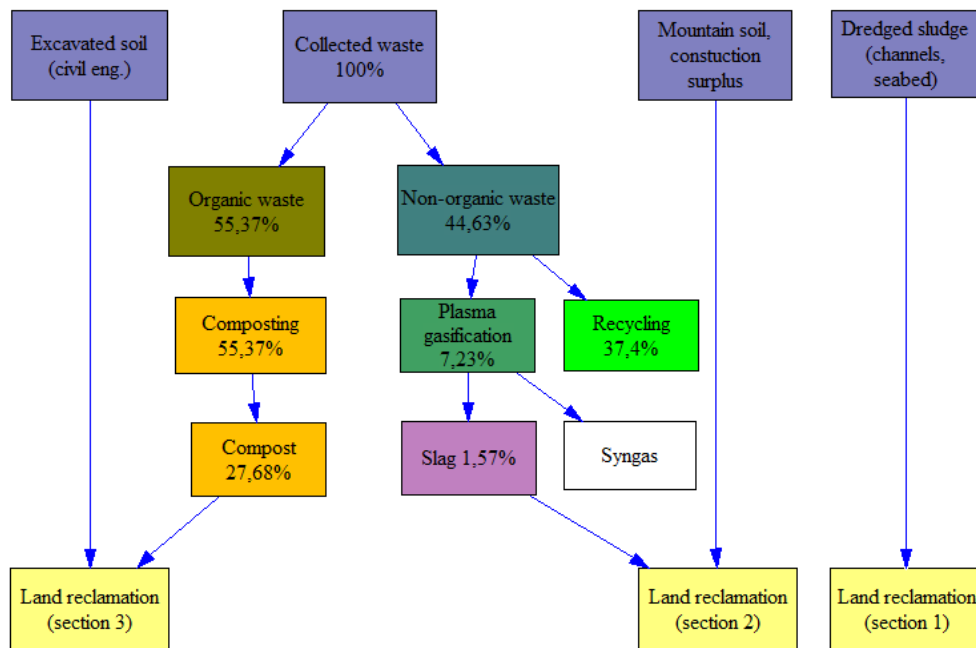
Figure 3: Material flow of the chosen method of land reclamation.

The table below gives an overview of the quantities of fill material.

Table 1: Quantity and cost estimates of fill material for an island of 300 ha.

	Conventional method			Method using waste		
	Material	Quantity (ton)	Cost ($)	Materials	Quantity (ton)	Costs ($)
Gained/year	Sand	2.242.585	$66.156.258	Compost	606.265	$11.519.035
				Slag	34.310	$34.310
				Excavated soil		
				Mountain soil		
				Sludge		
				Sand complement		
Total		2.242.585	€ 66.156.258		640.575	$11.553.345
Needed total		32.000.000			32.000.000	

Implementation analysis of the chosen method of land reclamation in Jakarta

As for the implementation of this method of land reclamation, based on the analysis of its strengths, weaknesses, opportunities and threats within the governmental, social, environmental and economic context of Jakarta, the following improvement changes are recommended; improvement within:

o   The SWM system: an adequate SWM system with all needed facilities and equipment needs to be in place. A system where waste collection is maximized and all collected waste is sorted, where the recyclables are recycled, the compostables composted and the remaining waste is gasified. Compost and slag could then be used as fill materials for the land reclamation projects. This includes (1) getting the inhabitants involved, (2) educating them regarding the whole SWM process and (3) accounting the cost of environment and health damages by following the concept of 'polluters

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pay' along with (4) a strong legal system to control and execute SWM rules and regulations;

o The state of the city's channels: the channels should be dredged, widened and deepened in order to use the dredged sludge for land reclamation, doing so also stimulating the water evacuation out of the city and reducing/preventing flood. Therefore the inhabitants living in the vicinity of those channels must be relocated with the least possible negative impact. Informing them about the reasons and necessity of the relocation and involving them within the relocation process along with offering them a suitable alternative living areas are important conditions;

o The land reclamation projects' support: governmental and social support should be promoted making sure all involved or needed parties are willing and motivated to participate and realize the project within the set conditions;

o Investments in constructions projects on the main land: investment in especially underground construction projects (parking garages, infrastructure etc.) should be promoted, in order to secure more excavated soil and construction waste for the land reclamation;

o Competences and "know how" of the involved parties: making sure all participating parties have the skill and competences needed for the realization of their roles within the project in order to limit the manageability issues due to the combination of several technologies or methods and the differences with the conventional way of land reclamation. So making sure the technologies are well known by the involved parties, the needed risk assessment is done and possible prevention measures are known and taken before start, for both the land reclamation and the SWM system.

Scenario development

The most favorable simulated scenario for the implementation of the chosen method of land reclamation in Jakarta, based on the city's demography and economy, was found to be the scenario where there is "Strong Economy and Population Growth". See axes below.
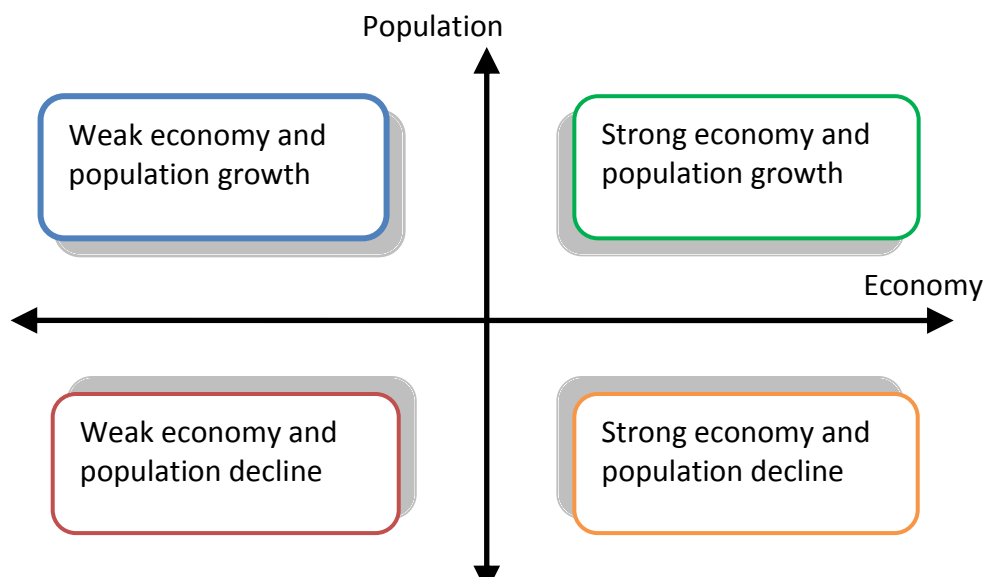
Figure 3: Scenario axes

Business is on the rise and the demand for urban development (residential, commercial, and office space) is increasing due to the stimulation of a wealthy economy. This leads to more

land use and an extension of underground constructions (massive shopping centers, high-rise buildings, parking garages, infrastructure etc.). More construction leads to more excavated soil from construction work sites and therefore more alternative fill material for land reclamation.

Population growth combined with welfare leads to more consumption and more waste production. There is more money available for technological innovations. The higher life standards demands adequate SWM system and more environmental responsibility. Leading to more processed waste and dredged sludge due to the widening of the city's channels and so resulting in the production of more alternative fill material for land reclamation. This scenario is the most favorable for the use of waste as alternative fill material within land reclamation projects.

The causal loop diagram below shows the positive loops created by this scenario.
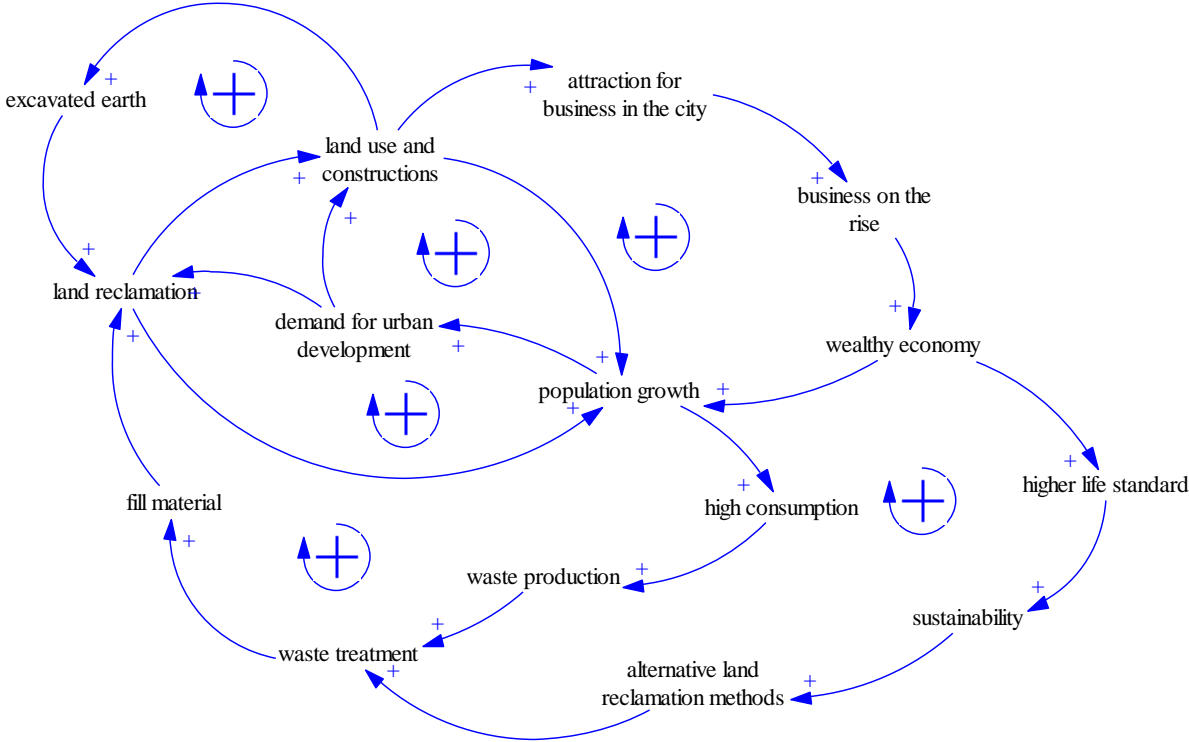
Figure 5: Causal loop diagram of the strong economy and population growth scenario

FURTHER RESEARCH
Furthermore, further research is recommended on:
- the governmental and social acceptance of the whole plan, and the willingness of the stakeholders to participate;
- the availability of fill material in the near future (construction waste, mountain soil, excavated soil and sludge);
- the strengthened sediment application process in this particular case and the willingness of the stakeholders to opt for this technology;
- a detailed cost and benefits situation and investment strategies among the shareholder

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Those last months of research have been very interesting with lots of interesting discussions and learning moments. I hope this research can contribute the challenge towards sustainable waste management and responsible land reclamation in Jakarta.

Curriculum Vitae

Sep 2010 – now	Master Construction Management and Engineering (Urban development) at the Eindhoven University of Technology (TU/e)
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Aug 2007 – Jun 2010	Architectural Engineering Business at the University of applied sciences of Utrecht (Hogeschool Utrecht). Graduated on June 2010.
Aug 2003 – Jul 2007	MBO Bol 4 Construction, Design and Architecture at Mondriaan Education in The Hague. Graduated on July 2007.

Work experience

Sep 2012- present	Graduation research on the use of waste as fill material in the land reclamation projects of Jakarta within Witteveen & Bos.
Feb – Jun 2010	Two (bachelor graduation) researches on (1) Sustainable Development within the Dutch Institute for Building Biology and Ecology (NIBE) and on (2) Collective Private Commissioning (CPO) within The Kok & Partners.
Feb – Jul 2009	Internship as assistant project and process manager at Smitshoek Melles & Partners.
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CORE BUSINESS: SEIZING OPPORTUNITIES IN RISK MANAGEMENT
A generic Fuzzy Logic prediction and Monte Carlo simulation method

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ABSTRACT

Implementing innovations and extending the core business increases both project opportunities and threats. Securing profit margins requires construction companies to redevelop their risk management process to prevent threats and promote opportunities. This research provides a renewed risk management method based on theory and practice. The traditional definitions terms involved with risk management are redefined and a framework is proposed using the definitions as restraints. In turn the activities in the framework are used as outline to create a supportive tool composed of the risk analysis and risk management principles. The main activities encompass identification, assessment and development of control and response measures. The assessment is supported by a combined fuzzy logic prediction system and Monte Carlo simulation tool to provide each risk with impact characteristics in terms of money and time. The renewed method provides a verified and validated approach to increase internal implementation and external application of risk management.

Keywords: Risk analysis, Risk management, Fuzzy logic, Monte Carlo simulation

INTRODUCTION

Risk is commonly seen as threat, it equally provides plentiful opportunities to differentiate the organization relative to the competitors creating a competitive advantage. Obtaining that advantage relies on identification and management those risks. Such an advantage expresses itself in e.g. better cost control, solution driven design practices and the ability to implement innovations. Recently lots of attention has been developed towards innovative forms of collaboration. Integrated collaboration between different disciplines is deployed in an increasing manner by both clients and contractors. Most of the research regarding risk management is descriptive-driven, lacking the generation of pragmatic and prescriptive results (Staveren, 2009). Rather than developing a new methodology, this research aims to adopt the method as proposed by Alaneme and Igboanugo (2012) and Nasirzadeh et al. (2008) and altering it to fit the current developments in practice generates an academic approach with practical applicability. Simultaneously, the method will encourage and urge the market to adopt integrated contracts providing flexibility, sustainability and durability for current and future projects by seeking out opportunities and accepting risks responsibly.

CONTEXT

According to Zook and Allen (2001) is '*the foundation of sustained, profitable growth a clear definition of a company's core business*', a statement which is gaining foothold in the construction market. Clients are increasingly desiring a facility that will guaranty the ability to focus solely on their core business activities (Fleuren, 2012; Titulaer, 2012), resulting in a paradigm shift for construction projects. New ways are being sought to raise the level of environmental and economical performance whilst simultaneously raising the quality of the facility. Achieving these goals means extending the definition of the construction market to include conception, construction, operations, retrofitting and maintenance of the build environment (ECTP, 2005). Rather than reducing the activities, the construction market needs to extend its core business. Normally risks are regarded as an inherent aspect of the market, thinking in and seizing of opportunities is still perceived as a distinguishing feature (ING Economisch Bureau, 2012). Opportunities obtained by extending the core business, lead to new profit margins. These margins are small thus need securing via proper risk control measures. Developing and deploying these measures relies on proper risk management (RM). Though the responsibilities increase once extending the core business, it also enlarges the influence which can be expressed on the risks. With this influences comes the possibility to improve the business' RM.

Improving the RM requires a grasp on status quo, hence this research has been conducted at Heijmans Non-residential (Heijmans Utiliteit). Operational processes need improvement to maintain the momentum of the integral advancement. Such improvements include cost reduction, process improvement and selecting projects based on margin rather than volume. Due to this focus, Heijmans provides a suitable platform and subject to conduct research regarding RM. Based on the centre problem of this research how to secure profit margins bij managing (core business extension) risks, the following research question was devised: '*How should Heijmans either improve or redevelop their risk management (RM) method to achieve the desired increase in internal implementation and external, commercial application*?' This question indicates that the current method doesn't function as desired. Effectively foreseeing in the aim of either improving or redeveloping first requires the identification and analysis of the problems that led to this non- or dysfunctional state. Hence the current method's components were assessed through interviews with the users, workgroup discussions and a *within case study* of the functioning, stating the following causes:

- Risk over opportunity: Due to the traditional perception of risk as a negative element the overall RM process focuses on the risks rather than the opportunities, leading to an unequal focus-division between risks and opportunities;
- Limited iteration: RM involves feedback processes from the developed measures towards the original design and management of the activities, the iterative process that allows for such feedback is hardly present let alone applied;
- Reduced team effort: Although RM is supposedly a collective team effort, due to insufficient knowledge users are incapable of providing a uniform team effort indicating the need for a redevelopment or improvement of the supporting tool;
- Shortcoming strategy: Without an overarching strategy RM has no predefined purpose, through a strategy RM can be deployed to identify specific opportunities and risks adhering to the clients expectations, allowing for result validation.

RISK CONCEPTS AND DEFINITIONS

In the current RM the emphasis is placed on risks as a negative entity instead of a supposed equally divided perception between risks and opportunities. Redeveloping Heijmans' risk management requires an understanding of the basic concepts, negating the subjective perception with clear definitions. The concepts are assessed through literature study, gathering, analysing, comparing and selecting applicable knowledge. The target is to obtain applicable definitions of these concepts serving a basic understanding and stimulating a positive perception. Among the many studies regarding risk management, the most common definition of risk proposed by for instance Jaafari (2001), is the exposure to loss or gain. This exposure in turn is described as the probability of occurrence of loss or gain multiplied by the magnitude of its impact. Probability ranges from 'certain events' with an occurrence rate of 100%, to events with a non-occurrence rate of 0%. Uncertainty indicates the varying probability of occurrence of events in the range between these two extremes (Jaafari, 2001). The outcome of the assessment proved however that the traditional perception and explanation of the concept risk to be inapplicable. Combining the findings led to renewed definitions for the terms risk, threat and opportunity. Risk indicates the likelihood of an event occurring, regardless of the nature of this event. An event with a positive gain for the project's objective function is called an opportunity, negative gain indicates a threat. Combined, 'opportunity and threat' are interchangeable with the concept 'risk', henceforth the leading definition for 'risk' in this research. Risk analysis (RA) and RM are required processes to seize opportunities and mitigate threats. RA foresees in the process-based activities needed to obtain all information regarding the origin, influence and likelihood of project risks. Based on this information, suitable response measures are developed to promote opportunities and mitigate threats. RM is the systematic implementation of the response measures. Due to the dynamic nature of project risks, RM adheres to a cyclical structure to provide a continuous, iterative process.

RISK MANAGEMENT FRAMEWORK

In order of structuring the process of RM and the necessary activities, a framework is devised. Embedding the renewed RM concept definitions provides an outline and direction for these activities. The framework should also foresee in the ability to implement actions developed to either promote or prevent risks, requiring an iterative process for continues feedback. Through literature studies and cross-comparison, the market's current and prevalent methods were assessed to obtain applicable elements for the framework. With the outline in place, a structure can be devised. In turn, activities are identified and assessed from which suitable activities are selected and placed in the structure, resulting in the proposed RM framework as shown in Figure 1**Error! Reference source not found.**. The main thought is to create a process that provides information regarding the identified risks in an increasing manner. At the basis of the framework lie the RA and RM principles resulting from the RISMAN method; aside from its current implantation, this method also allows for complete and proven integration in the overall project process. The activities embedded in the framework, are selected to create an unambiguous process with a clear stepwise procedure negating perceptive subjectivity. The RA principle, the underlying activities and subsequent products create a linear process of risk identification, assessment and response development. During these activities the equally divided focus on opportunities and threats can be monitored. The RM principle activities provide continues updates for the PMP,

ensuring the iterative process nature. The proposed framework structures all activities in an initially linear and continuous iterative process.
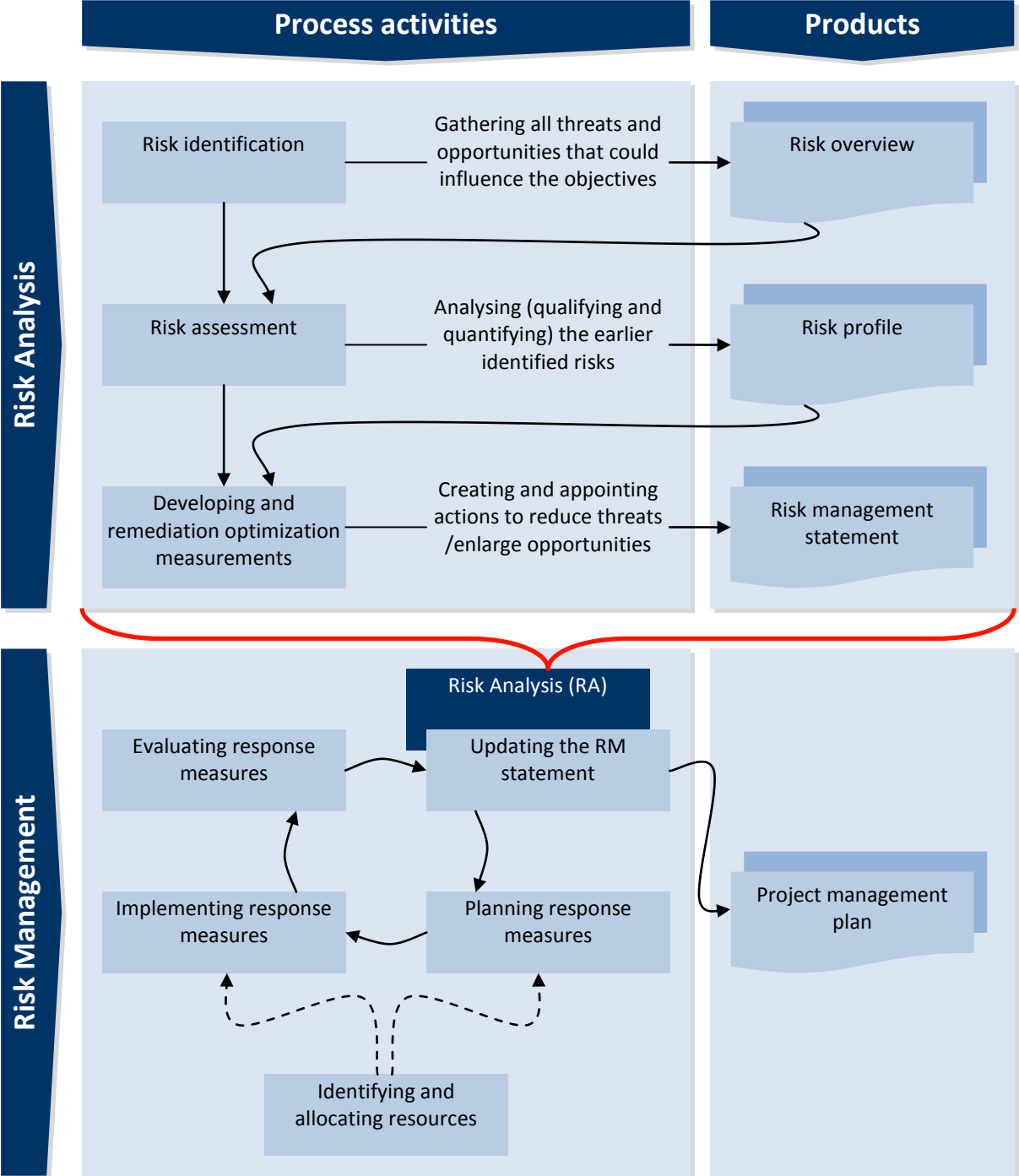
Figure 1: Proposed RM framework including the selected activities and products embedded in their respective RM principle; the framework focuses on the internal process, hence the overarching strategic step is, currently, omitted.

FRAMEWORK BASED TOOL

Working with the proposed framework foresees in an activity based stepwise process structure. Engaging in the process with the activities as a baseline provides an unambiguous approach, clearly stating the purpose and aim of every step. Following the purpose and aim, information is gathered during every step with an increasing amount of detail. This

information needs to be stored in an equally structured manner to prevent loss of knowledge and to promote traceability. Such a manner is provided through a tool in which the information can be stored. Simultaneously, a tool will also support and secures the stepwise process structure by defining which information needs to be gathered to complete each step. With the framework as outline for the tool, the tool itself is created with suitable methods selected through literature studies with comparable subjects or applications. The main aim is to create a tool that provides the process with a simplistic structure, thus making it understandable and applicable for every user. The outcome is an Excel based tool in which each step represents the identified activities in the framework. Information gathered in the steps is stored in the documentation scheme of the tool. With every increase in information, the following product-type is produced. Leading are the activities from the RA process, with their aim and subsequent information defined as following:

Risk Identification
The first activity is documenting the basic identification consisting of the description, nature, category (discipline based) and status. For sakes of traceability, each risk also receives a number, tag and the editor of the risk is obliged to note his name.

Risk assessment
Following the risk information transferred from the identifcation, this activity aims at defining the risk characteristics in terms of the factors 'money' and 'time'. Whilst defining these characteristics, the editor has to indicate whether he or she is certain regarding the values of these characteristics. In case the editor is certain, the expected impact in terms of money (€) and planning (calendar days) can be documented. When however the editor is uncertain of these values or there is no knowledge present, the impact in terms of 'money' and 'time' can be estimated using Fuzzy Logic. The editor indicates his or her estimation regarding the impact of the risk on the input factors 'quality, environment and safety' in terms of percentages; 0% means no impact and 100% means maximum impact. These values are treated as input for the fuzzy risk magnitude prediction system based on a Mamdani fuzzy control system. The input passes through fuzzification, rule base-inference and defuzzification to obtain the output values (Nasirzadeh et al., 2008). First the input factors quality, environment and safety are qualified through linguistic descriptions. For this transformation the Likert 5-point attitudinal scale was applied, providing each factor with the scales 'limited, small, average, large and major' (Alaneme and Igboanugo, 2012). For each description, a triangular distribution is provided based on expert knowledge, resulting in a triangular fuzzy number (TFN). For this research 20 experts with different professions were approached within Heijmans to gain a broad insight. In total 8 experts responded to the questionnaire, providing the estimations for the TFN's. Though insufficient for proper calibration, the gathered figures where used as input for the following functions:

$$A_i = (x_{min}, x_{mean}, x_{max}) \ where \ A: y(x) = (ax + b) + (cx + d) \mid x \in x_{min}, x_{max} \qquad (1)$$

Where A=TFN; i=ith TFN for each factor (i=1,2,3,4,5); x_{min}, x_{mean} and x_{max} are the minimum, mean and maximum values for the TFN; a and c describe the slope of both sides; c and d describe the point where the function cuts the y-axis for y(x)=0. Combining this TFN-function with the linguistic descriptions and the expert estimations results in membership functions for both the input and output factors. Figure 2 displays such a membership function for the
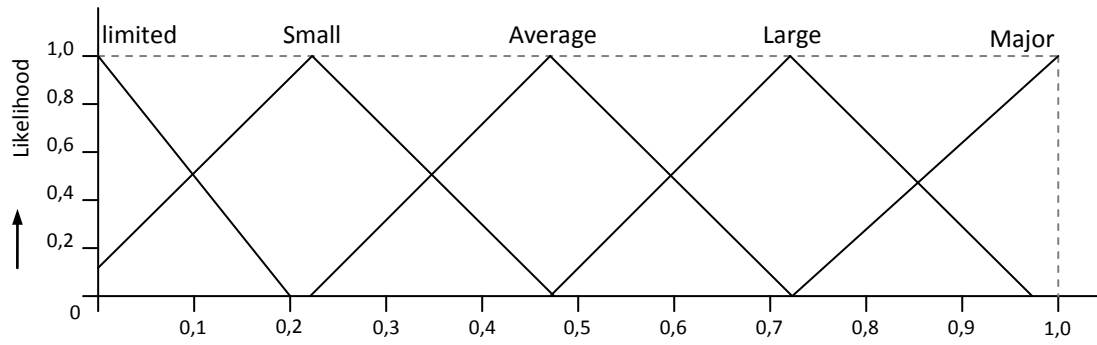
Figure 2: Visualization of the membership functions of the TFN's in the factor Quality

factor 'quality'. Nasirzadeh et al. (2008) state that '*the rules connect the input values with the output values and are based on the fuzzy state description that is obtained by the definition of the linguistic descriptions*'; e.g. if input TFN A:y for a given x, then the output TFN U is stated with y x $\in$ (0,0;y(x_A)]. This approach in which the output TFN is limited with the input factor's degree of fulfilment (α) is called the minimum-method, also known as the MAX-MIN-inference (Schulte, 1994). This inference is operated through logical if-then functions. Experts were requested to estimate the impact in terms of money and time for every input factor's linguistic descriptions in percentages relative to the total construction cost and total project duration. After the inference, defuzzification is performed, altering these input factors into crisp value outputs for the factors 'money' and 'time'. Nasirzadeh et al. (2008) proposed the use of the 'centre of area (COA) method' for the defuzzification:

$$x^{COA} = \frac{\int_x x*y(x)dx}{\int y(x)dx} \tag{2}$$

Where x^{COA} = the x-value of the COA, thereby the crisp value risk characteristic of that output factor; and y(x) is the membership function of the TFN in subject. Performing this calculation, the degree of fulfilment of the input factor should be taken into account. Substituting function (2) in this function and taking into account cases where a single inference relates to multiple output factor TFN's for a single α, results in a single adjusted membership defuzzification integral:

$$x^{COA} = \frac{\int_x x*y_1(x)dx}{\int y_1(x)dx} + \cdots + \frac{\int_x x*y_n(x)dx}{\int y_n(x)dx} \mid n = 1,2,3,4,5 \tag{3}$$

$$\bar{x}^{COA} = \sum_{i=1}^{m}(x_i^{COA})/m \tag{4}$$

Where n = the total number of TFN's implied through inference. But not only the output factors can encompass multiple TFN's, the same goes for the input factor TFN's. If that case should arise, the crisp value for each separate input factor TFN can be calculate through inference and defuzzification, after which the crisp values are added and divided by the total number of values thereby providing the average. This is provide in function (4) where m = the total number of input factor TFN's defined by the input value. The extend of membership, y(x), determines the α for each input factor TFN; since the x^{COA} of every defuzzification is calculated using the different α's, a weight factor is included into the overall calculation. Through this intricate prediction system, uncertain risk characteristics can be estimated based on the size of their impact.

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Control & response measures

With the characteristics known, suitable control proactive measures are developed to promote, increase or obtain opportunities and to prevent, mitigate or transfer threats. The editor needs to document the control measure description, target department, control owner, control cost and the control measure success likelihood category. The latter is a category-based aspect, defining how successful the developed measure will be when implemented. This success likelihood has been divided into the categories (SLC) 'Likely, Doubtful and Unlikely'. Actual values in percentages will substitute these linguistic descriptions later on, but defining these values is a task given to the decision making unit (DMU). In case a control measure has not been developed or is not successful, a response measure is required when a risk does manifest itself. The information documented for these reactive response measures is identical to that of the control measures, minus the control cost (these are incorporated in the expected risk budgeting and planning impact) and the SLC. Prioritization is provided by filtering the risks on the expected risk budgeting and planning impact. Risks with a high budgeting or impact might require more urgent attention, especially if the SLC is considered 'Unlikely'.

Risk management statement (RMS)

Once all risks are identified and assessed, they are statistically summarized. This summary displays the number of opportunities, optimizations or threats in each SLC, subdivided into the discipline categories. This provides an overview of the total number of entities for each specific risk nature and how likely these risk are managed during the RMP. Their individual characteristics are altered into a expected total impact spread for both 'money' and 'time'. For the latter the DMU first needs to identify the values for the SLC's, serving as input for the Monte Carlo simulation (MCS). This MCS provides the minimum, maximum and mean expected budgeting and planning impact for the entire project, documented as scenarios. Based on this expected spread the DMU can then determine the degree of risk acceptance, calculated through the confidence interval:

$$\bar{X}_{max} = \bar{X} \pm z\frac{\sigma}{\sqrt{n}} \tag{5}$$

Where $\bar{X}_{min}, \bar{X}_{max}$ are the minimum and maximum boundaries of the confidence interval respectively; $\bar{X}$ is the calculated mean from the MCS; z is the cumulative probability adhering to the confidence level P=(100-P^{-1}), derived from the statistic t-table (Nieuwenhuis, 2009); σ is the standard deviation MCS; and n is the number of simulations performed in the MCS. The planning impact is altered into values for the factor 'money' based on client discounts or contractor bonuses, finally prompting the risk-acceptance adjusted total project risk budgeting, explained as spread with a minimum, average (expected) and maximum value. This final value is compared to the project margins by the DMU to determine the net return on the project.

VERIFICATION AND VALIDATION

For the purpose of verifying and validating the developed tool two cases were assessed. For the verification several energy-management risks were conceived and implemented. The project which has been selected to serve as case for the validation (from this point onwards indicated as '*project*') is a combined tender for both the construction and installations. The

project cost are in between €37.500.00,- and €42.500.000,-, with a size between 40.000 and 50.000 m^2 and the duration of realisation has been assumed at 300 working days. For the documentation a price of €40.000.000,- has been assumed. All risks identified using the former (currently applied) model are transferred to the RMS of the renewed tool.

From the RMS the basic statistics can obtained fairly easy. In the project 4 opportunities, 7 optimisations and 50 threats have been identified. All opportunities' SLC's have been assumed likely and are estimated at a total of -€443.765,-; for the optimizations the estimated outcome is -€1.444.071,- with the measures mostly assumed likely, and; the total unadjusted impact for the threats is €8.159.097,- with half of the measures perceived as likely and nearly the complete other half as doubtful. From these figures, as shown in Figure 3, it becomes clear that the emphasis should be placed on reducing and mitigating the project's threats.
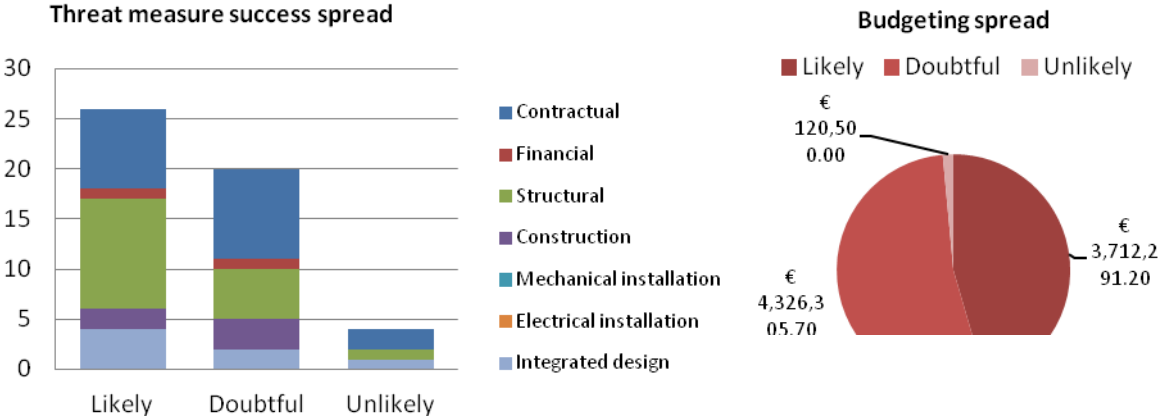
Figure 3: Outcome of the SLC's and budgeting for the threats in the validation case
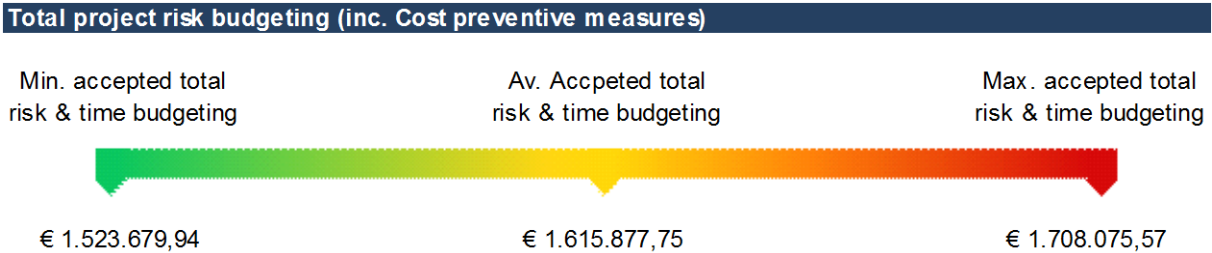
Figure 4: Total risk budget spread, adjusted to the planning impact and acceptance

For the risk features on the entrepreneurial summary, the following values have been given: Likely 90%, doubtful 50%, unlikely 10%; money-risk acceptance 10%, time-risk acceptance 5%. These initially broad boundaries have been selected since scoring the project is of importance for installations, nevertheless has the acceptance for time been reduced due to the hefty fine on project overrun; this fine is €5000,- per calendar day, no bonus present. These values have led to the total project risk budget spread over 1.523.680,- for the lower bound, 1.615.878,- for the expected value and 1.708.076,- for the upper bound, shown in Figure 4. For the source documentation the unadjusted risk budget was assumed at 1.450.000,-, seemingly close to the expected risk budget as proposed by the new tool. However, the old method relied on the assumption that risk should be quantified by multiplying the size of impact with likelihood, thereby ending a risk budget of €60.000,- (!) on a project of €40.000.000,-. The outcome of the new tool indicates that the proposed risk

budget makes up 4% of the total project cost and effectively covers half of the margin limited to 8%. This indicates that projects proposes a mediocre risk for the organization; margins will be small but present leading to profit. Maintaining this profitability strongly depends on successfully implementing the optimizations, simultaneously it is recommendable to direct some additional attention to the threats placed within the SLC doubtful.

CONCLUSION AND RECOMMENDATIONS

The renewed method with the concept definitions, process structure framework and supportive tool, foresees in an increase in both internal implementation and external application. Internally the users, ergo personnel and management, are handed a simplified and holistic method that provides a stepwise process structure and adhering documentation. Working with one uniform, easily understandable method, the users can now direct their focus towards the actual process rather than trying to understand the process. From a managerial standpoint the method increases traceability, thereby increasing the ability to steer and control the process. This combination of target-focus and control through traceability will increase the internal implementation of the tool. As a direct result of the internal increase of using the renewed method, a more detailed and well documented overview can be created from all risk entities in the project. From this overview insight can be gained on how and where to create added value for the client, increasing the quality and overall customer value. This is an improvement of the external, commercial application for a single project. On long term, the increased grasp on the risks influencing each project and the ability to excel in the creation of added value, resulting in a competitive advantage. Regarding the core business extension, the renewed tool is generic to such a degree that whatever the nature might be of an identified risk it can be documented and assessed. Due to the ability of quantifying both certain and uncertain values, it makes no difference whether previous knowledge or understanding is present in the project team or overall organisation. Applying innovations and gaining from their benefits therefore becomes an opportunity rather than a threat.

Though the research has provided a holistic RM method, is was also a first attempt at combining the theoretical methods with the practical notions and experiences of engaging in RM during the entire project life cycle. Recommendations can be made regarding the developed RM method and the applicability and possible future directions subsequent to or in conjunction with this research. Due to this being an early attempt, additional research might be desirable to e.g. provide extensive validation and calibration of the tool. The foremost recommendations when continuing the research with the developed method is 'validation, verification and calibration'. The current model functions, but several assumptions were made, e.g. the factors. Additional research can be performed regarding those factors, their values and the calibration of these values. Naturally, with made adjustments comes the necessity of (extensive) validation and verification, preferably in real life ongoing projects. Continuation of the research points to the implementation of either System Engineering (SE), chain management or database development. First SE allows to link risks directly to the element upon which they express their influence or by which they are influenced; when an object is handled or altered in the SE environment, the adhering risk automatically shows, providing extensive insight per risk. Second, developing chains of succession and analysing the subsequent impact of each entity in the chain, allows to

determine where the biggest impact stems from in the system. If a single risk event is leading for all other risks in the chain, it is far more efficient to focus on controlling that specific risk rather than trying to control all risks separately. Third, storing all information gathered in previous projects provides durable data creation. A database provides this storage ability and reuse for future projects, leading to a further increase of efficiency for the process in total, in turn supporting the profitability and the creation of added value.

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Risk management as research topic proved to be a versatile and complex subject, but the experience at Heijmans gave good insight in both the necessity and usefulness of risk management in the dynamic, innovating and integrating construction market.

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TRANSPORTABLE CO$_2$-NEUTRAL HOUSES FOR ONE-PERSON HOUSEHOLDS
How to house one-person households in CO$_2$-neutral dwellings on vacant land positions in The Netherlands?

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August 28th 2013

ABSTRACT

The housing market in the Netherlands is locked. Vacant land positions prove to be unmarketable and customers' in secureness is high which results in little movement of residents. Increased individualization affects the formation of households and renting has become more popular among starters than buying a house is. Construction company Heijmans seeks for possibilities to use their vacant land positions. A transportable CO$_2$-neutral house to accommodate one-person households is developed in close collaboration with professionals. This design is presented to respondents in an online discrete choice experiment. The preferences of respondents gave improved insight in important attributes of the draft design. These will be further elaborated on to translate the draft design into a final design which is to be build prefab and to be placed on various locations throughout the Netherlands.

KEYWORDS

Dutch housing market, Discrete Choice Experiment, rise of individualization, CO$_2$-neutral dwellings, one-person households, vacant land positions.

INTRODUCTION

There is little movement of residents on the Dutch housing market as few houses are built or sold and the number of sold houses is historically low. Uncertainty and fear about near future developments dominate consumers' feelings. Politicians are unclear about their intended line of policy. Financial markets are not showing improvement either. Banks are careful with lending money to both starters on the housing market as well as for the development of real estate projects, as their returned profit is not as certain as it used to be. The level of unemployment has risen to 6,6% and is expected to reach 7,1% by the end of 2014 (www.oecd.org). Less people generate a steady income of which they can afford their mortgage or monthly rent. Few signals indicate improvement on the job market, which results in little motivating prospects for the housing market. Furthermore, consumer

confidence dropped historically since July 2011, (Dutch Central Statistics Office, CBS). Increasing energy prices drive up the overall housing costs for residents. Along with that, the trend of increased individualization is noticeable in the Netherlands. This results in smaller households that generate less income to afford their accommodation.

PROBLEM DESCRIBTION

One-person households experience difficulties in finding suitable accommodation as there is a lack of accommodation that meets their financial possibilities. The company of Heijmans owns vacant land position, which they need to exploit in order to make them profitable. The central problem within this research involves these two viewpoints: It is unknown to the company of Heijmans what the requirements are for housing one-person households in CO_2-neutral dwellings on vacant land positions in the Netherlands.

RESEARCH PURPOSE

Two positions of stakeholders on the Dutch housing market have been taken in consideration. The aim of this research is to bridge the gap between the position of Heijmans, having vacant land positions in stock, and the needs of a growing group of potential customers, being one-person households. A business plan will be produced to be able to link the demand with a feasible business offer as the home seekers can be accommodated on the vacant land positions. This research provides an overview of residents' preferences regarding a proposed draft design of a one-person dwelling. A business proposal will be presented which is beneficial for both Heijmans as well as for one-person households in search for accommodation. The company and potential residents then help each other as they jointly create a new reality that is profitable for both parties.

RESEARCH QUESTION

The central research question is derived from the main problem: What are the requirements to house one-person households in CO_2-neutral dwellings on vacant land positions in the Netherlands?

RESEARCH LIMITATIONS

The scope of this research is limited to the elements needed to present a feasible is business plan, as this is the actual output the company is requesting for. Also a scientific methodology will be used to underpin certain components of the business plan. The research will be limited to the Netherlands as Heijmans operates only nationally with their division of Real Estate.

RESEARCH APPROACH

The research approach, captured in figure 1, provides an overview of the steps taken within this research. The graphic is to be read from the left to the right. Blocks on the left provide the input needed in adjacent blocks in the subsequent column.
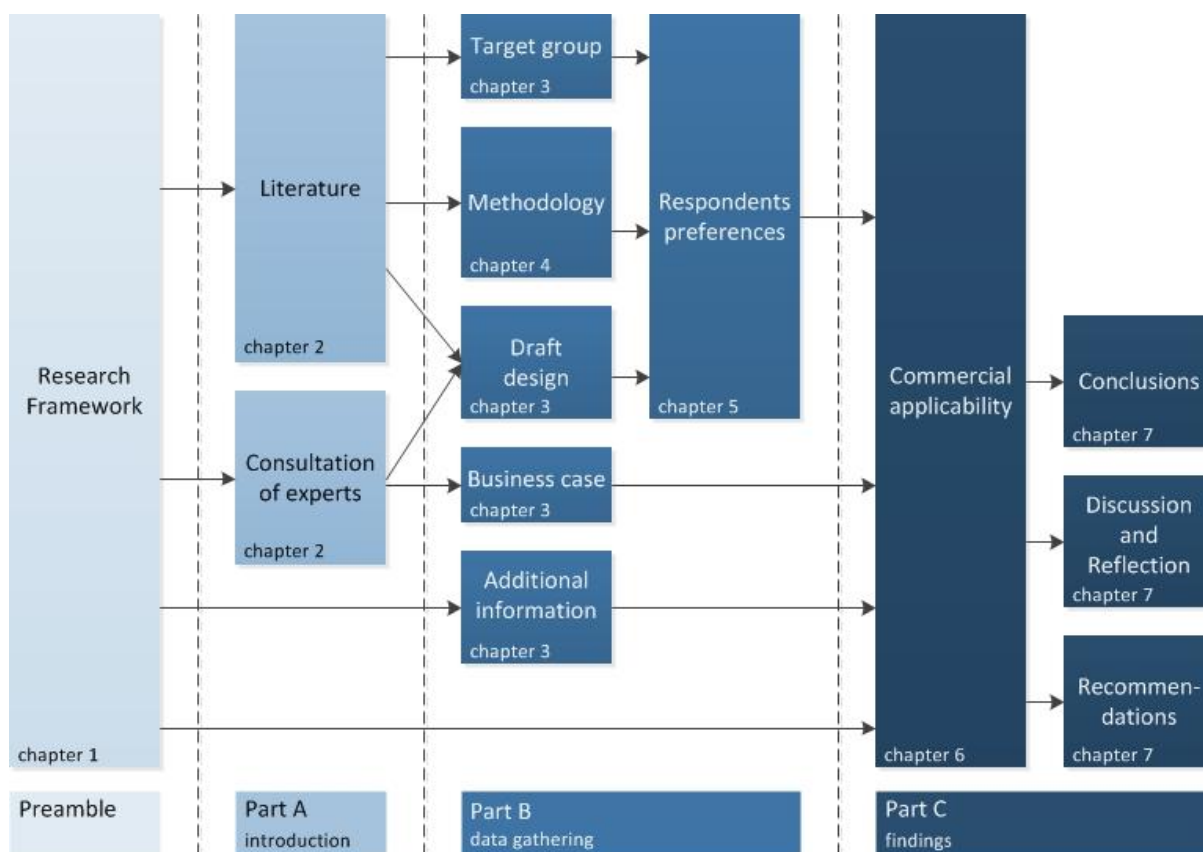
Figure 1 | research approach

The research can be divided into three main parts. Part A provides an extensive introduction on the research topic based on literature and the consultation of experts (chapter 2). The topics covered in the literature study are the Dutch housing market, the rise of singlehood, energy consumption of (one-person) households, and consumers' values regarding their accommodation.

Part B is used to elaborate on various components that eventually result into an integrated business plan. Chapter 3 elaborates on the target group of the business proposition, the generated draft design that is developed in order to research respondents' preferences and the associated business case. The methodology of discrete choice experiments (DCE) is used within this research. This will be discussed in chapter 4. Both the developed draft design and the specific methodology of DCE are used to undertaken an online survey. Chapter 5 will capture this research on respondents' preferences regarding the draft design.

Eventually, part C holds all findings. Part C presents the integral business plan (chapter 6) on housing one-person households in transportable CO_2-neutral dwellings on vacant land positions. Also the overall conclusions, the discussion and reflection and recommendations are included in part C (chapter 7).

LITERATURE STUDY

The current housing market shows a decrease of newly built houses. Renting a house becomes more popular for starters instead of buying a house. As values like freedom and

self-expression have become increasingly important, and people become economically more independent, individualization is on the rise. It is expected that half a million one-person households will add to the total of households within the upcoming twelve years (until 2025). All these people will be in need for suitable and affordable accommodation. It is expected that the current housing stock, which mainly consists of one family houses, does not meet the needs and financial possibilities of all these new households. Affordable housing accommodation is requested, especially for single starters on the housing market.

As current market conditions do not show improvement on the short term, it remains difficult to develop permanent buildings on vacant land positions. Still, temporal solutions might be a feasible alternative. Buildings can be temporally placed on vacant land positions for a maximum stay of five years, based on a temporal building permit. Temporal and compact accommodation could be an adequate alternative to satisfy the needs of one-person households in search for affordable accommodation.

Policy makers have improved awareness about the energy consumption of buildings, as the built environment accounts for a large share of all CO_2-emmisions. Residents prefer technical improvements of their dwellings, rather than they have to change their behaviour or consumer pattern. These findings make it worthwhile to emphasize on the development of CO_2-neutral houses.

As consumers identify themselves with products or services that touch upon their personal values, it is of essence to consider the impact of values within any type of industry. With designing a specific accommodation, it is worthwhile to take in consideration the values of one-person households (bases on Rokeach 1979). These can include the need to feel free and to live a comfortable life (terminal values) as well as having self-control and being independent (instrumental values). Architects and real estate developers can use values as guidance in their design process.

DEVELOPING A TRANSPORTABLE CO_2-NEUTRAL HOUSE

A housing concept that is tailored for the needs of single starters could be the starting point of a feasible and profitable business plan. As affordability and sustainability are important topics on the housing market nowadays, these aspects should be elaborated within the concept. This can be done to equip houses with photovoltaic panels and solar water heaters that arrange electricity and warm water in an environmental friendly and cost effective way. By doing so, residents can also save seriously amounts of money on their monthly energy costs.

A new integrated housing concept is not easily developed individually. Knowledge from various experts is needed in order to present a realistic proposition. Here for collaboration was sought with various professionals. This intense collaboration eventually resulted in a realistic draft design of a compact transportable and CO_2-neutral house that will be elaborated further on in an eventual business plan. The design is made of timber and is to be transported in two separated modules that are to be placed on top of each other on the eventual location. Photovoltaic panels and a ultra high vacuum boiler are used to generate the required electricity and warm water.

RESEARCH METHOD

Discrete choice experiment

Discrete choice experiment (DCE) is a research technique originally based in the field of economics. DCE's are distinct from other conjoint methods because preferences are elicited by asking respondents to choose one alternative from those presented, rather than to asking respondents to rank alternatives, or give them a rating. The goal of discrete choice experiments is to understand and model the behavioural process that leads to the respondents' choices (Taneva 2008). Over the last thirty years the technique became increasingly popular in all sorts of research fields, as organizations and businesses benefit from understanding and predicting the behaviour of decision makers when choosing among discrete goods (Hensher 2005). In 2000, Daniel McFadden won the Nobel Prize for economics for his pioneering work in developing the theoretical basis for choice modelling.

Discrete choice experiments have two components; the use of discrete choice analysis to model preferences from data and the use of experiments to generate the required data, eliciting stated preferences for products or programs (Viney 2002). Discrete choice experiments statistically relate the choice made by each person to the attributes of the person and the attributes of all of the alternatives available to the person. Discrete choice experiments are based on the Random Utility Theory (RUT), which is originally initiated by Thurstone, back in 1927. RUT provides an explanation of the choice behaviour of humans, which is applicable to this research. RUT assumes that all individuals will always choose the alternative with the highest utility.

A discrete choice experiment is a powerful tool for researching the preferences of respondent in hypothetical situations. DCE enables researchers to test the impact of certain aspects (attributes) of a hypothetical product or service. This tool can perfectly be used to research respondents' preferences regarding the proposed housing solution.

Data collection

Random individuals were able to complete the online survey, as the link to the survey was spread nation wide, through various channels. The provided information and the requested questions were kept to a minimum to make the survey as appealing as possible and to diminish the risk that people would terminate the survey before they would complete it. The language used is Dutch as the questionnaire is spread only within the Netherlands and there was no intention to specifically involve respondents who do not speak the Dutch language. In the first screen respondents were asked to participate. With some basic information about the chosen attributes and two images of the proposed transportable compact house, people were asked to fill out eight unique choice charts. Figure 2 shows an example of a possible choice chart.

■■■■■■■■■■■

Keuzeset - kies het alternatief van uw voorkeur:

kenmerken	alternatief I	alternatief II	geen van beide
maximale huurperiode	max. 5 jaar	max. 3 jaar	
energieprestatie	gemiddeld (label A)	laag (label B)	
afwerkingsniveau	gestoffeerd	gestoffeerd	
totale maandelijkse kosten	550 euro	650 euro	
woningtype	1 kamer appartement	1 kamer appartement	
gezamenlijke ruimte	zonder	zonder	
UW KEUZE:	◉	○	○

| vorige | | volgende |

Figure 2 | sample choice chart with explanation of the attributes.

CONCLUSIONS

Current market conditions prove the development of permanent buildings on available vacant land positions to be difficult. Still, or even therefor, temporal solutions might be a feasible alternative. Temporal dwellings may be placed on vacant land positions for a maximum stay of five years, based on a temporal building permit. Transportable houses can be placed on these vacant land positions to house people that otherwise have less chance in finding affordable accommodation. Investors will not have the risk of investing in permanent real estate that cannot be moved anymore. As the houses are transportable so they can be used in other locations, financial risks are minimized. After five years the temporal houses can be replaced to locations were they are needed more. In this way the transportable houses function as a temporal buffer on local housing markets. This can be in the Netherlands, but the houses can as well be transported to other countries, depending on the need for housing elsewhere.

Renting becomes more popular for starters instead of buying a house. Also individualization is on the rise in the Netherlands. Affordable accommodation is requested by one-person households. The next twelve years (until 2025) will add a half million (500.000) one-person household. All these people need to be housed and the current market provides little possibilities for this specific target group. About one seventh (+/- 71.000 people) of these 500.000 people are within the age group of 25-34 years. Many of them will find accommodation within the existing housing stock. Still, if only for 5% of these people a transportable house would be the ideal solution, then about 3550 dwellings could be realized over the next twelve years.

As our society has improved awareness about the energy efficiency of buildings, it has become worthwhile to emphasize on the development of CO_2-neutral housing concepts. Compact, transportable and CO_2-neutral houses could be an adequate alternative to satisfy the needs of one-person households in search for affordable accommodation. As the company of Heijmans (partly) owns about fifty vacant land positions, this idea is of great relevance for their organization. Their houses should meet the standard of being energy neutral. This can be achieved by making the houses all-electric, so no gas connection is needed. Electricity can be generated with photovoltaic cells on the roof. Warm water can be arranged with the use of a ultra high vacuum panel. Such a device is able to heat a dwelling as well as providing warm water to shower or to do the dishes with.

The online survey (n=280) that is performed to gather data about respondents' preferences provides hand on information on how a house should be configured in order to best meet customers demand. 75% perceived the proposed housing design as 'positive'. Respondents participating in the survey especially preferred alternatives with the maximum renting period of five years. Also an excellent energy label (A^{+++} label) has a great positive contribution to a certain proposal. It is worthwhile to invest in energy generating system beforehand as the can also result in lower monthly costs as the prices for energy is rising. A separate bedroom (2 room apartment) is also highly preferred above a studio (1 room apartment). Preferably, houses are padded and not furnished. Also no communal space is required, as respondents do not appreciate these extra offerings.

In short the conclusions can be wrapped as follows:

- There is a huge market for solo-living: 500.000 extra households in next 12 years (until 2025, CBS '13). About 71.000 of these will be in the category of 25-34 years of age;

- In order to present a healthy business case, the maximum cost per house should be €60.000,- all-in (transport, profit etc.);

- The building cost per house may be €38.000,- at maximum. The draft design is still €10.000,- over budget;

- A maximum renting period (5 years), having a separate bedroom and an excellent energy performance (label A^{+++}) are rewarded as being very important to potential renters. These aspects should be implemented in the final design;

- Respondents do preferably not require a communal space nor furniture.

DISCUSSION

Within the sector of real estate the slogan location, location, location is the holy grail. The question is what the fourth factor is that influences peoples' behaviour when they search for new accommodation. With reading about in secureness and weak prospects on both the housing and the job market, I personally believe that offering certainty would be a unique buying point (ubp) for potential residents. Instead of offering unique selling points (usp's), developers should act upon the actual demands of (newly arising) target groups. What is their position, what needs and (financial) possibilities do they have? And how can I help them with my business?

FURTHER RESEARCH

The methodology of discrete choice experiments (DCE) can be used to present to and to research on other housing concepts for potential residents. The company of Heijmans already started to organize open evenings so that potential residents can be asked about their desires and preferences for a certain building plot[1]. The use of discrete modeling can generate additional, more specific, information that could be of great value for the company and as well for policy makers, developers and designers. Using the internet to spread an online survey could reach a large number of people in no time. Heijmans has access to

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[1] Interactive evening with potential residents of the Dico plot, Uden. February 18th 2013.

various channels, their website, Twitter and Facebook accounts and additional newsletters to reach all sorts of target groups. With improved understanding of the preferences and desires of potential customers they strengthen their market position.

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ABOUT THE AUTHOR

R.J.M. (RUDY) VAN BEURDEN MSc
With this highly intensive and instructive graduation project I complete my time at the Eindhoven University of Technology. As I had anticipated, the last semester has been the crown on my entire studies. Various aspects, like market research, architectural design and managerial skills, came together to result in an integrated business plan. With this research report I strive to brighten the prospects of single home seekers on the Dutch housing market. Here, I would like to take a moment to thank my entire graduate committee, who most probably had some rough times with this stubborn graduate. Furthermore I would like to thank my parents deeply. They have always believed in me. And now I have achieved.

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EXPLORING SUSTAINABLE INVESTMENT BEHAVIOR OF THE PRIVATE HOMEOWNER – THE INFLUENCE OF NEIGHBORHOOD SATISFACTION:
A case study in the city of Eindhoven, The Netherlands

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ABSTRACT

When upgrading the existing housing stock, urging private homeowners to invest in sustainable improvements of their dwellings proves difficult. Can a neighborhood upgrade be used to urge private homeowners to invest? In this research, a relationship between neighborhood satisfaction and investment behavior is explored. A Bayesian Belief Network Model is used to find relationships between stated satisfaction levels, attitudes, knowledge, socio-demographics and indicated investment behavior, retrieved from a questionnaire released in selected case study areas in the city of Eindhoven, The Netherlands. An indirect relationship between neighborhood satisfaction and investment behavior is found, which forms the base of further research. Price consciousness of homeowners is found the biggest indicator of investment behavior.

Keywords: sustainable investment behavior; homeowners; existing housing stock; neighborhood satisfaction; neighborhood upgrade; decision model; Bayesian Belief Network; BBN; policy making.

INTRODUCTION

The worldwide energy use has increased the last few years and in the next twenty years, this will continue increase substantially. (Provincie Noord-Brabant, 2009) Not only the amount of households is increasing, but the average energy use per household is also increasing. This continuous increase in energy use poses a problem, because: 1) There are signs of climate change due to a rise in CO_2 emissions; 2) The fossil fuel reserves worldwide are decreasing; 3)Because of both previous reasons, the energy prices rise every year.

The combination these factors pose problems that have to be dealt with. The Dutch government, the province of Noord-Brabant and the Municipality all developed goals to deal with parts of these problems.

The Municipality of Eindhoven has the ambition to become energy neutral in 2040 (KENWIB, 2012). Fourty percent of saving potential comes out of the improvement of isolation and installation in existing housing stock. The existing housing stock is therefore the most important to improve.

The existing buildings stock in the member states of the EU accounts for 40% of final energy consumption in the European Union, and 63% of this represents the existing residential housing stock. (Poel, 2007) In The Netherlands, the built environment accounts for 30% of the total energy use (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2011). In the plans of all discussed parties. The biggest part of energy saving has to be gained from the existing housing stock with a low energy label, generally built before 1992. Corporations are already working on measures to update their existing housing stock. But the government cannot easily influence private homeowners to invest in energy saving measures to their own houses. Subsidy and information programs have been designed, but they still did not urge homeowners enough to make this important transition. The subsidy programs in The Netherlands are now being cancelled, which means new (and more effective) ways have to be found to urge homeowners to invest. That is why further research focusing on this target group is needed.

Research shows that homeowners that are satisfied with their neighborhood, will invest more in maintenance of his or her house (Galster & Hesser 1982). So when a homeowner is satisfied with his or her neighborhood the homeowner might be more willing to invest in sustainable improvements to his or her house.

That is why it may be plausible that there is a connection between neighborhood satisfaction (the link between the mentioned researches) and the level of sustainable improvements made to privately owned houses in this neighborhood. This connection will be explored in this research. If this connection exists, neighborhood upgrade can possibly be an extra incentive for private homeowners to invest in sustainable improvements of their houses and can be used as a policy tool by the local governments and municipalities.

NEIGHBORHOOD SATISFACTION
In our everyday life, the word neighborhood is used for multiple meanings and uses. A planning perspective views the concept of neighborhood as a subunit that builds the physical and social fabric of a city. Besides facilitating physical organization, neighborhoods serve as a means of social organization whereby, it is believed, interaction among residents is based on shared values and interests (Talen & Shah 2007).

There can be a difference between the general satisfaction and the total satisfaction outcome from adding the satisfaction rates from all different specific factors. (Lu 1999) describes that residents' judge their residential conditions based on their needs and aspirations. Satisfaction with the neighborhood therefore means that there is a high degree of congruence between the actual situation, the perceived actual situation and the desired situation of the resident. This also means that incongruence between actual perceived neighborhood conditions and wanted conditions lead to dissatisfaction.

Feijten & van Ham (2009) and Lu (1999) state that actual residential mobility can be seen as a mismatch between the residential needs and preferences a household has, compared to the characteristics of it's current residential situation, just as neighborhood satisfaction levels. So residents that are not satisfied with the quality of their neighborhood, are more likely to express an intention to move than residents that are satisfied (Parkes et al. 2002).

In addition, it is believed that residents that have a strong attachment tot their neighborhood may be less likely to move (Permentier et al. 2009). A relationship between the perceived neighborhood and residential quality and attachment was already generally accepted (Bonaiuto et al. 1999).

Part conceptual model
The sum of the evaluation of the different sub categories, together with the 'general' neighborhood evaluation, gives the neighborhood satisfaction and also a part neighborhood attachment. How much however each factor influences is not known. The influence of personal and household characteristics is visible in the perception, assessment and evaluation. A connection between neighborhood satisfaction and attachment is hypothesized, with neighborhood satisfaction predicting neighborhood attachment more. Both neighborhood satisfaction and neighborhood attachment are hypothesized to predict the wish to move. This is seen in Figure 1.
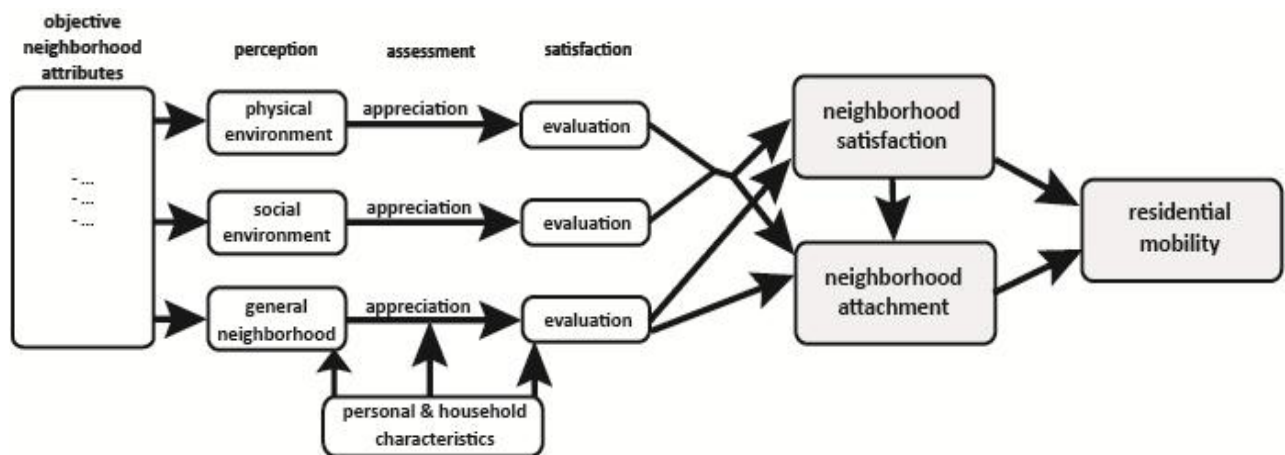
Figure 1: Part conceptual model

DECISION MODELS
To test the influence of the neighborhood satisfaction of residents on willingness to invest in sustainable improvements to their houses, it is necessary to identify the decision-making process and which factors also influence this. There are a lot of researches in the field of sociology and psychology that have tried to generate models for the decision-making process of humans on various different subjects.

In 1991, Azjen designed the theory of planned behavior. The central factor in this model is the intention to perform a behavior. The theory of planned behavior suggests that behavioral achievement depends on the combination of motivation (intention) and ability (behavioral control) (Ajzen 1991). Olander & Thogersen (1995) suggest a MAO model that includes "motivation, ability, and opportunity" Hansla et al. (2008) developed a model to

estimate the willingness to pay for green electricity within Swedish Households. This was tested by evaluating attitude (ATT), decreased with electricity costs and income. The attitude consisted of value orientation (VO), awareness of consequences beliefs (AC) and environmental concern (EC). The model proposed by (Han et al. 2013) is to test the influence of different forms of incentives on energy saving behavior of residents in Eindhoven and resulted in the identification of different target groups for incentives. This model is inspired by the MAO model and expanded to fit as energy saving behavior model. The model of Luijten (2010) places the attitude and knowledge as a direct influence factor on the buying behavior of consumers. Attitude in this model is formed by environmental awareness, price awareness, comfort and health. A positive attitude will increase the willingness to buy a new built house. This attitude is influenced by socio demographic and socio economic factors (Luijten 2010). This model is inspired by the model of Azjen (1991).

According to these models, the most important factors in decision-making are:
1. Attitude (Environmental Concern, Comfort, Health, Price Consciousness)
2. Knowledge (Aware of own energy use, Knowledge of sustainable improvements)
3. Socio Demographic factors (Age, household, education)
4. Ability (Income, payback period, height of investment)

Conceptual Model
In this model (Figure 2), the hypothesis of this research is inserted and marked as hypothesis. In this model, 'mobility' has a direct influence on the 'investment behavior'. 'Residential satisfaction' and 'residential attachment', influence 'mobility', as discussed. The direct influence of mobility on 'willingness to invest' is based on the fact that when a resident is planning to move, the attitude to invest can be present, but the resident can still decide based on the plans to move to postpone the investments to their new dwelling or even be motivated by the fact that the resident is moving, due to price consciousness. The second part of the model and the influences of 'attitude', 'knowledge' and 'ability' are derived from the discussion of the reviewed models. The socio demographic factors influence every variable in the model that influences the 'Investment Behavior'.
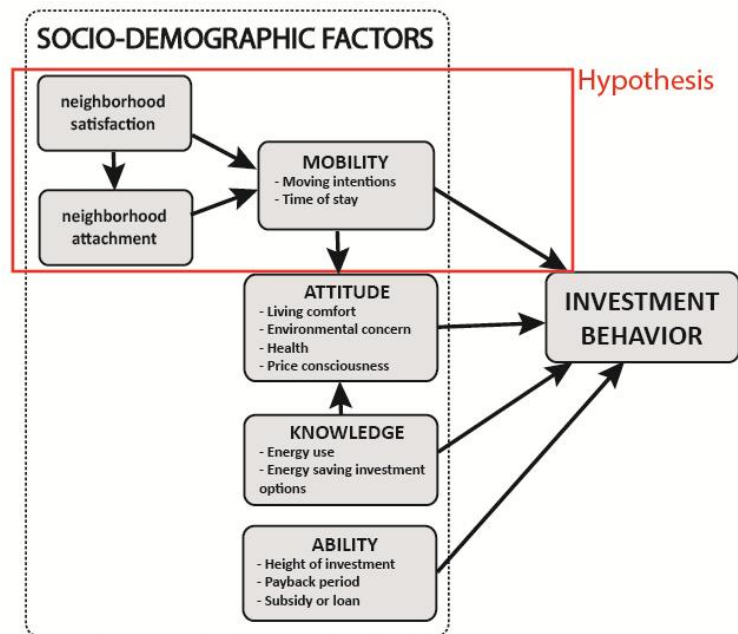

Figure 2: Conceptual model

METHODOLOGY
Choice-behavior often holds conditions beyond socio-demographics and just attributes of choice alternatives that influence the decision (Verhoeven, Arentze, Timmermans, &

Waerden, 2006). This is why a model is needed that allows estimating direct and indirect effects and allows testing of causal relations. For this research, a Bayesian Belief Network (BBN) model is used. BBN is an approach to probabilistic reasoning. The consequences of a decision or opinion are in many real life situations uncertain and also complex. It comes from combined work in the fields of Artificial Intelligence, Statistics, Operations Research, and Decision Analysis (Kemperman & Timmermans 2012).

The BBN is composed of a dataset of categorical variables. These variables are linked to show relations and interdependencies. A BBN network consists of several nodes that represent variables, and arcs, that connect the nodes and show the causal links between nodes (Verhoeven et al., 2006). Each node has an underlying conditional probability table (CP) which holds the data of how much a variable depends on its parent nodes (Kemperman & Timmermans, 2012). A parent node is a node from which an arc originates, while the child node is a node to which the arc links. Each state within a node has a certain probability that represents beliefs about possible outcomes. These beliefs can be updated when evidence is available, so when datasets are implemented for the nodes.

There are two ways to construct a BBN. These are: expert knowledge (based on literature and expertise) and network-learning algorithms. In this research, the BN PowerConstructor (Cheng, Bell, & Liu, 1997) is used to construct a network with a network-learning algorithm. Structural learning determines the (inter) dependencies of variables in a dataset and suggests a causal relation and direction. Parameter learning determines the CP tables of each node in the network, given the structure and data (Verhoeven et al. 2006; Kemperman & Timmermans 2012).

The network-learning algorithm is based on the three-phase dependency method (Cheng et al. 1997), Drafting the network, Thickening the network and Thinning the network.
Kemperman et al. (2012) describe the process as: In the first phase, mutual information of each pair of variables as a measure of closeness is computed and based on this information a draft network is created. The mutual information between two variables (X and Y) is defined as:

$$I(X,Y) = \sum_{x,y} P(x,y) \log \frac{P(x,y)}{P(x)P(y)}$$

where P(x) and P(y) are unconditional probabilities of X=x and Y=y and P(x,y) is the joint probability. The mutual information between variables X and Y measures the expected information gained about Y, after observing the value of variable X. This means that if two variables are dependent and the value of one variable is known, this will give information about the value of the other variable (Kemperman & Timmermans 2012). The model will be analyzed in Norsys Netica 4.16 (Norsys, 2012)

DATA
The case study area is the city of Eindhoven, The Netherlands. Two neighborhoods that have low neighborhood scores and two neighborhoods that have high scores opposed to the average scores of Eindhoven are selected. The average property value of the houses in the neighborhoods lie between €200.000, - and €275.000, -. The average property value of Eindhoven is €243.000, -, positioned in the center of this zone. This also makes the neighborhoods comparable on income levels and poverty rate. For the sample, only houses

built before 1992 are selected. Houses built after 1992 are often already very sustainable and are other than for sustainable energy systems not eligible for upgrading the house.

This results in a sample of 1237 households. The sample received an envelope, including an *invitation letter* which addressed the people to the importance of response from their neighborhood and mentioned the neighborhood they live in, a link to the online questionnaire and including a paper version of the questionnaire, for recipients that are not able to fill in the questionnaire online. The evaluation questions were composed using a five-point likert-type scale. A total response rate of 35,1% was achieved, resulting in a total of 434 surveys returned, of which 425 were valid to use in the BBN model.

ANALYSIS & RESULTS

Missing variables were taken into account in the model. The threshold of the accepted model is 0,7. A threshold of 1.0 is the default value. A higher threshold will result in less links and will leave the strongest links, which can be useful if the program produces too many links. A lower threshold results often in more links, of which must be kept in mind that some are less strong. In this model, the direction of some arrows are reversed, because the causality the other way around seems more plausible. All indicated relationships were accepted, see Figure 3.
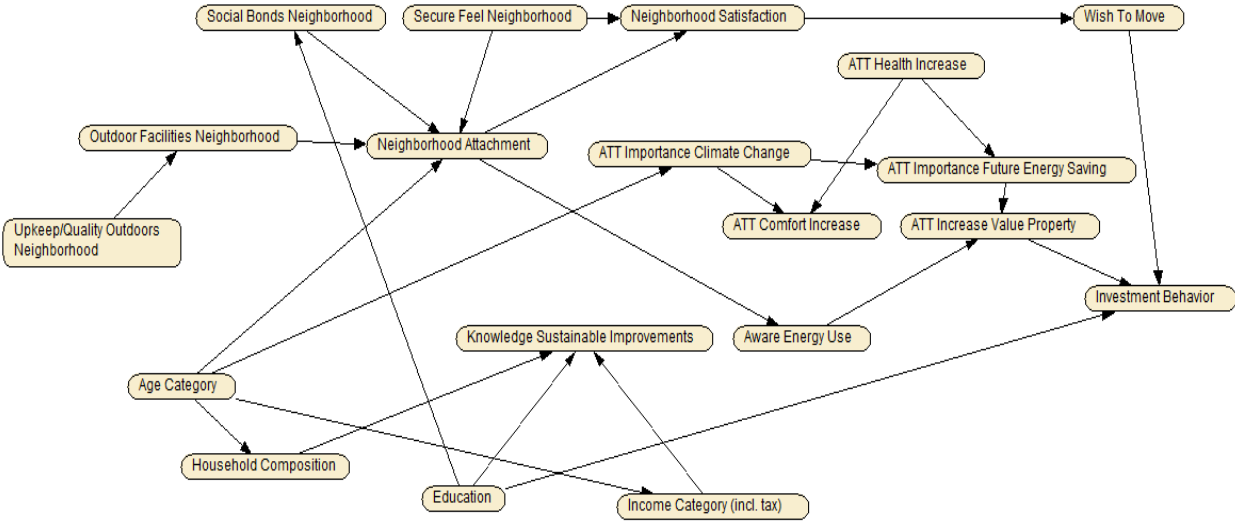
Figure 3: BBN Model

Results model structure

In this model a direct link as hypothesized is found between 'Wish to Move' and 'Investment Behavior'. 'Wish to Move' is again predicted by 'Neighborhood Satisfaction' and indirect by 'Neighborhood Attachment' and the neighborhood aspects. Socio demographics 'Age Category' and 'Education' show indirect effects. The attitude 'Increase Value Property' which is a price conscious attitude variable, is the only attitudinal variable that has a direct influence on investment behavior. The attitude for Comfort Increase does not seem to predict investment behavior. Of the socio demographic variables, only 'Age Category' has a direct influence on 'Importance of Climate Change' and indirect on the other attitudes except 'Health Increase'. 'Aware of Energy Use' is an indirect predictor of 'Investment Behavior', through attitude 'Increase Value Property'. Neighborhood Attachment again is considered a predictor of the 'Awareness of Energy Use'.

'Knowledge of sustainable improvements' is not found to be a predictor of any variable in the network. The ability value 'Income' only predicts the 'Knowledge of sustainable improvements' and does not have a link found to predict 'Investment Behavior'. ' 'Education' shows a direct relationship with 'Investment Behavior'. 'Age Category' shows indirect relationships through various variables. The household composition seems not determinant.

Results Scenario 1 and 2
Scenario 1 and 2 control for investment behavior, with either Yes set to 100% or No set to 100%. The significant predictors are discussed.

Wish to Move: Of the investors 7,50% more indicate they definitely don't want to move, while non-investors show more often that they would move if they could (2,73% more) or definitely want to move (3,61%), which is a total of 6,34% more moving wishes for non-investors.

Neighborhood Attachment: The percentage of homeowners that claim to be very attached, are the same within investors and non-investors. A slight change in favor of the investors occurs at the 'attached' answer, which occurs 2,70% more for investors than non-investors. Investors also state 1,90% more often that they have a neutral opinion about their attachment. Disattached was also indicated 0,20% more often by investors, where very disattached is more answered by non-investors, with a difference of 1,59%.

Neighborhood Satisfaction: Investors show 1,10% more often to be very satisfied, and 4,10% more often to be satisfied, so are in total 5,20% more often satisfied with their neighborhood that non-investors. In total, 69,5% of the investors claim to be satisfied with their neighborhood, opposed to 64,3% of the non-investors. Slightly more non-investors are neutral about their neighborhood satisfaction (0,40%) and 3,41% more of the non-investors is either dissatisfied or very dissatisfied about their neighborhood.

Attitudes: The level of attitude the property value increase from the investment is the most significant predictor for investment behavior. Between the 'very high' attitudes a difference of 7,6% occurs in favor of the investors, as well as the 'high' attitudes that show a difference of 12,2% difference in favor of the investors. This means that in total 19,8% of the investors are more convinced their property value increases from investment than non-investors, of a total of positive attitudes of 72,3% for investors, respectively 52,50% for non-investors.

The attitude about the importance of energy saving also shows to be a significant (but indirect) predictor. The investors show a very high attitude 4,60% more than non-investors, and a high attitude 1,30% more than non-investors. This is a total more positive attitude of 5,90% opposed to non-investors. The investors show in total a 78,5% positive attitude about the importance future energy saving, while the non-investors show only a 72,6% occurrence of a positive attitude.

The attitude about the importance of climate change shows some indirect effects. Very environmentally aware investors are 0,40% more than very environmentally aware non-investors. A high attitude shows a difference of 1,4% more for investors than non-investors,

making in total 1,8% of the investors more climate change aware (total 57,30%) than non-investors (total 55,5%).

Knowledge: Awareness of energy use seems significant for investors. Investors are 0,5% times more 'very highly aware' of their energy use, and 6,20% more highly aware. This means that 6,70% more investors claim to be highly aware of their energy use opposed tot non-investors, with total values of investors at 74,40% and non-investors at 67,70%.

Results scenario 3 through 8
Scenario 3 through 8 control for levels in neighborhood satisfaction.

Neighborhood Attachment: Very high neighborhood satisfaction corresponds with high levels of neighborhood attachment. When looking the other way around, attached homeowners are not as much very satisfied, as very satisfied homeowners are attached. Attachment level seems therefore a good indicator of high neighborhood satisfaction. The levels of attachment decrease when the level of satisfaction decreases.

Wish To Move: Very satisfied and satisfied homeowners express mostly the answer 'definitely not', with 77,6% respectively 73,10% of the answers. When neutral about satisfaction or dissatisfied, the homeowners express to be indifferent about moving, respectively 45,00% and 50,00%. Also, being dissatisfied raises the definitely yes category to 20,00% and for very dissatisfied homeowners even to 33,30%.

Investment Behavior: Very satisfied and satisfied homeowners show respectively 69.30% and 70,00% of the times investment behavior. Dissatisfied or very dissatisfied homeowners or very dissatisfied homeowners show less investment behavior (63.50% respectively 60.60%). This is a difference of approximately 8%. Neutral homeowners still show 67.60% investment behavior. This result also shows that the difference between very satisfied and satisfied is not very significant for investment behavior, even not being neutral about the neighborhood, but the actual difference between being satisfied and being (very) dissatisfied is somewhat related to investment behavior.

CONCLUSION & DISCUSSION
In the model, an indirect relationship between neighborhood satisfaction and investment behavior is found, through the wish to move. The wish to move or wish to stay influences the shown investment behavior. Also, the wish to move is influences by neighborhood satisfaction levels, so indirect there is a link. When looking at the differences that occur when controlling for investment behavior, only 5,20% more of the investors are (very) satisfied with the neighborhood and 3,41% of the non-investors are more dissatisfied. This shows that there is an effect. Next, when looking at the investment percentages that show in the model when controlling for neighborhood satisfaction levels, is that 8% more of the homeowners that indicate to be (very) satisfied did show more investment behavior. This again confirms that there is an effect. What also has to be taken into account, is that the difference between (very) satisfied with the neighborhood and investment levels opposed to being neutral about the neighborhood and investment levels, only differ at most 2%. So the biggest indicator seems to be dissatisfaction, rather than homeowners being satisfied with their living environment. Also, the neighborhood factors that should give more insight in

which factors have the most influence on neighborhood satisfaction do not show much difference between neighborhood satisfaction levels; so more research is needed to define what causes homeowners to be dissatisfied with their neighborhood to make this finding usable for policy making; using a neighborhood upgrade to make homeowners more willing to invest.

Resulting from the attitudinal study, price consciousness proved to be the best indicator for investment behavior, with the increase of property value as leading attitude. When the neighborhood upgrade will improve property values as well and is promoted as such, there might be a possibility to implement this as a policy in neighborhoods with homeowners that are dissatisfied with their neighborhood and the factors that are mostly responsible for this satisfaction are discovered.

The biggest impact however, should occur when providing information about price conscious attitudes, such as increasing property values and increasing energy prices.

RECOMMENDATIONS
It is recommended to go into further detail exploring the decision-making attitudes. A qualitative study based on interviews could get more in depth of understanding these attitudes and refine them more. Second, the influence of the ability factor, which consists of money, value and subsidy related influences is still a very important part in decision-making. Research focused on investment behavior without stimuli as subsidies can further be explored. Third, the influence of the growing number of elderly citizens (the aging population) has on the investment behavior. Investigating how elderly could be more urged and facilitated is a valuable addition to investment research. Last but not least, I would recommend researching further into the topic of neighborhood satisfaction in relation to investment behavior. Also, the best way of promoting this to homeowners and of course, after these researches find a good result, the way these neighborhood improvements could be implemented in terms of organization, finances, et cetera.

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CONCENTRATION OF PUBLIC SERVICES IN MUNICIPAL REAL ESTATE IN RESPONSE TO DEMOGRAFIC TRANSITION
A case of rural municipalities in Noord-Brabant, The Netherlands
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ABSTRACT

Due to demographic transition (DT) and budget cuts, the municipal budget is under pressure, which nourishes the debate about municipal public real estate. An increasing number of regions in the Netherlands will cope with DT in the near future. Due to DT, the lower bound of the threshold for public services is reached sooner than in other areas which do not cope with DT (Rijk et.al., 2012). Due to such developments, the current de-central spatial allocation of public services cannot be maintained. The concentration of (public) services is seen as beneficial by experts. The municipal councilors are mainly reluctant towards concentration and are eager to maintain all public services in all villages. This thesis provides insight in the preferences of the municipal actors and consequences of spatial allocation of public services in municipal real estate and attempts to show financial consequences. This research should contribute to the awareness of municipalities for the need to change the current structure of public facilities and related municipal real estate.

Keywords: Municipal real estate, public services, concentration, demographic transition, Analytic Hierarchy Process.

INTRODUCTION

Last decades, the construction policy of municipalities focused on population growth. New buildings were constructed for every increase in demand. As a result, the municipal real estate portfolio grew (Leent, 2008). Public services are most often housed in public real estate. Roughly 85,5 million square meter is in use as public real estate of which one third is owned by municipalities, making municipalities the most important actor (Tazelaar *et.al.*, 2011). Due to population decline and budget cuts, the municipal budget is under pressure. The transfer of tasks from the National Government to municipalities without an equal funding to execute these tasks adds even more pressure. Municipalities need to cut their expenditures where possible. This nourishes the debate about municipal public real estate. Municipalities become increasingly aware of the size and costs of their municipal real estate portfolio which includes the low occupancy rates, bad technical conditions, low sustainability of the municipal real estate and the amount of municipal capital stuck in buildings. Currently,

municipalities mainly invest in sustainability of new estate and not in existing real estate yet. While the existing real estate still comprise a large problem.

An increasing number of regions in the Netherlands will cope with DT in the near future. DT gives way to relatively unknown phenomena, because last decades spatial planning was focused on growth. Due to DT and social developments, the demand for public services and related municipal public real estate changes. DT is seen as a catalyst with which issues become visible earlier, the lower bound of the threshold for public services is reached sooner than in other areas which do not cope with DT (Rijk *et.al.*, 2012 and Nationaal Netwerk Bevolkingsdaling, 2011). This is a reinforcing feedback loop with a negative result, namely emptying villages and vacancy. Due to the described developments, the current de-central spatial allocation of public services cannot be maintained. A new approach to municipal real estate policy and public facility management is necessary to cope with the upcoming transition. The concentration of (public) services in one building is seen as beneficial by experts. However, the relocation of public services to regional centers or concentration often encounters reluctance of inhabitants as well as the local governments. Inhabitants like to have certain public services near their dwelling. In addition, municipalities strive for a proper living environment in which inhabitants are facilitated. Though, unprofitable social institutions can only be supported to some extent.

Within municipalities two types of relevant actors can be distinguished; municipal councilors and civil servants of the municipal departments. The civil servants implement the goals set by the municipal council. The municipal councilors are mainly reluctant towards concentration and are eager to maintain all public services in all villages. These groups of actors are not yet able to grasp the causes, effects and consequences of the continuation of the current spatial allocation of public services. This thesis provides insight in the preferences of the municipal councilors and consequences of spatial allocation of public services in municipal real estate and attempts to show financial consequences. This research should contribute to the awareness of municipalities for the need to change the current structure of public facilities and related municipal real estate.

Municipal real estate and public services
Municipalities manage their real estate either de-central or central. De-central means that each department manages its own real estate, in contrast to central department per municipality. De-central real estate management is currently most common. Though, an increasing number of municipalities shift to a central real estate management to increase their insight in the size and costs of their real estate portfolio. This insight is required to calculate the financial consequences of alternatives for the accommodation policy.

The municipal real estate portfolio grew historically. At the moment, most municipalities have large municipal public real estate portfolios, often with a deficient quality. According to the EPBD of the EU, in 2018, new governmental buildings should be nearly-zero energy buildings, which is in accordance with an energy A-label. Although nothing is said about existing buildings, policy should be made to increase the energy efficiency of these buildings. Currently, many municipalities are reformulating their accommodation and real estate policy. Their focus is on:
- the decrease of the amount of square meters,

- the increase of occupancy rates,
- the increase of the energy efficiency of the municipal real estate portfolio, and
- a supply of public services which suit the demand of the inhabitants.

The term public facility is increasingly separated into the service and the accommodation. The service is provided by a social institution and the accommodation concerns the space is which the service is provided (Bouwstenen voor sociaal, 2013a). In this thesis the sectors education, health care and welfare, sports and culture are included. Municipalities are not in all sectors mandatory by law to provide a certain service. In primary education, the municipality is responsible for accommodation and afterwards large maintenance of the school building. The municipality is fully responsible for the implementation of the WMO. However, specific tasks are not addressed and differ per municipality. Concerning sports and culture, municipalities do not have any specific responsibilities, but these sectors might help to achieve other societal goals. Although each actor is responsible for their own finance management, social institutions often get subsidy from the municipality. Indirect subsidy is given if the municipality asks for a lower rent than market conform prices, direct subsidy is given if the subsidy is provided based on the output of a social institution. Increasingly, municipalities take actions to convert the indirect to direct subsidy.

Actors
The most important actor in the provisioning of accommodations is the municipality. Municipalities subsidize social institutions to execute public services. The users are the most important stakeholder, because they determine the demand. Social housing corporations became more involved in the accommodation of public services, but because of current developments their future involvement is uncertain. Below, the main actors are listed, along with their role, interest, ability to finance and responsibility.

The municipality:
- role: providing public real estate, implementing the WMO, stimulating sports, culture and social participation, determining and implementing accommodation policy,
- interest: enabling citizens to participate in society and balancing of interest of inhabitants and other actors,
- finance: by state funding and local taxes, which both decrease in the near future,
- responsibility: implementation of national and municipal policies and wellbeing of citizens.

Municipalities compete with each other to maintain the public services in their villages, while the situation might become unsupportable and public services disappear in every village. Regional agreements should be made to prevent this from happening. But the regional gap limits the possibilities to make such agreements.

The social institutions:
- role: offering a public service,
- interest: achieving a societal goal,
- finance: membership dues, state funding, direct or indirect municipal subsidy. These institutions are mostly non-profit organizations,
- responsibility: providing a high quality public service.

The users:
- Role: creating demand for public services,
- Interest: the fulfillment of their public service needs,
- Finance: payment per service or membership due,
- Responsibility: low, volunteering in social institutions.

Demographic transition
DT are changes in population composition of which shrinkage is the most commonly known. DT can also be the decline of parts of the population, resulting in for example aging and dejuvenation. Both phenomena also occur for households; absolute decline and a changing composition due to a decline of specific type of households. The causes are for example dilution or selective migration. Thus, demographic transition includes the following aspects (Nimwegen and Heering, 2009 and Dam *et.al.*, 2006):
- population decline,
- changing population composition,
- household decline,
- changing household composition.

In some regions, one aspect of DT occurs while another does not. For example, an area could cope with dejuvenation and aging, while the total population does not decline. The total Dutch population is expected to grow until 2040. However, growth is dispersed unequally. Peripheral municipalities have to cope with DT more often than urban municipalities. The Ministry of Interior and Kingdom Relations designated three top shrinkage regions and several future shrinkage regions which should anticipate on DT.

The effect of DT on the demand for public services and municipal real estate
DT influences the demand for services in a region. In shrinkage areas, the threshold to maintain a service is reached earlier. The number of users of a service, occupancy rate of the accommodations and incomes of the institution decrease while the fixed costs of the institution for the accommodation do not (Mulder *et.al.*, 2012). The service cannot be operated profitable anymore and thereby the future continuation of public service in rural areas is at stake. Van Dam *et.al.* (2006) states that also a changing consumer behavior, increased mobility and up-scaling contribute to a decreasing demand for services in shrinkage areas. By provincial and municipal governments the provisioning of public services is seen as worrisome.

The effects of DT differ per sector. In case of health care, the demand increases. But health care services are not accommodated in municipal real estate and will not influence the municipal real estate portfolio. The welfare services are accommodated in municipal real estate. Although the demand is expected to increase, it cannot be expressed in numbers because the effects of the decentralization on the demand are not yet clear. In addition, the welfare services offered differ per municipality. Due to dejuvenation, the demand for primary school and child care after school hours decreases which influences the occupancy rates and accommodation costs per pupil, which on its turn has a negative effect on the quality. The demand for sports accommodations decreases by age. Due to dejuvenation, the demand for sports will decrease. The demand for public libraries and community centers is

hard to determine. The amount of visitors of public library shows a clearly decreasing trend. Though, efforts are made to turn this trend.

ANALYTIC HIERARCHY PROCESS

In order to answer the research question; 'which criteria are most important in the decision making process of municipalities to concentrate facilities' the Analytic Hierarchy Process (AHP) is used. AHP is a multi-criteria analysis in which quantitative as well as qualitative aspects can be taken into account. AHP derives one numeric scale and priorities for all alternatives and the criteria used to judge the alternatives (Saaty and Vargas, 2012). Below, the AHP model is shown. The levels represent the goal, the main and sub-criteria and alternatives. Because a policy cannot be implemented if it is not financially feasible, the sub-criteria of financial feasibility are further examined in this thesis.
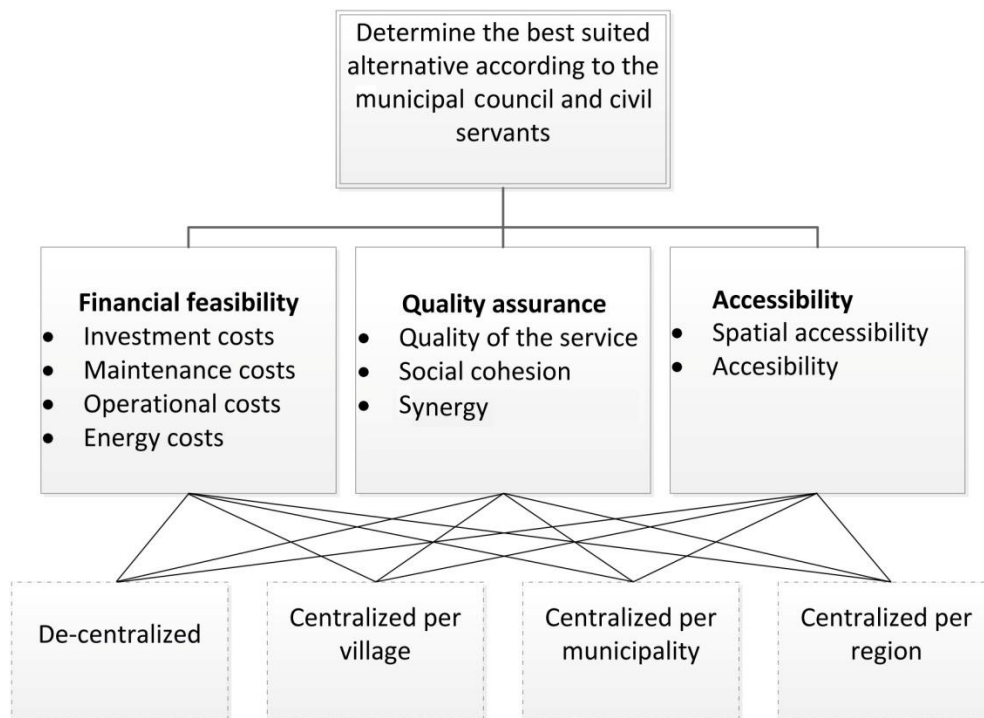

Figure 1 The Analytic Hierarchy Process model

To gain insight in the importance of the criteria and the most preferred alternative, two questionnaires are developed. One is distributed under municipal actors, namely municipal councilors and civil servants, in which they were asked to pair wise compare criteria. These two municipal actors were chosen because they determine the municipal policies. The other questionnaire was distributed under experts in the field of demographic transition, public real estate and/or accommodation policy, in which was asked to pair wise compare alternatives. Multiplying the relative weights of the criteria by the performance of the alternatives on each criterion provides insight is the most preferred alternative according to the municipal actors. The respondents of both questionnaires are also asked to rank the alternatives directly.

CASE-STUDY

The case-study of the municipality of Woensdrecht is performed to gain more insight in the practical implementation. The criteria and alternatives are elaborated for the municipality of

Woensdrecht, further called Woensdrecht. Woensdrecht is located in the southwest of Noord-Brabant, within the future shrinkage region West-Brabant.

Woensdrecht does do not have insight in the size and financial data of the total real estate portfolio, nor on building level. Thus, the municipality lacks a solid basis to make a sound decision for a new accommodation policy. First, this information should be obtained. Insight could otherwise be given by indicators or standards, if these were available.

Secondly, the future demand for public services is hard to determine for the sectors health care, welfare and culture, though large developments are taking place. For health care and welfare a trend can be observed in the direction of an increasing demand. In case of education, the future demand is more clear, but the pupil prognoses are seen as untrustworthy because the method used to determine them is based on population growth. Although founded decisions cannot be made on the basis of the current data, it does provide insight in the trends of future demand and consequences for reasoning.

The elaboration of the case-study showed the financial consequences of low occupancy rates, maintenance costs and energy costs for primary schools in each alternative. There is a clear relation between the accommodation costs per and the quality of the service.

Not all services can be concentrated easily. For example, the concentration of sports accommodations is difficult because certain sports require a specific kind of accommodation. Especially, sports subsidized by municipal funds are divergent. In addition, sport complexes or fields need more space and are therefore often located at the border of the village. But, options like merging sports complexes with scouts are worth examining. The case-study does make clear that each area should be examined integrally. For example, for inhabitants of Putte public services might be on shorter distance on the other side of the border. In that case, the demand from inhabitants of Putte should not be taken into account when concentrating per municipality. There is not one alternative which functions best in all regions, some exceptions should be made or choices should be made regionally.

RESULTS

From the response on the questionnaires results can be derived. Figure 2 shows that municipal councilors give the highest importance to the quality assurance, while civil servant experts give the highest importance to the financial feasibility. Both give the lowest importance to accessibility. For the sub-criteria of financial feasibility, the structural costs weigh more than the onetime investment costs.
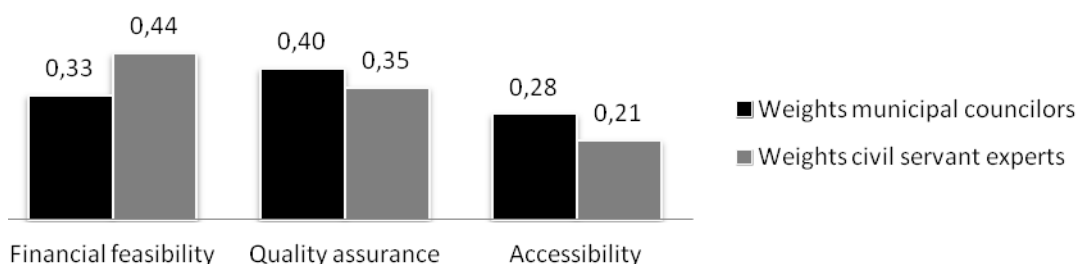

Figure 2 Relative weights of the main criteria

A distinction between the sectors is preferred, because large differences in relative weightings can be observed. Municipal actors seem to make a distinction between education, health care and welfare, and on the other side sports and culture. For education, health care and welfare the highest importance is given to the quality assurance, while for sports and culture the highest importance is given to the financial feasibility.

The performances of the alternatives on each criterion are determined by the experts using pair wise comparison and AHP. The optimum can is between village and municipal level.
- Financial feasibility increases with a higher level of concentration
- Quality assurance is best on municipal level and worst in a de-central allocation
- Accessibility decrease with a higher level of concentration

From AHP ranking, the municipal actors agree upon the preferred level of concentration. If municipal councilors are asked directly for their preference they often choose for concentration to a lesser extent. The preferences of the municipal actors differ per sector when asked directly. Per sector, municipal councilors also choose for a lower level of concentration. The difference might be due to the fact that the experts rated the alternatives, who might have a different idea about the performance of the alternatives on each criterion. Or the municipal councilors do not have sufficient knowledge about the consequences of the alternatives. Civil servant experts choose for a similar level as with the AHP ranking. Experts of choose for a higher level of concentration, though still within municipal borders.

Sector	AHP ranking	Direct ranking		
	Municipal actors	Municipal actors		Experts
		Municipal councilors	Civil servant experts	
Education	Village	Village	Village	Municipality
Health care and welfare	Municipality	Village	Municipality	Municipality
Sports	Municipality/ region	Village	Municipality	Municipality
Culture	Region	Municipality	Municipality	Region

Figure 3 Ranking of the alternatives

Municipal actors do see concentration of public services as a solution for the consequences of DT. The concentration is preferred to be limited to the municipal borders. This is probably because municipality itself wants to control the supply of public services.

Experts prefer concentration on a higher level. The expected discrepancy between municipal actors and experts is present, but smaller than expected. Experts also prefer concentration within municipal borders. This is probably due to the regional gap and the fact that municipalities are only accountable for their own municipality. Current governmental structure does not provide the commitment for a group of municipalities to engage in a regional (concentration) project.

In order to make a substantiated decision on the accommodation policy, the financial consequences of the alternatives should be clarified. Municipalities should obtain financial data on the public real estate in their portfolio. Another important aspect in the decision making process is awareness of the consequences regarding quality, accessibility and social aspects. On the basis of this research, the civil servants appear to be slightly more knowledgeable on the subject than municipal councilors. This could be expected prior to the research because the topic concerns the daily tasks of the approached civil servants. As a result, it can be said that municipal councilors could be made more aware of the consequences of their preferences.

RECOMMENDATIONS FOR MUNICIPALITIES
Municipalities are recommended to gain more insight in the consequences of the alternatives. For this purpose, more specific information on the parameters of financial feasibility, quality and accessibility are required. The level of detail determines the certainty of the consequences. The size and costs of the real estate portfolio need to be detailed on building level.

Per municipality, the number of services which can be combined might be different. An integral approach on municipal level is said to be beneficial, according to experts. The knowledge of civil servants could be used more extensively. The experts recommend a higher level of concentration than current policy and municipal preference.

RECOMMENDATIONS FOR FURTHER RESEARCH
The financial elaboration of the alternatives in the case-study showed that financial data and indicators are missing. In order to calculate on economies of scale concerning public real estate more benchmark research should be done on the structural cost of multiple building sizes.

To use the tool in practice, more influential criteria should be determined and specified in sub-criteria. A (computer) program should be developed to standardize the process and generate the result automatically. Filling in the questionnaire might be time consuming, but probably decreases the time spent on discussions during the council meeting.

The effect of indirect subsidies is not yet examined. The effect of the abolishment of indirect subsidies remains unknown, while it could influence the found results.

The number of criteria could be extended in further research. Sub-criteria are examined for the financial feasibility main criterion. Other criteria are not yet subdivided in the questionnaires. Several secondary costs are not taken into account in this thesis. For example, the cost of real estate vacancy or costs for adapting buildings for other functions.

The future demand for the amount of floor area for a service is based on national prognoses. However, these prognoses are often based on growth and in shrinkage regions these prognoses seem too positive. Thus, prognoses' models must be adapted in order to make sound prognosis for (future) shrinkage regions.

This thesis considers only concentration as a solution to problem resulting from DT. Other solutions might be present and need to be balanced. A broader study with an overview on the DT problems could show the role of concentration.

DISCUSSION
The application of AHP gave insight in the decision process of the municipal actors. However, there are assumptions made which influence the final result. These are listed below:

- Four public sectors are further taken into account. Apart from public sectors also private sectors, such as retail could be taken into account to increase the occupancy rates of municipal real estate. This increased occupancy rate may result in higher financial feasibility of the service and thus lower need for concentration.
- Apart from concentration, municipalities have more alternatives such as the sale of their real estate. This could lead to a shift in preferred level of concentration.
- More criteria might be influential in the decision process. These could differ per municipality, but also per alternative. More criteria with accurate data results in a lower uncertainty.
- In this thesis it is assumed that unnecessary municipal real estate is repelled from the portfolio. However in practice, to sell public municipal real estate might be difficult because the buildings are equipped for a specific function. Municipalities are faced with structural costs in vacant real estate, such as energy bills, water, insurance and maintenance. Taken vacancy costs into account might limit the financial benefits of concentration.

The approach used in this report can be highly valuable in the decision making process of municipalities. The used AHP method clarifies the importance of the criteria and determines the most preferred alternative. This method gives insight in the decision process which is especially valuable for municipal councilors who appear to be less aware of their preferences. Thus, it is a useful tool in this context. For civil servants, the importance municipal councilors give is highly valuable. Civil servants can determine the best suited alternative and submit this for approval at the municipal council, instead of solely implementing the goal set by the municipal council.

I agree with the outcome to concentrate public service either on village or municipal level. On this level, the positive and negative consequences of the alternatives are in balance. The most important criteria are valued the highest in these alternatives. Although the optimal level of concentration for the different sectors might be different, they should be accommodated integrally. For example, education can be concentrated on village level as long as the provided quality is sufficient. This school accommodation could also function as a gathering place for the community, replacing other relocated gathering locations. The historically increasing mobility of citizens nurtures the willingness to travel further for a higher quality service. Elderly have also shown to have increased mobility due to devices such as the scoot mobile, which makes it easier for them to travel a longer distance. For people with very limited mobility, special visits of the service per village might be a solution. Thereby concentrating the accommodation, but making the service more mobile.

The full concentration on municipal or regional level will leave lots of municipal real estate vacant. These buildings are made for a specific function which makes it, in current times of

economic crisis, even harder to sell. Vacant buildings will therefore remain a structural expenditure on the municipal budget. In addition, vacancy decreases the livability of an area, which on its turn decreases the value of the buildings in the surrounding.

The thesis showed a knowledge gap between the municipal councilors and the civil servants. The case study areas were the rural municipalities in Noord-Brabant which do not cope with DT yet. This might influence the result. When the municipalities actually cope with DT, municipal councilors might get more aware of the consequences of alternatives. If the policy can be made and implemented prior to the occurrence of DT, possibly expenditures can be lowered and negative consequences can be mitigated.

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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 situations. 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 led 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	Weaknesses
- Reducing 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 - Contribution global issues	- 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.
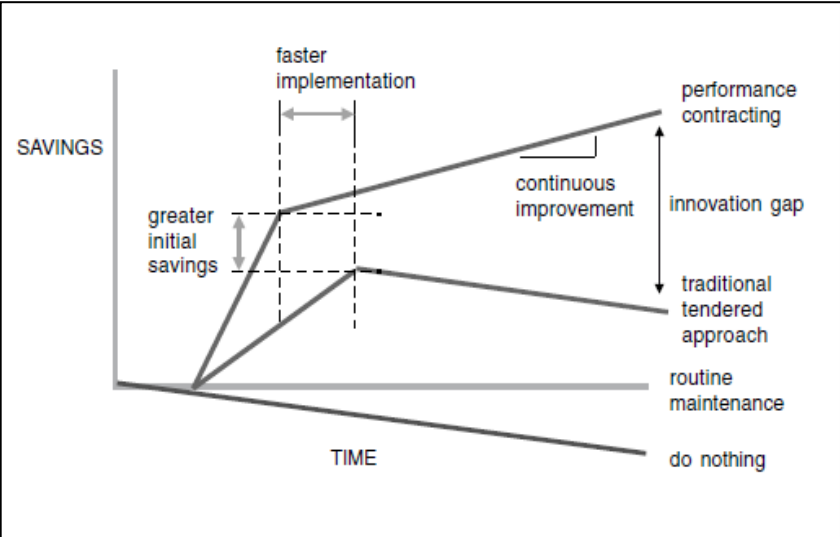

Figure 1: Concept Energy Performance Contracting (Energy Charter Secretariat, 2003)

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.

$$R_b = \left(C_g * P_g\right) + \left(C_e * P_e\right) + \left(C_w * P_w\right) + Tax + R_m \tag{1}$$
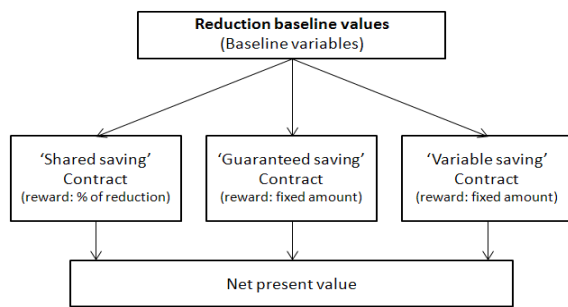
Figure 2a: baseline situation
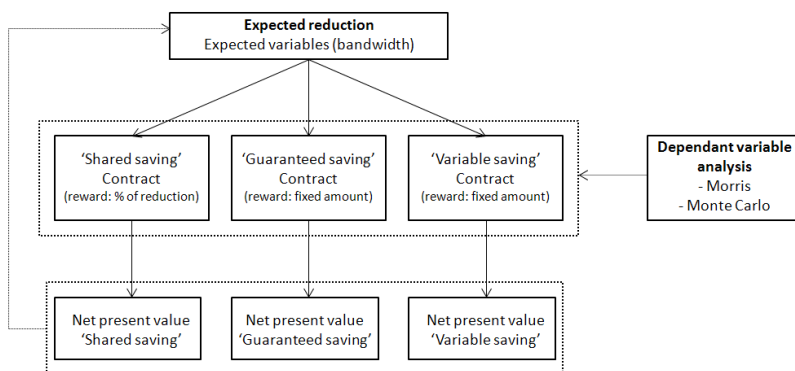
Figure 2b: concept of changing benefits

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.

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

guaranteed reduction.

Formula: Benefit customer all contract types

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

(2)

Formula: Benefit 'Shared saving' contract (ESCo)

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

(3)

Formula: Benefit 'Guaranteed saving' contract (ESCo)

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

(4)

Formula: Benefit 'Variable' contract (ESCo)

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

(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 Δ is the difference between the minimum and maximum value.

$$d_i\left(\underline{x}\right) = \frac{Y(x_1,...,x_i + \Delta,...x_k) - y(\underline{x})}{\Delta}$$

(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

|		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	*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

Step 2: dividing risks

Figure 3: Output; risk management decision model

Contract and risk combination
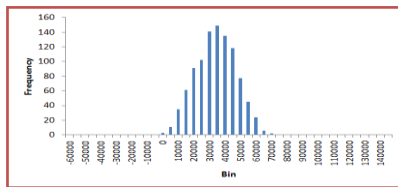
Model output; combination C1
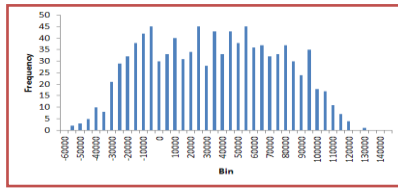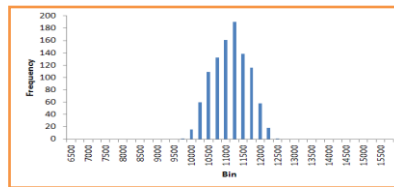

Benefits/risks ESCo
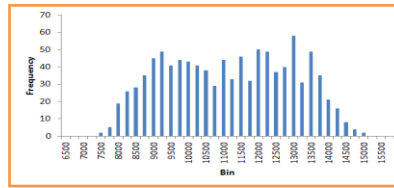
Benefits/risks Customer

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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ABSTRACT

By making existing dwellings more sustainable large energy savings can be realized. Consumers are often unaware of the benefits that are in it for them and don't take the step to make their dwelling more sustainable. The research makes the benefits of making a dwelling energy neutral insightful, by means of a total cost and benefits of ownership approach. The research also focusses on the added benefits when consumers make their dwelling energy neutral as a collective.

Keywords: Energy neutral dwelling, consumers, collective renovation, existing dwellings.

INTRODUCTION

Sustainability policies and measures are made and carried out by governments and businesses. The government have set in their regulations that from 2020 new built dwellings should have an Energy Performance Coefficient (EPC) of 0, this means that in 2020 only near-zero energy buildings are allowed to be built (Agentschap NL, 2010). Besides this, municipalities have set goals to make districts or even entire cities energy neutral. To reach these goals dwellings can play a large part in it, because in the Netherlands 35% of the energy usage is for the account of buildings and almost half of this amount is used by households (Agentschap NL, 2012).

When all the new built dwellings will be energy neutral in the future, there will be a difference with the existing dwellings that are less energy efficient regarding energy usage and energy costs. An energy neutral dwelling will have low housing costs and a dwelling with low additional costs will have more value than the same dwelling with a lot of additional costs. This difference will be increasing in the future, because the forecast about energy

prices indicates that they will increase in the future, but how much is still uncertain. To make the difference smaller or disappear it is necessary to make existing dwellings more energy efficient. When a dwelling is renovated to energy neutral added value can be created, the dwelling will be more independent from uncertain increasing energy costs, the lifespan of the dwelling is prolonged and the quality of the building will also be improved.

But not all consumers want to make the investment to make their dwellings more sustainable, because of the costs or ignorance about the topic. A solution can be that consumers renovate their dwellings as a group, where they can have collective benefits. There are already some initiatives to renovate dwellings with a group of people from the neighbourhood. But it is not certain what the added value of renovating as a group is and what the benefits are for the consumers. When the benefits and the created value are known, then people who are hesitating can be persuaded to renovate their dwelling. The participation of consumers is needed to realize energy neutral districts.

This has led to the following research question:

What are the benefits when consumers make their dwelling more sustainable into an energy neutral dwelling as a collective?

The main research objectives are to show the added value and benefits that consumers can gain by making their homes energy neutral and showing the added value when consumers renovate their dwellings as a collective. The research is limited to one group of stakeholders the private home owners and the existing dwellings that can be made energy neutral. The research will also be limited to the dwelling and the measures that can be carried out to make the dwelling energy neutral. The building process and materials are excluded from the research.

Energy neutral dwelling

In the research first the energy neutral dwelling and the measures to make a dwelling energy neutral were examined. The definition of an energy neutral dwelling used in this research was based on a definition by PeGo(2009). The used definition is: *'A dwelling is energy neutral during the use phase when on a yearly basis there is no net import of fossil or nuclear fuel from outside the property needed for the exploitation building. This means that the energy usage from inside the property is equal to the amount of sustainable energy that is generated within the property or on basis of external measures may be contributed to the project.'*

In this research the dwelling needs to be energy neutral on a yearly basis and use 100% renewable energy on a yearly basis. This means that it is possible to extract energy from the net during peak hours when the renewable sources are not sufficient and it can resupply the sustainable energy back to the net on other hours.

The Trias Energetica principle is often used as a guideline to make buildings more sustainable. Dobbelsteen (2008) developed an updated version of that strategy, the "new steps strategy". This strategy was used to determine the measures that are needed to make a dwelling energy neutral. These steps are:

- *Step 1: Reduce energy demand.*
- *Step 2a: Use of energy from residual flows.*

- *Step 2b: Use of energy from renewable sources.*
- *Step 3: If usage of finite (fossil) energy sources is inevitable, use them very efficiently and   compensate them on a yearly basis with 100% renewable energy.*

To deal with the energy usage as efficient as possible these steps should be completed in the correct sequence. In the research for each of the steps measures were identified. Important factors were that it must be possible to apply the measures for existing dwellings.

Reduce energy demand

The first step to make a dwelling energy neutral is reducing the energy demand. This is done by insulating the entire dwelling. From several building insulation measures a selection was made of the measures that can be applied best to realize an energy neutral dwelling. These measures are exterior wall insulation, exterior roof insulation, floor insulation from the bottom and replacing window and door frames with better insulated frames. For all these measures it is possible to realize high insulation value and this Is needed to reach energy neutrality. Another advantage of these measures is that with these measures also the chances for draft and thermal bridges are minimized.

Use energy from residual flows

A lot of energy is wasted through residual flows of a dwelling and by their residents. Air and water are heated, but they are simply discarded while these flows contain residual heat or in other words energy. The heat and energy of these flows can be used to heat new water or air, resulting in less energy that is needed to heat these air or water flows.

Use energy from renewable sources

When the energy demand is reduced as much as possible and energy from the residual flows is used, the remaining part of the energy usage should be generated sustainably. In the research several options to generate renewable energy were examined. The best options to apply in an energy neutral dwelling are a solar boiler and PV-panels.

Ventilation

When a dwelling is well insulated it is necessary to install a ventilation system to provide a healthy and comfortable indoor climate. The ventilation system that can be best applied for an energy neutral dwelling is a decentralized CO_2 demand regulated ventilation system. Because this system provides the most healthy and comfortable indoor climate and it only ventilates the rooms where it is necessary.

Value creation

Value creation also plays a role in investment decisions, it determines the profitability of an investment for the involved stakeholders. For consumers the created value can be a reason to make the investment and therefore it is important that the value creation is insightful. To determine the added benefits for consumers when a dwelling is made energy neutral the Triple P approach was used. The triple P stand for the dimensions People, Planet and Profit, they represent a social-cultural, ecological and economical dimension (Puylaert and Werksma, 2011). In sustainable development it is important that value is created on all three of the dimensions and that these values are in balance with each other. Future value is an important part of the value creation and future value can be maximized when value is

created on all three parts of the triple P. Because if the investments in the renovation have a low or no future value then the added value and benefits are lower than if the investments have high future value. Renovating the dwelling is also increasing the future value of the dwelling, because the future value of a dwelling is increased when the condition and the building quality of a dwelling are increased (Otter, 2008).

There are several studies that show that the financial benefits of an energy efficient dwelling are most important for consumers and they are followed by the factors comfort and health (Groenstein, 2011). Another important characteristic is the environmental awareness, but this is not valued financially (Groenestein, 2011). This indicates that most important value for consumers is the financial value, followed by the user-related value and then the environmental value.

Profit

The added value for the profit aspect are an increased value of the dwelling, a decrease in housing costs and more stable housing costs. Evidence from literature states that an energy neutral dwelling has a higher value than a standard dwelling(NWBO, 2008, Groenestein, 2011 and Brounen & Kok, 2009). This value can be between € 5.000 and € 10.000, but it can also be higher when the difference is larger. But the remark should be made that the value of a dwelling is hard to predict and that future prices are uncertain. The housing costs also have decreased and have become more stable, because the energy costs have decreased. When housing costs are more stable consumers know exactly what their future expenses are and they have more certainty about their financial situation.

People

The most important added value for people aspect is the improved indoor climate, since draft is limited and a healthy indoor climate can be regulated by a CO_2 demand regulated ventilation system. This improves the living quality of the consumers, because the quality of the indoor climate is increased. It is also possible to create added value during the renovation, by making sure the inconvenience for consumers is minimized.

Planet

The added value for planet aspect is that a the dwelling is no longer depending on fossil fuels, the energy usage has decreased and for the remaining amount of energy renewable energy is generated. Consumers no longer depend on suppliers of energy and changes in the energy market, they generate their own energy and are more independent. Another added value for planet are the decreased CO_2 emissions.

Renovating dwellings as a group

Benefits that arise when consumers renovate their dwelling as part of a collective can be categorized in organizational, financial and other benefits. There are major organizational benefits for consumers when they renovate as part of a collective. Because it is possible to outsource management, so they don't have to figure out the details of the renovation themselves. They can also cooperate with a business that takes care of the entire renovation for them. The financial benefits concern lower renovation costs, because the measures can be carried out in serial and if the scale is larger than 50 dwellings there are even more financial scale benefits. When consumers are part of a collective they can be part of

favourable financing regulations. There are several cooperation forms and financing regulations examined in the research. This indicated that there are several option that would be interesting for consumers to explore, because they can have a lot of benefits for them both organizational and financial.

Other benefits that occur when dwellings are renovated as a collective besides the organizational and financial benefits are that it is possible to improve the quality of the neighbourhood. The exterior of the dwellings will be improved by the renovation and when all consumers work together they can improve the entire neighbourhood together. Another benefit is that there can be group pressure in a neighbourhood to renovate the dwellings, so more consumers will take part of the renovation. The final benefit could be that collective energy generation can be applied, but these options are very expensive and not always applicable for existing dwellings. Therefore the collective energy generation was not taken in account in the case study.

Case study

A case study was carried out to gain insight about the value creation for consumers when they renovate their dwelling individually or as a collective. The goal of the case study was to create an overview of the benefits for the consumers and what the added value is when the renovation is done as a collective. The case that was selected for the case study is the district Venne-Oost in Drunen. This district was selected, because a large amount of the dwelling are owned by private home owners, the district was built before 1990 and there is added information available about the dwellings.

METHOD

To determine the costs and benefits there was chosen to use the Total Cost of Ownership approach. This method gives an overview of all the costs involved with the ownership of a product or service. Included costs cover the initial investment and other occurring costs during the life of a product, but these costs can differ by industry the method is applied for. The TCO approach is stakeholder-based and addresses the costs from the point of view of the stakeholders. The approach can be used to support management decisions that involve costs over a longer period of time. It can also be used to determine the total economic value of an investment or display the cash flows for several scenarios. This makes the approach suited to make financial comparisons between several alternatives. This method was chosen because the method can give insight in the different cash flows, it is possible to include only the different costs and benefits that are influenced by the renovation, the examined period can be determined up from and it is possible to make a comparison between several scenarios. The Discounted Cash Flow method was used to construct the cash flows and convert the cash flows into the present value. The DCF method is uses the time value of money to discount all the estimated future cash flows to their present value. The Net Present Value of a project can be determined based on the DCF's and it represents the current value of the project. The NPV will be used to make comparisons between the total value of the alternatives. Another method was needed to determine the energy neutrality of a dwelling. The method that was used was determining the energy savings in kWh. There was opted for this method, because it results in a universal unit for energy, it is easy to compare with other dwellings and it is easy to understand for consumers.

The scenarios

In the model a base scenario and three renovation scenarios were incorporated. The base scenario will function as a reference scenario were no renovation was carried out. One of the renovation scenarios will be the scenario to energy neutral. In this scenario the entire building envelope is insulated very well, a ventilation system is applied and a solar boiler and PV-panels are applied to generate sustainable energy. There were two renovation scenarios added that are common options for consumers now. When consumers are making their dwelling more sustainable they often choose to insulate the dwelling or to generate sustainable energy. Because they often do not have the financial possibilities to realize the option to renovate to energy neutral and the costs of these options are considerably lower. These options were added, because it are options consumers take in consideration when they choose to make a dwelling more sustainable. Goal of adding these options is exploring if it is more profitable to make a dwelling energy neutral or do less than energy neutral by applying insulation or generating sustainable energy. The insulation option will be implementing relative good insulation, but not as much as for energy neutral, because that is relative expensive. The generating sustainable energy option will be a solar boiler and PV-panels on one side of the roof.

These four scenarios will be varied by certain scales to determine the added benefits of renovating as a collective. These following scales were taken in account in this case study: individually (1 dwelling), one row of dwellings (8 dwellings) and an large scale(100 dwellings). For the three renovation scenarios two different ways of financing were taken in account. These are making the investment at once in 2014 or financing the renovation by means of a mortgage. The option for a mortgage was added, because often consumers do not have the financial means to finance the renovation at once.

MODEL

A model was developed in Microsoft Excel to determine the costs and benefits. To set up the model the Total Cost of Ownership approach was specified to fit the scope of the case study. The costs that are included in the model are all the costs that are influenced by the renovation. These costs are investment costs, energy costs and maintenance costs for installations. Other costs, such as costs for water, internet and television were left out, because they are not relevant for the investment that is made and are not influenced by the renovation. The value of the dwelling was also left out of the equation, because the value of a dwelling is very uncertain at the moment, because of the current crisis in the dwelling market and sustainability is not yet good reflected in the dwelling price. Leaving out an uncertain value of the dwelling provides a more certain outcome of the model. This does not mean the increased value of the dwelling is not an important factor, the increased value can be seen as an added benefit when the consumer wants to sell the dwelling. The examined period of time in the case study should not be too long or too short. It must be able to earn the investments back with the benefits, but also the examined period must not be longer than the lifespan of the installations. The examined period in the case study is 25 years, this is based on the guaranteed lifespan of the main installations of an energy neutral dwelling.

With these starting points and selected method the financial model was developed. In the model the total investment costs, the energy savings, energy costs were determined separately and were used as a base to construct the cash flows. To make these calculations

several kinds of data were needed as input, these were data about the investment costs, the dwelling and a set of parameters. A sensitivity analysis was carried out to determine how much the outcome of the analysis depends on these parameters and values. Because the future cash flows are determined by using the estimated values and parameters, and future predictions are inherent to some degree of uncertainty. Doing a sensitivity analysis leads to more certainty about the dependency of the benefits and profitability of the renovation on the set parameters and values, and how certain it is that they occur after the renovation.

Results

The results from the case study have showed that the renovation to energy neutral has the highest investment costs, but it also has the highest benefits. The measures to make the dwelling energy neutral have high costs, but when the dwelling is energy neutral there are no energy costs left, because it is no longer necessary to extract energy from the net. Both the other scenarios generating energy and only insulation have both lower investment costs, but the benefits are also lower than for the renovation to energy neutral. The energy costs

for the energy generation scenario are only costs for gas, because in that scenario no electricity will be extracted from the net. The energy costs for the only insulation scenario are mostly costs for electricity and a small part costs for gas. The base scenario in the case study showed that the energy costs will double in within ten years.
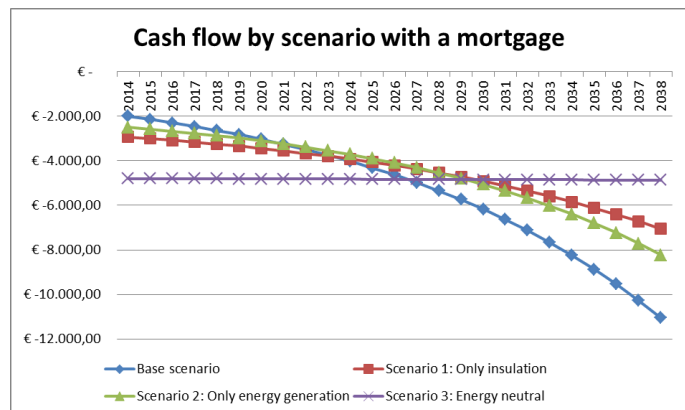
Analysing the Net Present Values have showed that the scenario to energy neutral is the option with the highest costs over 25 years. The most profitable option is the scenario generating sustainable energy, followed by the scenario only insulation. These both options are also better than the base scenario of doing nothing. The energy neutral scenario is the least profitable option for one dwelling. The benefits for the energy neutral scenario over 25 years are not high enough to compensate the high investment costs, thus this scenario is not profitable over 25 years. The costs for the scenarios energy generation and only insulation are lower and the benefits are high enough to make the investment of these two scenarios profitable over 25 years. There are also some differences for the profitability when a mortgage is used or when the investment is paid at once. Mortgage costs are very high, so they have a major influence on the profitability when a mortgage is used. It is more profitable to make the investment for the renovation at once if that is possible for the consumers. The case study showed that when dwellings are renovated on a larger scale there are added financial benefits. The first are the benefits in costs when measures are carried out in serial. These benefits are the highest for the insulation measures and therefore

have the most influence on the profitability of scenario only insulation and energy generation. Second are the added scale benefits when the scale is larger than 50 dwellings, these benefits are the same for all renovation scenarios.

	NPV mortgage	NPV without
Base scenario	€ -60.100,71	€ -60.100,71
Only insulation	€ -55.638,05	€ -54.475,30
Energy generation	€ -54.295,39	€ -53.304,02
Energy neutral	€ -65.989,48	€ -62.783,67
NPV by scenario for a single dwelling		

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The sensitivity analysis showed that the profitability of the scenarios is influenced by parameters, some of them more than others. The parameters inflation rate, interest and discount rate and increase and electricity and gas price do not influence the energy neutral scenario, but they influence the other scenarios a lot. This has as result that when these parameters change the energy neutral scenario becomes relatively better or worse. A change in the parameters changes percentage scale benefits and energy usage have the same influence all the renovation scenarios. The influence of a change investments costs becomes larger when costs are higher and influences all the renovation scenarios. The sensitivity for the investment moment shows that now is the best moment to make the investment, but when longer is waited with the investment the better option the energy neutral scenario becomes.

CONCLUSION
Through the literature research and the case study the benefits for consumers when they renovate their dwelling to energy neutral individually or as a collective have been analysed. The case study has showed that renovating a dwelling to energy neutral is not profitable in a period of 25 years. When the scale becomes larger the renovation for energy neutral will be more profitable in a period of 25 years. Thus the scale benefits have a positive influence on the profitability of a dwelling. Also when there are scale benefits the renovation to energy neutral without a mortgage pays itself back within the period of 25 years.

Besides this financial analysis there are also a lot of benefits that consumers can gain from renovating their dwelling to energy neutral as mentioned before. Some of these added benefits such as increased comfort levels and a healthier indoor climate are also valued financially by consumers. Thus do these benefits weigh up to the high investment costs? This depends partly on the perception of the consumers if they think it is worth it. But the literature also have showed that consumers are willing to pay between the €5000,- and €10.000,- more for energy efficiency measures when they buy a dwelling (Luijten et. al, 2010). So the increase in living quality is worth a certain amount of money. Besides that when the added value of a dwelling would be added to the financial equation the renovation would be profitable in 25 years, even if only the average added value of € 8395,- (Brounen & Kok, 2009) would be taken in account. This added value can go up to € 30.000,- when there is a large difference before and after the renovation, so then the financial benefits are also higher. Thus by adding these benefits up, it can be concluded that renovation to energy neutral is a good renovation option and besides the costs there are a lot of benefits that can be gained for the consumers.

The profitability of a scenario can also be influenced by a change in the parameters. The sensitivity analyses have showed that changes in parameters do have an influence on the profitability of the energy neutral scenario compared to other scenarios. Thus if a couple of parameters would change the profitability can increase or even decrease. This is still an uncertain factor in the model, because it is hard to predict the future exactly. As indicated before when consumers renovate their dwelling as a collective there can be a lot of added benefits, that concern organizational, financial and other benefits. Mainly the organizational and financial benefits are directly beneficial for the consumers. Financial benefits concern lowered investment costs, because the renovation can be carried out in serial. The financial benefits can even increase more with 2-3% when the scale is larger than 50 dwellings.

The case study has showed that the scenario to energy neutral is less profitable than the scenarios only insulation and energy generation over a period of 25 years. Even though the yearly benefits are smaller, because both these scenarios still have energy costs. The difference in profitability was mainly caused by the fact that these two scenarios have much lower investment costs than energy neutral and the benefits of these scenarios weigh up to the costs. Thus the scenarios only insulation and energy generation can be more profitable than the scenario energy neutral, but their other benefits are a lot less than the energy neutral scenario. The added benefits for the energy neutral dwelling weigh up to the higher costs and the lower profitability over 25 years. Both the scenarios only insulation and energy generation will still have costs for energy at the end of the examined 25 years and the energy neutral scenario does not. Thus after the 25 years the benefits are only increasing more for the energy neutral scenario and for the other two scenarios the costs are increasing. Also the increased value for an energy neutral dwelling will be more than for the scenarios only insulation and generating energy, because the dwelling has been renovated more extensively and it is more energy efficient. Thus the energy neutral scenario will have more added benefits, but it will also have more costs than both the other renovation scenarios.

DISCUSSION

The sensitivity analysis have showed us that the accuracy of the parameters have an influence on the outcome. Because the model is very sensitive for a change in certain parameters, this results in the fact that the results have a degree of uncertainty in them and that the outcome can differ a bit from the reality. The value of a dwelling was not taken in account in the financial model, while literature indicated that a more sustainable dwelling has more value than an unsustainable dwelling. Adding the value of the dwelling to the financial model would increase the profitability of the renovation to energy neutral, but the outcome of the model would also be more uncertain. To provide the outcome with more certainty it was best to let the value of the dwelling out of the equation. The renovation scenario will not lead to energy neutrality if the consumers use more energy than the average amount. It is not possible to keep saving energy, while consumers still use a lot. Part of making a dwelling more sustainable is also using less energy.

RECOMMENDATIONS

Recommendations for further research are:
- Incorporating different future scenarios with each a different set of parameters. By doing this the outcome can be predicted with more certainty for different future scenarios and it will depend less on one set of parameters.
- Examine possible business models and earning models further for consumers renovating their dwellings as a collective, because there are several interesting options that can be applied in the research.
- Expanding the model so different types of dwellings and different sets of energy efficiency measures can be analysed.
- Further examine the options to generate collective energy.

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This research was carried out at ARCADIS and marks the end of my study at the TU/e. During the research I have gained a lot of knowledge and experience about the subject. Therefore I

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PRIORITIZING AREAS FOR THE IMPLEMENTATION OF AN ADATIVE TRAFFIC MANAGEMENT SYSTEM WITHIN THE MUNICIPALITY OF COPENHAGEN

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ABSTRACT

In recent years, governments are facing the challenges of climate change. T*raffic* is responsible for several environmental problems in urban areas. Traffic congestion poses a challenge for all large and growing urban areas. Especially Carbon Dioxide has become an increasingly serious problem due to its negative impacts on the climate change. Because of this, the municipality of Copenhagen wants to become completely CO_2 neutral by 2025. Within the area of mobility, budgets have been set for the coming years. A part of this budget is reserved for the implementation of ITS solutions in Copenhagen, which among other things will contribute to a CO_2 reduction. One of the studies is focused on the implementation of adaptive traffic management systems within municipality of Copenhagen.

Keywords: Adaptive traffic management systems, Analytical Hierarchy Process, Pair-wise comparison, Quantitative dominance scores, Municipality of Copenhagen.

INTRODUCTION

Carbon Dioxide has become an increasingly serious problem due to its negative impacts on the climate change. Because of this, the municipality of Copenhagen wants to become completely CO_2 neutral by 2025. At present, traffic is responsible for 21% of the city's overall CO_2 emissions, but it is intended that this will be reduced to 11% by 2025.

Alongside the limited budget within the area of mobility, the municipality has to deal with the 'old' fixed time traffic technologies in the city and the limited possibilities for expansion of the infrastructure. Because of that, the municipality aims to optimize the current traffic network. One of the solutions is to implement adaptive traffic management systems (ATMS) in several areas of the city. One attraction of ATMS is the potential to achieve a better performance off an existing traffic network infrastructure without having to build expensive extra lanes or change the physical geography of a city's street network.

But one of the most difficult challenges is to find out which areas are (most) suitable for implementing an adaptive traffic management system (ATMS). This level of suitability depends on several criteria with various importances that characterize an area. Obtaining this knowledge is the first step in selecting areas for implementing these ATM-systems.

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RESEARCH AIM

The main objective of this research is to show a ranking of areas that are (most) suitable for implementing an adaptive traffic control systems within the municipality of Copenhagen.

In order to achieve this main objective, the following goals are formulated:

- Construct a list of most important criteria for implementing an ATMS, and set the weights/priorities of each criteria;

- Select and characterize the different (relevant) areas within the municipality of Copenhagen by means of the chosen criteria;

- Rank the alternatives by using the overall dominance scores.

RESEARCH APPROACH

To gain data for this research project, a certain approach has to be adopted. First of all, it is important to select the required methods and techniques.

Methods and techniques

There are several scientifically research methods available. In this research an Multi-Criteria Evaluation (MCE) is used. The MCE is a qualitative research method, used for comparing several independent alternatives based on various criteria. The complexity is caused by the multiplicity of criteria that are important in the strategic choice: ranking the areas for implementing an ATMS. A multi-criteria evaluation approach is suitable when an intuitive approach is not appropriate, for example because the decision-maker(s) feel the decision is too large and complex to handle intuitively, because it involves multiple objectives, or multiple stakeholders.

In this study, AHP (Analytical Hierarchy process) has been applied to identify the best suitable area for an ATMS. AHP is a specific research method of the Multi-Criteria Decision Analysis (MCDA). The AHP method makes it possible to decompose the decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analysed independently.

The composition of the entire set of criteria that play a role in the strategic choice between alternatives, were identified based on literature research and in-depth interviews with experts in the field of ATMS. To compare areas with the AHP method, it is important to know which criteria are more important. One of the major strengths of the AHP is the use of pair-wise comparisons. In this research the pair-wise comparison is applied to obtain the weights of the elements.

The next important step in a AHP is defining the alternatives (or choice-possibilities). The alternatives represent the 'different possibilities to solve the problem'. In this study, the alternatives are the different areas in Copenhagen and were selected in a group session with expert panel II. Expert panel II consist of several decision makers from different departments within the municipality of Copenhagen.

The criteria applied in a MCE serve as a tool to test the various decision alternatives from a particular point of view. After defining the areas, an online questionnaire is constructed to

characterize the alternatives. The characterization of the areas is conducted by experts from 3 different departments of the municipality of Copenhagen. This characterization includes all criteria selected in the previous step.

The information obtained from the previous described steps will lead to the final step. The final step is to rank the chosen alternatives by using the characterization of the alternatives and the obtained weights. In this research the quantitative dominance overall scores will be used to rank the alternatives.

RESULTS

Twelve criteria (or characteristics) were evaluated in this pair-wise comparison. Changing network conditions is considered as the most important characteristic for implementing an ATMS, while public transport priority (0,118) and conflicting modalities (0,0102) are considered as second and third most important characteristics. This is not surprising , because a network with a high degree of changing traffic conditions is difficult to manage with fixed time control. A network managed with fixed time control can work with several timing plans changed based of the time of the day. However when traffic conditions change frequently, the adaption of fixed time is limited. Partly because of these reasons, a high degree of 'changing traffic conditions' is considered by experts as the most important characteristic. One of the strengths of an ATMS is, that it can adapt to changing traffic conditions in real time. Table 1 shows the constructed list of most important criteria for implementing an ATMS.

Sub-criteria	Global weight
Changing traffic conditions	0,124
Public transport priority	0,118
Conflicting modalities	0,102
Network congestion	0,099
Network robustness	0,097
Unpredictable traffic patterns	0,095
Expansion possibilities	0,082
Car priority	0,079
Network complexity	0,067
Heavy traffic priority	0,050
Bicycle priority	0,044
Special lanes	0,022
Red light violation	0,020
Sum	1,00

Table 1: Final weights of all sub criteria

Si	Alternative	Name	Ranking
0,045	A1	Central station	1
0,044	A3	Nørreport	2
-0,016	A4	Jagtvej	3
-0,028	A2	Lyngbyvej	4
-0,045	A5	South CPH	5

Table 2: Total scores Si and final ranking.

The second part of the research contained the characterization of the selected areas. Experts are required to evaluate the alternatives, as their judgments possess deeper knowledge about traffic management and they are familiar with the different areas in Copenhagen. For this online survey 50 invitations for participation are sent to experts of three departments of the municipality of Copenhagen (København kommune). These departments are: Traffic design, Traffic plan, and the Cycling department. The response rate of the 50 invited experts for the online survey was about 50 % (i.e. 26 completed questionnaires).

The results from both previous results are combined to calculate the final ranking. The quantitative dominance overall scores is used to rank the 5 area's. Table 2 shows the final ranking of the areas. Central station and Nørreport area are ranked as the most suitable areas for implementing an ATMS. Compared to the other areas evaluated in this research, these two areas are located in the centre of the city and contain all modes of travelling. These areas are both characterized by the many major and minor bus lines driving to or leaving to the Central station or Nørreport station. Together with the many cyclist and pedestrians this results in many conflicting situations. Considering the criteria it is not surprising that these two areas are ranked as number one and two.

FURTHER RESEARCH
For further research, it could be interesting if the various objectives for each area of the city will be determined. In some areas there is need for reducing the average waiting time for buses; in other areas the number of stops of cars should be reduced. There may be objectives concerning minimizing queue lengths, or prioritizing public transport, cyclers, trucks etc. To reach consensus between all involved actors and define the various objectives for each area is the basis for the implementation of ITS (e.g. ATMS).

The first ATMS is currently implemented in Valby. Valby is located south-western corner of the municipality of Copenhagen. An evaluation of the implementation of the real-time ATMS in the area of Valby should be performed. Disparities between the real operational improvements and the data from the simulation should be compared. Also the obstacles and difficulties during the implementation need to be defined. This evaluation will improve the implementation in other areas of the city in the nearby future.

ALIGNING SUPPLY AND DEMAND FOR ENERGY SERVICE COMPANIES IN THE CURE MARKET USING ANALYTICAL HIERARCHY PROCESS AND SYSTEM DYNAMICS

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ABSTRACT

Outsourcing to Energy Service Companies (ESCos) is an arising concept in the Cure market. Market supply and demand of Energy Service Companies should be aligned to benefit from energy savings and lowering energy costs. The research method of Analytical Hierarchy Process is used to give insight in the needs and considerations for a hospital in their decision to outsource and the relative importance of key performance indicators that can be incorporated in energy performance contracts. System Dynamics in combination with Monte Carlo simulation is used for a sensitivity analysis of a specific business case. The two methods proved to be useful in estimating risks influences and bandwidths of key performance indicators. Several expert interviews have been organized to verify and validate the results.

Keywords: Energy Service Companies, Health Care, Analytical Hierarchy Process, Monte Carlo simulation, Key Performance Indicators

INTRODUCTION

Implementing energy service companies (ESCos) is an arising concept and relatively new for the cure market. According to research from SBR, the building sector uses 40% of the total primary energy use, living and service together. Thinking and acting differently contributes to reducing the CO-2 emission and reduced energy pollution and costs (SBR). Gert-Jan Peeks states that the implementation of energy service companies involves a new way of thinking both for the supplier and the client. A precondition is that building owners leave their traditional way of thinking and tendering. This new way of thinking creates a lot of opportunities with which a lot of energy savings can be achieved (Peek & van Remmen, 2012). A few hospitals are starting to implement energy performance contacts, outsourcing to an energy service company. At first glance a lot of opportunities for hospitals to outsource exist. Overall hospitals lack the capacity to actively deal with energy savings. The user and maintenance company do not have sufficient knowledge and experience on the energy subject (Builddesk, 2011). A lot of energy and money can be saved by applying sustainable

energy systems and installations which can be implemented by energy service companies. According to van AgentschapNL and Heumen and Traversari, a healthier, safer working and living environment can thereby be created (van Heumen & Traversari, 2010) (AgentschapNL, 2010).

Problem Description

The priority for outsourcing is low and a lack of insight in the willingness and considerations of hospitals to collaborate with energy service companies exists while substantial and profitable energy savings can be achieved (NL Energie en Klimaat, 2010). The problem is that supply and demand are not aligned. On both the supply and demand side several misunderstandings, ambiguities and lack of trust are present (Builddesk, 2011).

Research Purpose

The goal of this research is to give insight in the consideration framework of hospitals in their decision to collaborate with an energy service company and the measures to be taken to respond to hospitals and/or financial institutions to cooperate in ESCo projects. The demand of hospitals for energy service companies should be clear but also the type of energy service company that can be put on the market. This research will therefore consist of a market analysis and business case. The importance and bandwidth of the most relevant KPI that can be incorporated in an energy performance contract should be found. Another obstacle that should be overcame is the risk perception of the client as well as the energy service company. When risks are incorporated in the business case, trust for both parties can be increased. Eventually the most optimal energy service company for a hospital will be outlined.

Research Questions

From the problem definition and research purpose the following main research question is created: How can we improve the implementation of Energy Service Companies in the cure market?

Research Boundaries

Although a wide network of stakeholders is involved in an ESCo project, this research focuses on the client, with the hospital in particular, the financial institution and the energy service company. For this research within the organization of a hospital, financial directors, facility management, technical service and the real estate department play a role.

According to 'Stichting Kien' the following considerations for further development of the ESCo are necessary (Te Boekhorst, 2012). This research focuses on the aspects in bold. Logically the aspects will be elaborated for the cure market specifically.

- Covering financial and performance risks.
- Governmental assurances and guaranteeing conditions
- Developing financing constructions
- Setting up a knowledge platform for all the stakeholders
- Standardization of performance contracts and ESCo-business models
- Defining critical key performance criteria

Research Design

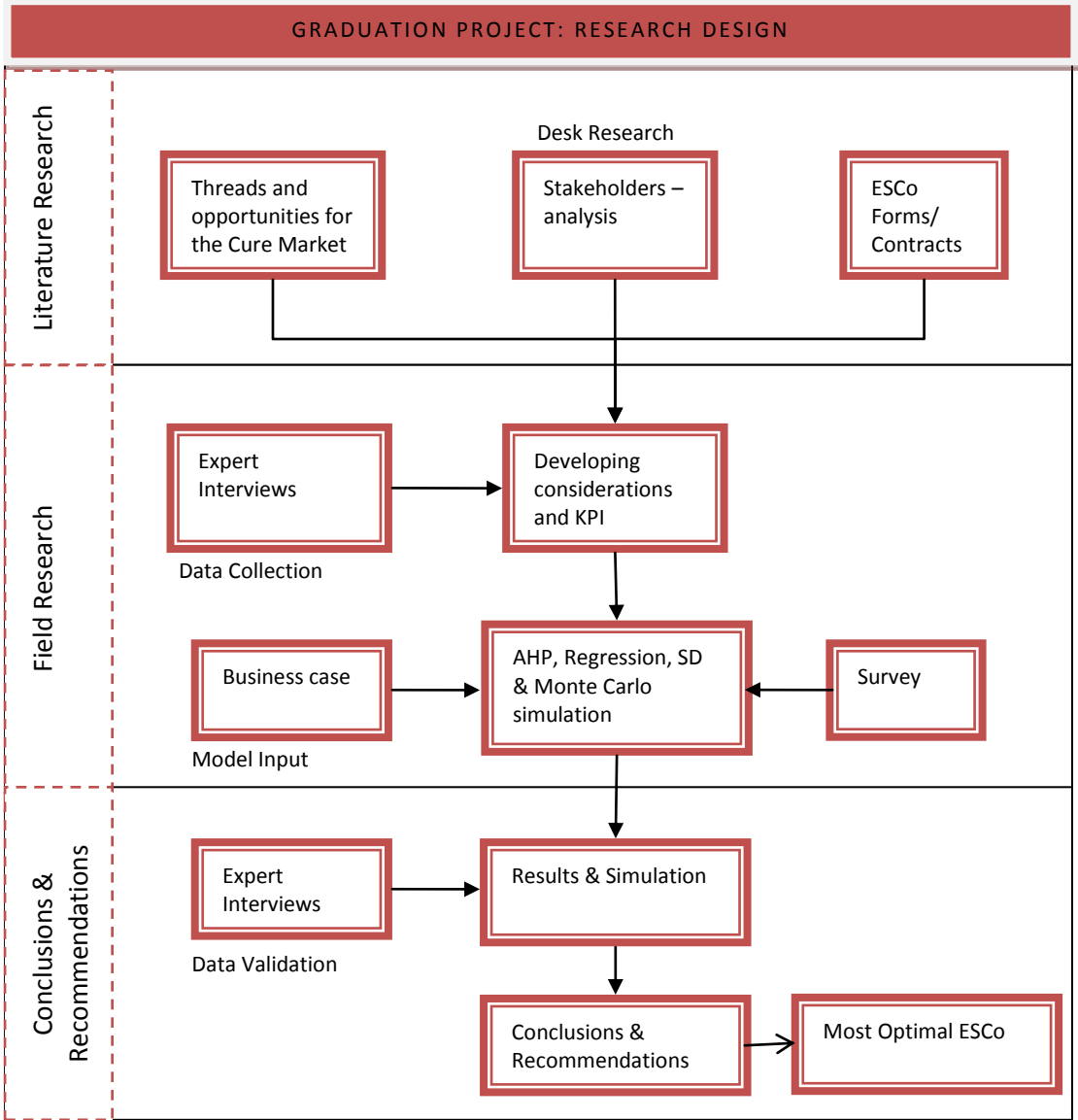The research design is depicted in Figure 1.

Figure 1: Research Design

METHOD

At first, expert interviews in the field of hospitals and energy service companies and additional experience of Kuijpers should appoint the most important considerations of hospitals towards energy service companies. The pair-wise comparisons of Key Performance Indicators will be processed by the method of Analytical Hierarchy Process. Regression analysis will be used to identify interaction effects of variables incorporated in the questionnaire. System Dynamics is used to set up a specific business case. Monte Carlo Simulation incorporates the most important risks within this business case with which also the bandwidth of key performance indicators can be underpinned theoretically.

Regression Analysis

The method of logistic and multiple regression is used to interpret the data output of the questionnaire. Correlation indicates the interaction of two variables. However correlation

does not tell anything about the predictive power of variables. The subsequent step is the regression analysis where one variable is predicted by another. Multiple regression seeks to predict an outcome variable from several predictor variables.

Analytical Hierarchy Process
The Analytical Hierarchy Process (AHP) is a decision-aiding method developed by Thomas L. Saaty in the late seventies. It aims at quantifying relative priorities for a given set of criteria on a ratio scale, based on the judgment of the decision-maker, and stresses the importance of the intuitive judgments of a decision-maker as well as the consistency of the comparison of alternatives in the decision-making process (Saaty, 1980).

System Dynamics
The System Dynamics method (SD) is used to understand complex issues by modeling it in a mathematical way. It represents real life problems with different scenarios and tests to realize an optimal result in the end. The public and private sector can be supported by system dynamics models with which policies can be designed. Dynamic systems characterized by interdependence, information feedback, mutual interaction and circular causality can all be modeled by using System Dynamics (Sterman, 2000). In this research System Dynamics is used to set up the business model with which a sensitivity analysis can be carried out using Monte Carlo Simulation.

Monte Carlo Simulation
Monte Carlo simulation is a technique used to understand the impact of risk and uncertainty in financial, project management, cost, and other forecasting models. Since energy service companies guarantee energy savings established in a contract over a long time, the project involves a lot of risks and uncertainties. These uncertainties should be incorporated in the business model of a project.

FINDINGS
Literature Study
Because of the broad definition of the concept of energy service companies, the concept has been subdivided in terms of *depth, scope* and *method of finance* (Sorrel, 2007). The *scope* represents the number of useful energy streams and/or final energy services that are wholly or partially under the control of the contractor. The contract *depth* relates to the number of organizational phases required to provide the service or product that is under control of an energy service company. The following phases have been distinguished for this research: Staff training, monitoring, ownership, installation, energy purchase, financing, maintenance, operations and engineering. The *method of finance* in terms of Third Party Financing can be subdivided in the shared savings concept and the guaranteed savings concept. The depth, scope and method of finance can be varied, generating multiple options for an energy service company which are also incorporated in the questionnaire.

The energy intensiveness resulting in a high energy saving potential, a growing privatizing and liberalizing market, lack of financial or technical abilities of hospitals and an increasing focus on health care within hospitals favor the introduction of energy service companies. Hospitals are currently subject to several developments. Lately the financing structure changed. All activities and operations of the hospitals derive from the demand of the patient

instead of fixed tariffs. Therefore energy cost savings directly benefit the quality of health care. The European guidelines for energy savings and application of sustainable measures set targets for governments on all levels. However most hospitals do not notice any enforcement of the environmental act of the municipalities. The beneficial tax arrangements EIA/MIA and SDE+ subsidy stimulate the application of sustainable measures.

Expert Interviews

In Figure 2 the most important considerations for hospitals towards energy service companies are appointed. In interviews with different working functions of hospitals these considerations have been validated. Financial and technical outsourcing, trust and energy costs are the most important considerations for a hospital. The most important considerations for financial institutions to cooperate in an ESCo project are the creditworthiness of the client, quality of the energy performance contract and quality of the object to be leased.

Demographical Factors	Political Factors	Economical Factors	Technological Factors	Ecological Factors	Social-Cultural Factors
•Adjustability Hospital •Compliane with current medical systems	•Environmental law •Subsidies •Municipal targets	•Energy costs •Job Employment •Payback Period •Attracting Customers •Value Real Estate •Financial power	•Technical knowledge	•Environment •Health •Indoor climate •User-quality	•Continuity Operational Activities •Trust •Resistance medical specialists •Public opinion

Figure 2: DESTEP Energy Service Companies in the Cure Market

Data Collection

The respondents of my questionnaire for the Analytical Hierarchy Process (AHP) and Regression Analysis had to be working in a hospital environment with a function related to energy and installation techniques or contract management. After phone calls and two reminders by e-mail, a total of 37 respondents of different hospitals completed my questionnaire. . Data for these methods is collected from employees of the Technical Service or Facility Management from different hospitals. In addition, perspectives from financial directors make the overall picture of the attitude of a hospital towards energy service companies complete. Eventually 7 interviews with financial directors were organized. The amount of expert respondents turned out to be plenty enough to be able to carry out the AHP analysis. Quantitative data for the business case has been obtained from Kuijpers.

Regression Analysis

Following from the questionnaire, financial outsourcing proved to be more of a reason than technical outsourcing. Half of all respondents are willing to implement energy service company in some form. Most of the respondents look for a solution in the middle. Finance, Maintenance, Operations/Energy purchase and Monitoring appeared to be the most relevant phases to outsource for a hospital. For facility managers technical outsourcing turned out to be a stronger motive to outsource than for the technical service according to the outcomes of the survey. The technical service might have a conflict of interest. This effect strongly favors the facility management to approach as an energy service company. In

general the link between the facility manager and financial directors is also stronger. An interaction effect could be noticed between the willingness of implementing an energy service company and high age and low floor surface of a hospital.

Most financial directors are not familiar with the ESCo concept. The wish to save more energy and apply sustainability in the broadest sense exists. The financial directors operate on strategic level and confirmed that their hospitals were currently in transition after the governmental interventions. An increasing focus on health care can be observed. A lack of financial capabilities and aging of technical service is perceived. Thus financial directors indicate that outsourcing energy might be a solution for the future. However trust in the other party is very important since it should not be at the expense of health care. From these interviews also a difference between facility management and real estate is indicated. In general facility management focuses on the availability of installations while the real estate department aims to reduce operational costs. The new way of thinking is therefore in line with real estate management while the new concept is harder to understand for a facility manager. However, the notifying is that real estate is managed differently between hospitals.

Analytical Hierarchy Process

The key performance indicators incorporated in the questionnaire are listed in Figure 3 developed by author based on literature. The relative importance of these key performance indicators that can be incorporated in an energy performance contract for hospitals was assessed by the method of Analytical Hierarchy Process. A focus of the different (levels of) KPI could be identified. The service, costs and comfort indicators are preferred over the innovation and sustainability indicators. The safety, maintenance costs, amount of malfunctions, energy use and air quality and thermal indoor within the comfort indicators turned out to be the most applicable KPI within an energy performance contract.

Service (People)	Sustainability (Planet)	Costs (Profit)	Comfort (People & Planet)	Innovation (Planet & Profit)
• User experience • Status Installations • Malfunctions • Response time • Safety	• Energy use • Efficiency Installations • Energy label • BREE-AM certification	• Maintenance costs • Energy costs	• Thermal indoor • Air quality • Lightning and scenic vision • Acoustic indoor	• Renewal • Revision information

Figure 3: Key Performance Indicators

System Dynamics

The outcome of the model depicted in Figure 4 is the net present value based on the discounted cash flow and discount rate of 15%. A discount rate of 15% for a long-term project including risks is plausible. The cost items influencing the Costs flow have been determined for this specific business case in cooperation with Kuijpers. The investment costs, labor costs, maintenance costs and energy costs including energy taxes are always present in the business model of an energy service company. The maintenance costs are influenced by a yearly maintenance indexation and include a share of fixing costs. The energy costs consist of the generated energy peak and off-peak by the different installation systems and the energy price per kWh. The energy costs are subject to a yearly electricity indexation.

The generated energy depends on the running time and capacity of the installations (Source Pumps, Heat Pump, Circulator Pumps and Electricity Balance Facility). The coefficient of performance of the heat pump and actual electricity use eventually affect the energy costs. The circled variables are the parameters that are varied, creating different scenarios used for the Monte Carlo simulation.
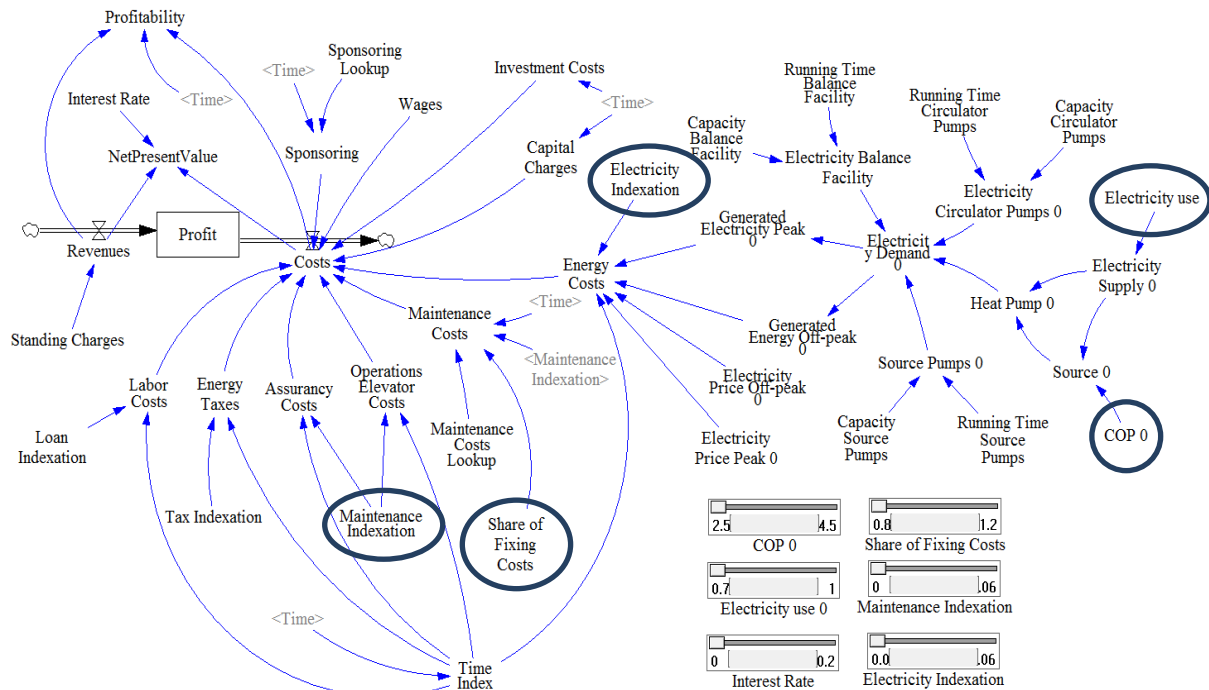

Figure 4: Stock Flow Model Business Case

Monte Carlo Simulation

Monte Carlo simulation is used for the sensitivity analysis of the business case in which five parameters are varied following a probability distribution. The specific business case for this research deals with an energy service company implementing a heat-cold storage installation. The uncertain parameters that could vary over time are listed in Table 5. 50.000 simulation steps were carried out following a PERT distribution.

Table 5: Parameters Monte Carlo Simulation

Dependent variable	Unit	Affects the	Expected Value	Uncertainty range
Indexation electricity	%	Energy costs	6%	4-8%
Energy usage	kWh	Energy costs	90%	70-100%
Coefficient of Performance	Dmnl*	Energy costs	3.5	2.5 – 4,5
Indexation maintenance	%	Maintenance costs	2%	0 – 6%
Percentage repair costs	%	Maintenance costs	100%	80 – 120%

Results of this business case are confidential and can only be found in the appendix of the full report. A bandwidth of the net present value with a certainty of 80 percent could be predicted. This business case proved to be sufficiently profitable to continue the collaboration. Thereby the individual risk contribution of the parameters have been estimated. It appeared that the risk contribution of maintenance indexation has the largest

influence on the outcome followed by the fixing costs and coefficient of performance. Controlling and focusing on decreasing the maintenance costs is therefore recommended.

CONCLUSIONS

The main conclusion of this research is that the most optimal energy service company that can be offered to a hospital at this moment is highly dependent of the current demand and structure of the organization. The structure of the organization of a hospital should first be explored before the concept of energy service company can be introduced. The most optimal form of energy service company for a specific hospital is highly dependent on the current situation and needs of the hospital. Answers to the following questions need to be identified at first:

- At which point of the transition is the hospital at this moment?
- How are the departments of technical service, real estate and facility management structured within the organization of a hospital?
- What are the technical and financial capabilities of the organization?
- Who is responsible for energy management and the energy bill?
- What are the sustainability targets?
- What is the current state of installation techniques and condition of the building?

Otherwise the needs and considerations of a specific hospital can hardly be estimated. When insight has been gathered on these questions, recommendations can be given because each question is more or less related to the willingness of implementing an energy service company. The relevant answers to these questions and recommended strategies that suit the implementation of energy service company best, are summarized in Figure 6. The terms in bold are given preference over the other.

Market pull	-	Market push
Regional hospitals	-	Academic hospitals
Large hospitals	-	**Small hospitals**
Older hospitals	-	New hospitals
Facility management	-	Technical service
Facility management	-	**Real estate department**
Financial direction	-	**Real estate department**
Service, comfort, costs KPI	-	Sustainability, innovation KPI
Financial outsourcing	-	Technical outsourcing
Shared Savings	-	Guaranteed savings
Outsourcing	-	**Shared responsibilities**

Figure 6: Comparisons Main Conclusions

System Dynamics in combination with Monte Carlo simulation can be very useful in estimating risks within business models and the bandwidth of the key performance indicators. A bonus or penalty can be assigned depending on the percentage deviation of the expected value. In estimating the bonus or penalty, Monte Carlo simulation estimates the probability a certain deviation is expected. The energy service company is then able to underpin their bandwidth of the key performance indicator theoretically.

Most Optimal Energy Service Company

Flaws still exist within the concept where a hospital is completely outsourced by an energy service company. A portion of the consumed energy use for example is beyond the scope of influence for the ESCo or dependent of the user. A penalty can be beneficial financially for the client. Clients should not be tempted to let energy service company exceed the established bandwidth according to the energy performance contract. A way to optimize the unique selling points of energy service companies in my perception is to create a so-called special purpose vehicle in which a new cooperation is established where all involved parties are jointly responsible. Shared responsibilities in which sustainability, optimization and proper maintenance are the mainspring.

In addition, to decrease submerging responsibilities during the contract period by one of the parties is to make smart arrangements for profit sharing. An example of profit sharing based on the agreed bandwidth of a key performance indicator is depicted in Figure . The share of profit is plotted against the KPI percentage of expected energy savings. A target of potential energy savings should be estimated on which a percentage deviation should be agreed upon. In this case a bandwidth of 95% to 101% of the expected energy savings is acceptable where the ESCo performs as it should be. However when even more energy is saved, the client will have a 25% share of profits rising to 75%. This will stimulate both parties to save as much energy as possible. On the other hand, the client should also carry a little part of the burden for 25% of the losses in case of underperformance. The client and user are partly responsible for shortfalls of energy saving. The special purpose vehicle aims to create a long-term collaboration in which every party has the influence it comforts. The risks and savings are distributed in line with each interest and responsibility in the most optimal way.
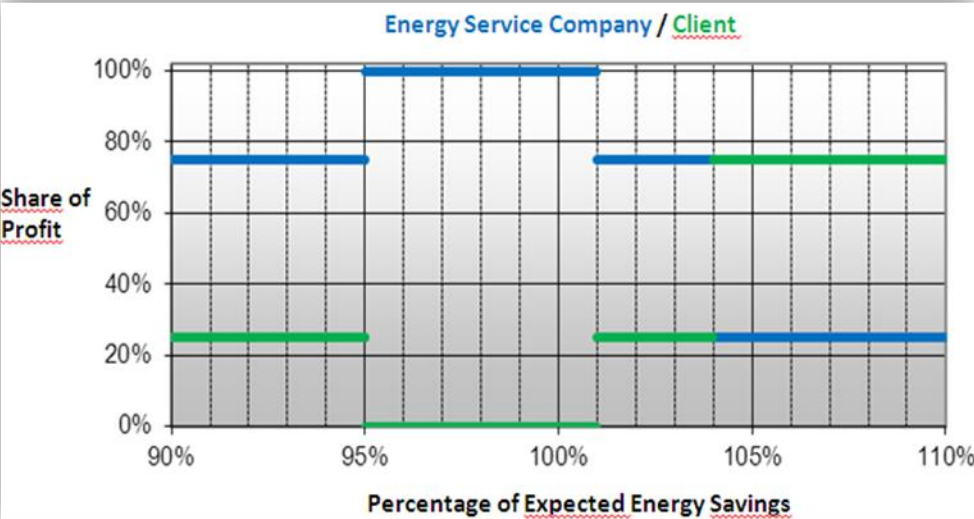

Figure 7: Distribution of Profit (developed by author based on Kuijpers models)

DISCUSSION

One useful conclusion is that the implementation of energy service companies within the cure market is highly situation dependent. The most important needs and considerations of hospitals are provided in this research. An energy service company should first know about these considerations of a specific hospital before a product can be offered. Only then key performance indicators can be implemented where a good balance of trust and KPI within the contract should be found.

The findings of this research can be strengthened in a quantitative and qualitative way. A more complete image of the cure market can be outlined with more data from hospitals. Also more in-depth data can be gathered when an extensive collaboration is engaged with a hospital. The System Dynamics method in combination with Monte Carlo simulation proved to be useful but can also be improved by generalizing the model and also taking the business model of the client into account.

Further Research
To sum up, the recommendations for further research resulting from the conclusions and discussion are the following:

- Estimating key performance indicators in the practical field
- Investigating the application of Real Options Analysis (ROA)
- More extensive theoretical underpinning
- Generalizing and extending the System Dynamics model
- Giving insight in the Health Care (real estate) transition
- Giving insight in the possible financial (tax-)arrangements

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K.J. (Koen) Hemink

Thank you for reading this summary of my graduation report. The graduation project was an inspiring time in which I learned a lot on the field of energy service companies, sustainable installation techniques and the health care sector. I hope I have contributed to an understanding of the health care sector and showed the potential of energy service companies within this sector with useful tools. I want to thank Kuijpers Ecopartners for giving me the opportunity to graduate on an interesting and topical subject and to experience with the scientific methods in the practical field.

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CAR DRIVERS' PREFERENCES REGARDING PARKING INFORMATION
How to reduce search traffic by inform car drivers better about parking facilities close to their final destination
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ABSTRACT
These days, urban areas suffer more and more problems concerning emission of harmfull gasses. One of the causes of these problems is the emission by local traffic. Several studies show that a certain amount of traffic exists of search traffic. Traffic is searching for a parking spot nearby their final destination. By providing real time parking information towards car drivers, the drivers do not have to search for a parking spot. This means a reduction of search traffic and resulting in less emission of harmful gasses. This study is focused on the car drivers' preferences regarding parking information.

Keywords: Parking Information, Preferences, Stated choice, Hierarchical information integration, search traffic.

INTRODUCTION
These days, sustainability is a hot item amongst (local) governments and other interested parties. Sustainability is hot because of the environmental issues (the global heating effect, emission of harmful gasses, etc. etc.) which become increasingly important these days. Therefore governments and other interested parties are searching for solutions which can encounter the environmental problems. One of the major problems within urban areas is the emission of harmful gasses, which consequently contributes to environmental problems. The emission of harmful gasses does not only have effect on the environment. It also affects the livability of urban areas and will have effect on the health of its inhabitants living in these urban areas. According to calculations by the Planbureau voor de leefbaarheid (Office for Liveability), Centraal bureau voor de Statistiek (Central Office for Statistics) and the University of Wageningen traffic is responsible for about 15% of total energy consumption in the Netherlands (Cramer, 2012). In addition, nearly 47% of the total (fossil)fuel consumption accounts of passenger cars. From these facts, it is obvious to say that local traffic contributes to the environmental problems. By decreasing the amount of local traffic, the pollution of harmful gasses can decrease enormously. Recent studies show that a certain amount of local traffic exists of search traffic. Those studies show also that a certain amount of this search traffic is searching for a parking spot close to their final destination (e.g. Arnott et al, 2005; Shoup, 1997; Spittje, 2007; van Ommeren, 2011; Gallo et al,2011; Geng et al, 2012).

Concluding that if people or in other words, car drivers, know where to park the amount of search traffic will decrease. This is indirectly related to the emission of harmful gasses and results in a better livability of the urban area. Therefore, car drivers need real-time and specific information about parking facilities close to their final destination. So they do not have to search for a parking spot (Felici and Schurink, 2011).

RESEARCH AIM
At this moment there are several initiatives providing some amount of the available parking data. It seems that those projects are not successful. In addition, parking guidance systems appear not to have the desired effect as was expected. Such systems only prove to be successful when complete information as service providers (may) offer, is the integration of: Latest parking information; Current traffic information (i.e. road works); Navigation services; Other (personalized) information, such as multi-modal travel information and weather info.

This study only takes into account the information flow which is useful for the user and not the information flows between the various parties associated with the parking world. For example information concerning occupancy is important for a user while information about the use of energy is not. There will be a focus on what kind of information the user needs to create a suitable/preferable choice.

Consequently, the following research questions are formulated:
Main question 1: 'What parking information supports a drivers' parking search behavior?'
Sub-question 1.1; 'What information do travelers want to make an optimal parking choice?'
Sub-question 1.2; 'Do travelers adapt their behavior based on distributed information?'

Most important in this project, is the collection of the car drivers' preferences regarding parking information, therefore an instrument has to be developed which is able to measure those preferences.

THEORETICAL FRAMEWORK
This part describes the various aspects concerning the problem statement for this research project. As stated earlier, these days, governments and other parties are dealing with various problems concerning the environment. The emission of harmful gasses who causes problems like the global heating effect and health problems of citizens living nearby.
<u>Sustainability</u>
Several researchers investigated the effects of air quality on health (Pope et al, 2002; Janssen et al, 2003; Oberdörster et al, 2003; Schlesinger et al, 2003; Gouderman et al, 2007; Knol, 2009; Pope et al, 2009). Gouderman et al (2007) show in his case that children, who live within 500 meter of a highway have a reduced growth of long function. Research from Pope et al. (2009) specifies that long-term exposure to combustion-related fine particulate air pollution is an import environmental risk factor for cardiopulmonary and lung cancer mortality. Beside, research shows that a reduction in exposure to ambient fine-particulate air pollution contributed to significant and measurable improvements in life expectancy (Pope et al, 2002). Nowadays, the air quality in the Netherlands is getting better. Yet there are still places where the requirements are not met in terms of particulate matter (fijn-stof) and NOx concentrations. At these places where the requirements from the Wet Luchtkwaliteit are not met, road traffic delivers an important contribution to the (too) high concentrations of pollutants in the air. A reduction in the amount of traffic or a shift to cleaner road transport can make a significant contribution. It is important to reduce the amount and/or duration of car trips. This will lead to a reduction of the emission of harmful

gasses. Which will eventually results into a better livability of urban areas. Ensured by a better air quality it will lead to a decrease of health problems. In the following paragraphs of this chapter an inside will be given into the possibilities to counter these problems.

Accessibility and search traffic

Providing a good accessibility is these days an important task for municipalities/ governments But what is accessibility actually and why is it so important for governments? This part of the study treats all the elements concerning accessibility. The Dutch national government stated, in their structural view concerning infrastructure and environment (structuurvisie infrastructuur en ruimte), that to be competitive towards other countries, a good accessibility is essential to achieve this goal. Thereby, accessibility improves the livability of citizens (van Wee et al, 2001). Thereby research shows that there is a linkage between accessibility and trip generation (Geurts et al, 2001). These findings are rarely miscellaneous instead that accessibility always increases the amount of trips. In general, the accessibility of a destination improves when search-time reduces. By providing parking information to car drivers, accessibility of the destination will increase because the travel time will be shortened. So in term of accessibility, for governments it is important to have a good provision of parking information to improve the accessibility of their municipality. Thereby the comfort of traveling for the car drivers will be ensured. These days, a non-negligible part of the total travel time can be spent for searching for a free parking lot. The search for parking spaces increases road congestion significantly (e.g. Gallo et al, 2011). It is hard to define the amount of search traffic. Actually cruising for a parking space creates a mobile queue of cars that are waiting for parking space vacancies (Shoup, 1997). The problem is that these cars are mixed with other traffic that actually goes somewhere. Before most transport economist and city planners neglected it as a source of congestion because this kind of cruising is invisible. Nowadays, due to the still becoming stringent requirements concerning air pollution and CO_2 emissions this kind of congestion is investigated. Some researcher attempted to estimate the volume of cruising and the time to find a free parking facility/space (Shoup, 1997). It was estimated that between the 8% and 74% of traffic is generated by cruising for parking (e.g. Arnott et al, 2005; Shoup, 1997; Spittje, 2007; van Ommeren, 2011; Gallo et al,2011; Geng et al, 2012). It was also estimated that the average time to find a parking space is ranges between 3.5 and 14 minutes (e.g. Shoup, 1997; Gallo et al, 2011). Eventually we can conclude that search traffic is responsible for a certain amount of traffic congestion within urban areas. This results in effects on the environment. Besides it has effects on environment and health, all this 'search traffic' has a (indirectly) negative impact on the accessibility of citycenters. What causes economic implications for the region.

RESEARCH APPROACH

To gain data for this research project, a certain approach has to be adopted. First of all, it is important to select the required methods and techniques. In the end the data collection will be described

METHODS AND TECHNIQUES

With choice modeling, the model attempts to model the decision process of an individual or groups of individuals in a particular context. Within the world of choice modeling, stated preference or choice is a common used subset of choice modeling. The method of stated preference has several advantages seen from a practical standpoint. First of all, with stated preference experiments, the attribute levels are pre-specified by the analyst and given to the

decision maker by the researcher as determined by some statistical design. Secondly, with stated preference data, respondents are usually shown multiple choice sets, each of which has different attribute levels. However stated preference elements are often used, the method has a large limitation due to the inability to handle a large amount of potential influential attributes. Research shows that limitation of the amount of attributes has influence on several aspects of the experiment (e.g. Helvoort-Postulart et al, 2009). First of all, people cannot process that many attributes at once, when the respondents have to handle large amounts of attributes they become tired and consequently they ignore or address attributes in random and uncontrolled ways. Secondly, excluding potentially significant attributes may bias estimates of utilities, reduce predictive validity and/or lower the value of the results. Hierarchical information integration is an alternative method, to use more attributes than is possible with stated choice experiments. In this, hierarchical information integration categorizes the relevant attributes into meaningful subsets also known as constructs. This allows preference functions to be estimated 'as if' one full profile design had been administered, without the information overload of such a large full profile experiment (see Helvoort-Postulart et al, 2009). Discrete choice modeling is a research method to analyze collected choice data. One of the most used and traditional models is the Multinomial logit model. Compared with other choice models, the multinomial logit model is particularly attractive in many modeling scenarios due to the nature that it is linked to the decision-making behavior via maximizing (minimizing) the utility (e.g. Baibing, 2010). Furthermore, explaining the multinomial logit model, the model assumes that the random components are independently and identically double exponential distributed.

Selecting the attributes

By providing car drivers information about parking facilities, close to their final destination, the drivers do not have to cruise around searching for a parking spot. This information can be provided pre-trip, during the trip or at the final destination. With the provided information, the user can choose were to park best. Of course with a for the user best selection criteria. Several studies have been done on the effects of information provision in the context of parking (e.g. Khattak et al, 1993; Polak et al, 1993; Thompson et al, 1997; Paniati et al, 2007; Van der Waerden et al, 2010; Van Der Waerden et al, 2011). Information about occupation, tariffs, and, walking distance is most valued by the car drivers. Figure shows elements that researchers investigated in their studies.

Element	Element	Element	Element	Element
After transport	Electric charging point	Occupancy rate	Presence of a AED	Space to park motorcycle
Bad layout or design parking lots	GPS coordinates	Opening hours	Presence of ATM	Special days
Capacity	Handicap parking spots	Opportunity for reservation	Presence of bottle bank	Safety property (car etc)
Chance of free space	Hours when to pay	Parking guidance system in parking facility, directing you to a parking spot	Presence of Trolleys	The staff is first aid trained
Cleanliness	Lockers	Parking fee costs	Present of discounts	Toilet
Difficulty entering parking lot from street	Maneuverability limits of vehicles in parking lots.	Parking time restriction	Present of signs	Type of parking
Difficulty exiting parking lot to street	Maximum drive-through height	Personal safety	Range mobile phone/car navigation inside parking facility	Visibility
Difficulty to see pedestrians	Methods of payment	Poor aesthetics	Security	Walk ways for pedestrians
Distance of parking facility to intended destination / Walking time	Moment of payment	Poor design of lanes to drive across	Size parking spot	Security at entrance
Distance of parking spaces from entrance	Number of free spaces			

Figure 1: Parking information elements

As mentioned before, stated preference method has a large limitation due to the inability to handle a large amount of potential influential attributes. Hence, it is meaningful to downsize the number of attributes, or search for a method that can help to create a manageable research design. Therefore we chose for the Hierarchical Information Integration method. It helps us to carry out a stated preference experiment, without the result that people have to process that many attributes at once. After categorizing and downsizing the attributes it results in the next list (see figure 2).
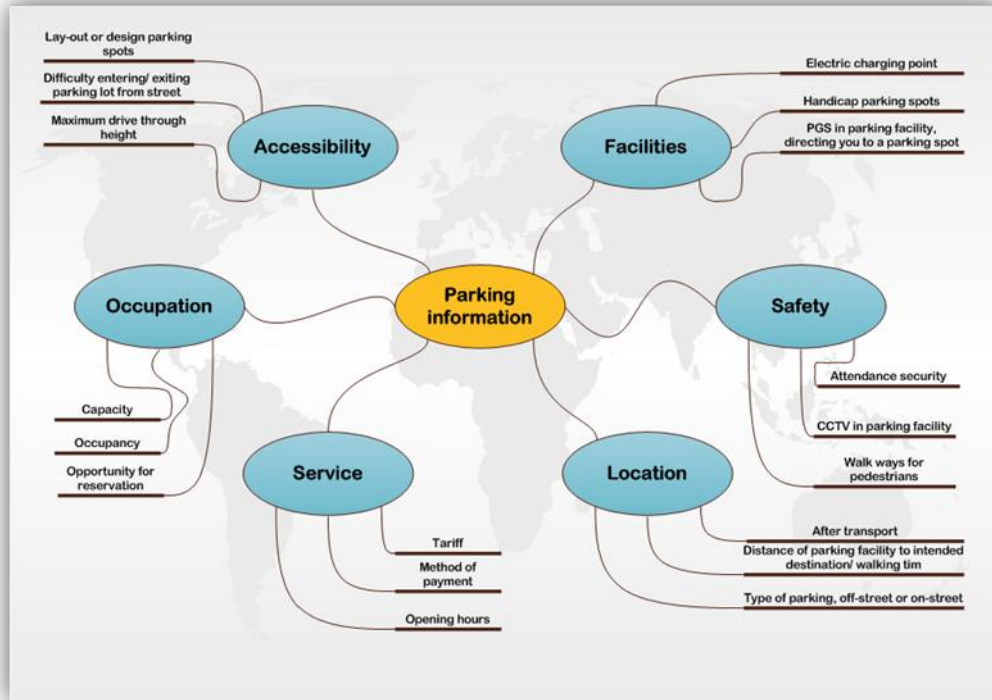
Figure 2: Relation of attributes and constructs with parking information
Experimental design
The construction of the questionnaire is the next step within the data collection process. The attributes, the amount of them and the way in which they are categorized are now known. Therefore construction of the experimental design and the choice tasks are necessary. Actually, now six different experimental designs were constructed to link the attributes of each decision construct to the high-order descriptions of the five other constructs. With randomization all the profiles were categorized into choice tasks with three choice sets. Randomization ensures a completely orthogonal design. For each choice task, three choice alternatives are represented (see Figure). So, there are in total nine choice tasks per construct. Totally, this is still quite a lot. The respondent, now has to evaluate 54 choice tasks (6 constructs in total, 9 choice tasks per construct). Again this is still too many for meaningful research. Therefore, the decision is made to distribute those choice tasks among nine respondents. This means that each respondent will evaluate one choice task of each construct. With a total of six choice tasks, each from another construct. For respondents it is now manageable to handle the amount of attributes. The main part of the questionnaire, the stated preference part, see Figure , where the choice task is visualized, the respondents are asked to evaluate the choice alternatives. First respondents are asked to evaluate, per choice set, the specific combinations of attribute levels that describe a particular decision constructIn the second question, the respondents were asked to state whether they would choose choice alternative 1('informatiepakket 1'), choice alternative 2('informatiepakket 2')

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or choice alternative 3('informatiepakket 3') to support their parking decision making process.

Figure 3: Choice task questionnaire

Officially, the questionnaire was launched on the first of May 2013, the total number of 525 completes was reached on the 23rd of May 2013. Approximately 875 people started with the questionnaire, the amount of people invited for the questionnaire is around 1700.Before launching the questionnaire, conditions about the respondents are set. The minimum age of the respondents has to be 18 years. Finally, ownership of a driving license is required.

DATA ANALYSIS

To analyze the stated choices multinomial logit modeling is used. Therefore the NLOGIT 4.0 software package is used to process the choice data. Formally, the utility model is expressed as follow:

$$U_i = V_i + \varepsilon$$
$$V_i = \beta X_{cj} + \gamma C_j + \eta_{ic} + \varepsilon_{jn}$$

c = construct i, i = alternative i, j = detailed construct i, n = number specific construct

In these equations U_i is the car drivers' utility for using a specific information package i. V_i is the respondent specific utility for the choice task. X_{cj} is a vector of the detailed attributes of construct c in profile j and β is a vector of parameters for the effects of these attributes on the consumer's utility. C_j is a vector of values of the constructs i that are not presented at the detailed level, and γ is a vector of parameters for the effects of these values on the consumer's utility. Finally, ε_{jn} is an error component in the utility function that captures, among other things, measurement errors on the part of the researcher. This error component is assumed to be Gumbel distributed and drives the logit probability structure.

η_{ic} is a construct specific intercept correction in case that construct c is presented at the detailed level. With the mean η_c and random error component τ_{ic}.

$$\eta_{ic} = \eta_c + \tau_{ic}$$

For the multinomial logit model the equation as stated below is used.

$$P(J_i) = \frac{\exp(U_i)}{\sum \exp(U_i)}$$

$P(J_i)$ Gives the expressions of the probability for alternative i. Therefore, the Utility U_i has to be compared with the overall utility $\sum U_i$. The goodness of fit for the statistical model has to be evaluated. Based on the outcomes of Nlogit software. For the null model (all parameters equal to zero) the value of -3480.4037 is used, and for the most optimal, alternative model the value of -2952.730 is used. Comparing the R-squared result (0.15) with other similar parking research projects this result does not deviate compared to other research projects (e.g. Van der Waerden, 2012). For the log-likelihood estimation, the log likelihood ratio statistic is 1055.35 with 29 degrees of freedom. Thereby, the critical chi-square ratio is 42.56, this resulting that the log-likelihood is much higher than the chi-square ratio indicating that the optimal model outperforms the null model. Per construct and per attributes the utility and significance is generated.

Figure 4: Results analysis constructs

This is visualized in Figure & Figure . First of all, as we expected most of constructs are increasing, in an almost fluid line, when the amount of information provided also increases. Only by 'Service' and 'Occupation' this is not the case. Only after increasing the amount of information from 'average' to 'broad', the utility of the constructs 'Service' and 'Occupation' decreases. As information is compared, based on the range covered, 'Occupation' is the

highest ranked constructs. This means that when information about this construct is provided limited and this will be changed into broad this has the highest influence on car drivers' preferences. For 'Facilities', this has the least influence on car drivers' preferences. Thereby it is remarkable to state than when broad information is provided about 'Service' this has a negative influence on car drivers preferences. Overall, the following ranking of most important constructs can be generated(number one is the highest ranked construct and number six is the lowest ranked construct):1) Occupation, 2) accessibility, 3) Location, 4) Safety, 5) Service, 6) Facilities.

By treating each construct, the following can be concluded. First of all, the constructs 'Accessibility', 'Safety', 'Service' and 'Occupation' have high utilities of their attributes. 'Facilities' and 'Location' does not have that. Based on the values of the utilities showed in figure 13.**Error! Reference source not found.** the attributes 'Difficulty entering exiting parking facility (construct Accessibility)', 'CCTV in parking facility (construct Safety)', 'walk ways for pedestrians in parking facility (construct Safety)', 'tariff (construct Service)', 'methods of payment (construct Service)' and 'occupancy (construct Occupation)' are in the general the most important attributes. In general it is important to provide information of one of these constructs also to provide information about this particular attributes.

Figure 5: Results analysis attributes

CONCLUSION

To collect and provide parking information, the national database parking facilities is introduced. At one end, the database contains data from the owners/operators of parking facilities and on the other side the database provides information towards service providers.

For this initiative, the national database parking facilities needs to know which information is the most important in the car driver's decision process towards parking. This graduation project deals with this question.Not only the reduction of the harmful gas emission is one of the benefits when providing parking information to car drivers. Also the provision of relevant information improves the accessibility of the destination, because visitors do not have to search for a parking spot which reduces their travel time. It also contributes to the livability of urban areas. Less search traffic means less emission of particulate matter. This will eventually lead to a better healthiness of the surrounding residents. The implementation of the national database parking facilities has many (social) benefits, making it that more interesting for governments and other stakeholders.

To get insight into the car drivers' preferences regarding parking information, a questionnaire is constructed to collect data. In this questionnaire several choice experiments were designed to obtain information about car drivers' preferences. A stated choice experiment was used to support the data collection regarding the preferences. Because the large amount of attributes, it was important to organize them in a manageable way. First, the attributes were selected based on a literature study. Later on, using hierarchical information integration, the attributes were categorized into constructs. By doing this, respondents will not be overloaded with information of a large full profile experiment. The questionnaire was completed by 525 respondents.

Multinomial logit modeling was used to analyze the obtained preference data. For this kind of research, it is one of the most used analyses techniques. By log-likelihood estimation, the goodness of fit of the model was tested. From calculations there was concluded the goodness of fit meet the requirements. Thereby, respondents' characteristics were analyzed, the distribution of the respondents amongst sex, age, educational level, car drivers experience and type of car was representative compared to the national average.

From the analyses of the car drivers' preference part, results were obtained concerning the provision of parking information. The provision of information about occupation and accessibility will have the most influence on car drivers' preferences. Thereby, it is important to know that information about the attributes 'Difficulty entering exiting parking facility (construct accessibility)', 'CCTV in parking facility (construct safety)', 'walk ways for pedestrians in parking facility (construct safety)', 'tariff (construct service)', 'methods of payment (construct service)' and 'occupancy (construct occupation)' are the most important when providing information about the construct related to the attribute.
In general, most of the respondents think that provision of parking information will help them with their parking behavior. Therewith, the last sub question of the research questions is answered.

For further research, this instrument/tool to measure the car drivers preferences the data could be analyzed more deeply. For example by using mixed logit modeling. Furthermore the data can be transformed with the respondents characteristics.

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Ing. T.A.A. Jansen
First of all I would like to thank my graduation committee for supporting me during this project. In the beginning of the project I started very broad with analyzing the whole parking world. Later on I focused myself more and more towards parking information and generated this instrument to collect car drivers preferences regarding parking information. With this result I hope it would be a great start for more research into this problem, besides the interest for the scientific world, this topic is very interesting for all the stakeholders concerning this initiative.
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THE POTENTIAL OF PV PANELS NEAR ROAD INFRASTRUCTURE IN THE NETHERLANDS

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ABSTRACT

Energy from PV panels is considered as very important to decrease the greenhouse gas emissions and leave behind some fossil energy sources for future generations. In the Netherlands space is scarce and not all buildings are suitable for PV. Unused land space or noise barriers near road infrastructure can be used for PV. Ideally, the revenues can contribute to maintain our high quality main road network.

In this paper, the feasibility or potential for a road section in the Netherlands is determined. This is done by using a costs benefit analysis, complemented with a sensitivity analysis. Three technical variants are considered and compared. Besides the economic aspects, also issues as legal, technical, practical, contract and learned lessons are considered to draw conclusions about the potential. It can be concluded that PV panels near road infrastructure can be profitable in combination with a DBFM project and is interesting to investors. PV panels in an open field configuration is currently more profitable than a Photovoltaic Noise Barrier(PVNB).

Keywords: PV panels, Road infrastructure, Photovoltaic noise barrier(PVNB), Cost benefit analysis, Sensitivity analysis

INTRODUCTION

As most people know, energy is a hot topic nowadays. The demand for energy increases every year. In order to comply to this increasing demand in the future, renewable energy is necessary. However, the share of energy from renewable sources is still very low in the Netherlands. In this regard, the Netherlands is one of the worst performing countries in Europe. This is especially the case for energy from solar radiation by using photovoltaic(PV) panels. PV panels are often installed on buildings and rooftops, thus there are often limitations regarding available space, orientation and tilt of existing buildings. Another option is to install PV panels in an open field configuration, called PV parks. But since space is scarce in the Netherlands, PV panels along the roadside could be an interesting option.

In addition to the issue regarding energy generation by using PV panels, there is an issue related to road infrastructure. Not only the demand for energy will increase the coming years, the demand for road infrastructure will increase too. In 2015, the number of

kilometers travelled by car is expected to be 14% higher than in 2010 with average economic growth. Economic development and increasing population are factors that are responsible for the increasing demand. In 2015 there will be 16% more congestion than in 2010 (Kennisinstituut voor Mobiliteitsbeleid, 2010).

The increasing demand for road infrastructure would suggest high priority will be given to investments for construction of new infrastructure and expenses for maintenance in order to keep up with the trends. However, this is not the case. Due to the economic situation, budget cuts seems necessary and are already taken by policy makers in the Netherlands.

When the two issues described above are putting next to each other, opportunities may arise. The opportunity that will be considered in this study is PV panels near road infrastructure. This could be PV panels incorporated in noise barriers or installed at the unused land near road infrastructure. In the best scenario, revenues from the generated electricity are used to finance partly road construction or road maintenance.

Research question
Could PV panels bring added value to the main road infrastructure in the Netherlands, and what will be the potential?

Research objective
Just a few studies are already published regarding PV panels near road infrastructure. Most of them only considers photovoltaic noise barriers(PVNB), none considered the option to install standard PV panels in the road shoulder, near interchanges, exits or entrances. Some studies are about technical insights, one is about the potential of PVNBs in Europe. This study isn't limited to technical insights but aims to cover all issues that are relevant regarding PV panels near road infrastructure. The most important objective is to provide insight in the economic aspect, thus costs and benefits of PV panels near road infrastructure. This is done by using a cost benefit analysis (CBA), included with a sensitivity analysis. For this, a financial model is developed. Besides the economic aspect, this study also covers aspects like technique, legislation and directives, DBFM contract and learned lessons.

In the following section, the necessary background knowledge is discussed. Next, an explanation of the model is given, including the used methodology. Then, a description of the case study is given, and the results of the different variants and the sensitivity analysis are presented. The paper ends with conclusions and recommendations for further research.

BACKGROUND KNOWLEDGE
In order to build a sufficient financial model and be able to answer the research questions, extensive background knowledge is essential. Important parts are briefly discussed in this section. Subjects like the energy market and photovoltaic systems will be discussed. Specific issues when installing PV panels near road infrastructure, are also included in the section.

Energy market
The energy market in the Netherlands consists of multiple components and is influenced by multiple factors such as regulation, taxes, EU-agreements, subsidies etc. The energy branch in the Netherlands has significantly changed as a result of the liberalization which started in

1998 and was completed in 2004. The production, trade and selling of energy have become commercial activities. Since the liberalization of the Dutch energy market the composition of the market has changed, and so are the parties involved. These parties are listed below:
- Producers;
- National grid operator(Tennet);
- Regional grid operator;
- Program-responsible parties;
- Suppliers.

The energy rates in the Netherlands are considered as the lowest in Europe, exclusive of taxes. However, the taxes that are inherent to the energy rates are high. So in the end, the rates that have to be paid are relatively high compared with other countries. The costs of energy for households have risen steadily over the previous 15 years. The energy prices are in January 2012 almost 120% higher than 15 years ago. Thus the average annual increase in the energy price is more than 5%(CBS).

The price of electricity consists of three components, which are electricity production, grid/network costs and taxes. Taxes consist of energy tax and VAT. The share for taxes at the total electricity price is dependable on the type of energy consumer. For an average household, this share varies between 40% and 45%. For companies, this share is much lower. The energy tax is based on a degressive principle. This means the energy tax per kWh decreases when the consumption increases. To keep the electricity grid safe and reliable, maintenance is necessary and thus expenses are made. Eventually, the energy consumers have to pay for this. The price that has to be paid for electricity itself depends among others on the supplier and the contract that is agreed. However, the price for which electricity is sold at the APX-ENDEX is a good indication. The APX-ENDEX is an energy exchange for electricity and natural gas in the Netherlands, the United Kingdom and Belgium.

The Netherlands isn't the best performing country in Europe regarding renewable energy generation. The share of energy from sustainable sources is very low compared with other countries. Only Malta, Luxembourg and the United Kingdom perform even more worse. One explanation for this low position is that in other countries, energy from sustainable sources is more supported by the government than in the Netherlands. For the Netherlands, the share of renewable energy at the total energy consumption was 4,3% in 2011, compared with 3,7% in 2010. The share of renewable energy consumption at the total electricity consumption was 9.8% in 2011. Approximately 58% of the consumed renewable electricity was produced with biomass, about 39% by wind turbines. The share of electricity from solar power compared with the total electricity consumption from sustainable sources is just 0.8%. Regarding PV capacity, 15 countries in Europe perform a lot better than the Netherlands does(CBS).

Every member state of the European Union is obliged to contribute their share in achieving the climate goals of the European Commission(EC). So the EC defined tailor made goals for every member state, including the Netherlands. The Dutch government committed herself to the European goals concerning renewable energy sources. The current government 'Rutte-Asscher' committed themselves to the following goals for 2020: 20% CO_2 reduction

compared with 1990 and 16% of the total energy use should come from renewable sources. In 2010 the share of renewable energy in the total national energy consumption was 4,0 %.
In order to achieve the climate goals which are set, the government uses subsidies and fiscal measures to stimulate renewable energy generation. Laleman and Albrecht(2012) concluded in their paper they can safely say that European governments should critically evaluate current renewable subsidy schemes, especially for PV-systems, and raise public RD&D investments. However, the subsidies and measures which are currently in operation are:

- EIA;
- SDE+;
- KIA;
- MIA/VAMIL.

Furthermore, there is another mechanism available in the Netherlands to foster the development of energy from solar radiation. This mechanism is called net metering(Dutch: salderen). Officially it isn't qualified as a subsidy, but it can be considered as one since consumers receive a much higher price for their self produced electricity than the market prices for renewable electricity. It is regulated by law that 'small consumers'(< 3 x 80Ampere) have the right on net metering.

Photovoltaic systems
Energy from solar radiation by using photovoltaic systems is becoming more and more popular. The market share of energy from solar radiation is slowly increasing every year and gains ground against energy from conventional resources such as fossil fuels and nuclear power sources. The potential of this energy source is enormous. World photovoltaic industry has an average growth rate of 49.5% over the past 5 years (Yan, Zhou, Lu, 2009). The total PV installations grew in 2011 to 70 GW, compared with a total installed capacity of 40 GW in 2010(REN21, 2012).

The yield, the amount of produced electricity, of a photovoltaic system depends mainly on the irradiation of the photovoltaic system. The solar irradiation is influenced by the tilt and orientation of the system, but also by the solar radiation and temperature. The yield depends also on the technique and quality of the photovoltaic cell. The photovoltaic cell is able to convert light directly into electrical energy. In this process, semiconductor materials such as silicon, gallium arsenide, cadmium telluride or copper indium diselenide are used(Ecofys, 2005). One cell on itself is very small and produces very little power, therefore a PV module consists of multiple individual solar cells that are connected in series in order to increase the power. A cell consist of two differently doped silicon layers, called a p- and n-layer. An electric field is produced at the boundary of these two layers. When sunlight falls upon the cell, the charges are setting free. Metal contacts that are attached to the front and the back make it possible to generate electricity. This photovoltaic process continues as long as there is sunlight falling on the cells. No materials are being lost during this process, that's why this method is very sustainable.

The costs of PV systems has been going down for decades and is now approaching competitiveness. Over the last 20 years, PV has already shown impressive price reductions, with the price of PV modules decreasing by over 20% every time the cumulative sold volume of PV modules has doubled(learning factor).

PV systems and road infrastructure
The realization of energy generation with photovoltaic along the main road network can be considered as a complex process. Lots of stakeholders will be involved. One of the most important stakeholders is Rijkswaterstaat (RWS). RWS doesn't want to produce renewable electricity because energy production isn't a public task anymore. They say commercial parties have to take the first step. This doesn't mean they sit back and wait until others take action. RWS will do everything in their power to create a situation in which it's possible for private parties to generate electricity at the land or objects owned by the government.

When planning a PV installation near road infrastructure in the Netherlands, one has to deal with regulation related with both road infrastructure and electricity. Therefore it is important to gain insight in the Dutch, and sometime European legislation when planning such projects. Legislation will set boundaries to develop PV installations near road infrastructure and will definitely have influence on the financial gains. Also regulation regarding noise and the zoning plan is important.

The electricity law sets boundaries regarding the operation of a energy-grid. One cannot just build her own grid and connect electricity consumers on it. Since the liberalization everyone is allowed to sell/supply electricity, except to small consumers. In general, to supply to small consumers, a supply license is required. However, there are a few exemptions when no license is required. Net metering is only allowed in case of a small consumer, a large consumer has to find buyers for the produced electricity and negotiate a price. Taxes have to be paid for all electricity that is consumed, except when net metering is allowed or when the electricity is produced in a sustainable manner behind the connection.

In accordance with the provisions in article 2 section 1(Wet beheer rijkswaterstaatwerken), it is not allowed to make use of a 'waterstaatwerk' for other purposes than it is intended for, without permission from the Minister of Transport. To receive permission, several conditions have to be met. It is very likely ground lease has to be paid to the government. This depends on the expected revenues. In case of a DBFM contract, this won't be the case. Furthermore, there are guidelines compiled in 'Nieuwe Ontwerprichtlijn Autosnelwegen'(RWS, 2007) regarding the design of highways.

If PV panels are installed on noise barriers, regulation and directives should be considered. Issues regarding finance, noise blocking and reflection are very relevant. The efficiency of PV panels near road infrastructure is influenced by contamination, reflection, shadowing and aging. Contamination is the most important one. Pilot projects in the Netherlands proved efficiency will drop with more than 5%. On the other hand, projects in other European countries showed no significant decrease due to contamination.

MODEL DEVELOPMENT
The financial model, which is developed as part of this study, is essential in order to answer the research question. This financial model allows decision makers to assess the financial aspects of a PV project. The importance of the situation regarding ownership of the PV system and the end-users of the generated electricity is explained.

Ownership situations

In general, everyone could install PV panels near road infrastructure if they comply with the required conditions. For the financial model, it is important to know which party who owns the PV system and who the end-user(s) of the generated energy are. It is also very relevant to know how the generated electricity is transported to the end-user(s). Without this information it is impossible to calculate/estimate revenues. The model is developed in such a way it is applicable for many situations, but input for the model requires knowledge about the situation.

Many situations are imaginable, but two examples are briefly mentioned. The first is a situation when PV panels are installed within a DBFM contract. In that case, a private party is responsible for the maintenance of the road section for multiple years, thus pays the costs for the electricity demand of the road. The private party is obliged to buy this electricity from RWS, for a price which is fixed during the total contract period of for instance 25 years. The private party is allowed to use the road to generate electricity. Net metering would be possible in this situation. In another situation, a group of companies that are located near the road install PV panels at the land of RWS and consume the generated electricity themselves. When no DBFM contract is applicable, the electricity can't be used to cover the electricity demand of the road since RWS will not buy this electricity. Thus the electricity can be fed into the grid or can be transported via a private grid to the companies.

Methodology

In order to model and evaluate the financial aspects of a project, a Cost Benefit Analysis(CBA) is applied. For purpose of comparison, an assessment will be made on the basis of separate elements. These are: the net present value (NPV), the internal rate of return (IRR), the payback period (PBP) and a sensitivity analysis. To be able to perform a cost benefit analysis, the financial model is developed. In order to understand the working of the financial model easily, a activity diagram is developed. The activity diagram describes the process that is applicable when one has the intention to install PV panels near road infrastructure. The activity diagram is based on the Unified Modeling Language.

It should be noted some assumptions are included in the financial model. Acceptation of the assumptions is extensively contemplated and constantly is kept in mind what the influence of the assumptions are to the output of the model and objectives of this thesis. All made assumptions comply with these conditions. It is assumed revenues are directly paid, shortages are complemented by the equity supplier and surpluses of money will be paid out directly. Working capital isn't taken into account. When the subsidy EIA is applicable, it is assumed this can be modeled as an addition to the cash flow because the company who invests makes sufficient profit. One tax tariff for the tax on profit is assumed. Furthermore, the model assumes the revenues per kWh that are saved on the electricity bill, equal the price consumers normally have to pay to the utility company.

CASE STUDY

The project that is considered for this case study comprises the design, construction, maintenance and financing(DBFM) of the expansion of existing and new road infrastructure between intersection Diemen(A1) and Almere Havendreef(A6). The length of the road section is approximately 14 kilometers. The road section has in total 5 entrances and exits, and two interchanges are present. The direction of the roads are favorable regarding energy

generation. Lots of unused area's are present, a very safe estimate will show this result in a total area of […] acres. Noise barriers are also included in the project, the surface of the noise barriers cover [………] m^2 with an angle of […]°. The energy consumption of this road section is estimated at [……………] kWh per year. The contractor has to bear the costs for energy and the electricity has to be bought from the client whom determined a fixed electricity price of €[……] per kWh. Three variants are developed to generate electricity with PV panels near infrastructure:

- Variant 1: standard PV panels are installed in (multiple) open field configuration(s) near the road;
- Variant 2a: Powerglaz® BIPV replaces the standard transparent panels of the noise barrier;
- Variant 2b: standard PV panels are fitted on the aluminum panels of the noise barrier.

The numerical values of the parameters and input per variant are summarized in **Table** . Some values are the same for all variants, such as WACC([…]%), maintenance costs([…]% of total investment), tax on profit(25%), inflation([…]%) and efficiency degradation([…]% p/y).

	Variant 1	Variant 2a	Variant 2b
Investment(€/Wp)	€[…]	€[…]	€[…]
Power(kWp)	[……]	[……]	[……]
Annual yield(kWh)	[……]	[……]	[……]
Performance(kWh/kWp)	[……]	[……]	[……]
Subsidy	SDE+, EIA	SDE+, EIA	SDE+, EIA

Table 1: Input values and parameters per variant.

Results

The CBA indicates the PV panels in this case study are only profitable for variant 1, from an economic viewpoint, see **Table** . It is profitable since it gives a NPV of €1.013.136 and an IRR of […]% for the project evaluation. According to the payback period it would take 10,33 years to break even from undertaking the initial expenditure. Even the equity evaluation is positive for variant 1. The noise barrier variants(variant 2a and 2b) perform poorer.

Project evaluation		Variant 1	Variant 2a	Variant 2b
	NPV	€1.013.136	€-1.059.865	€614.822
	IRR	[…]%	[…]%	[…]%
	Payback period	10 years and 4 months	18 years and 11 months	10 years and 9 months
	Average kWh price	€0,1351	€0,2696	€0,1409
Equity evaluation				
	NPV	€22.251	€-1.330.334	€-58.776
	IRR	[…]%	[…]%	[…]%

Table 2: Results of the CBA.

Sensitivity analysis

To incorporate the uncertainty regarding the values of the input in the CBA, a sensitivity analysis is conducted. The sensitivity of four parameters is determined, namely investment, maintenance costs, kWh-price and yield(efficiency). The sensitivity of the maintenance costs have proved to be very little to the output. The sensitivity of the other 3 parameters is visualized in the figures below. The NPV in the figures is for the project evaluation.
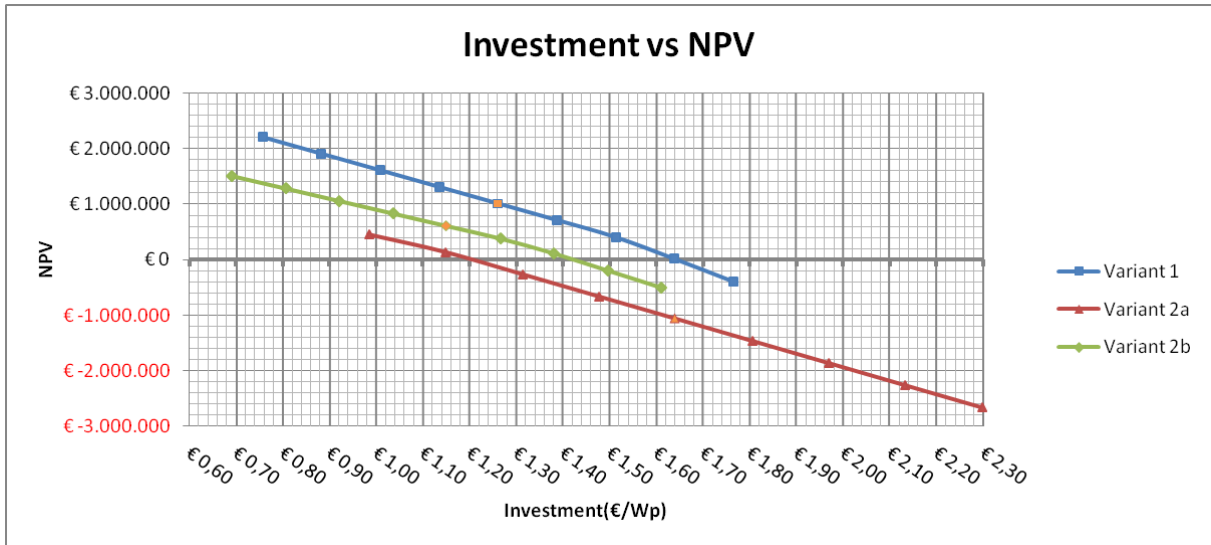
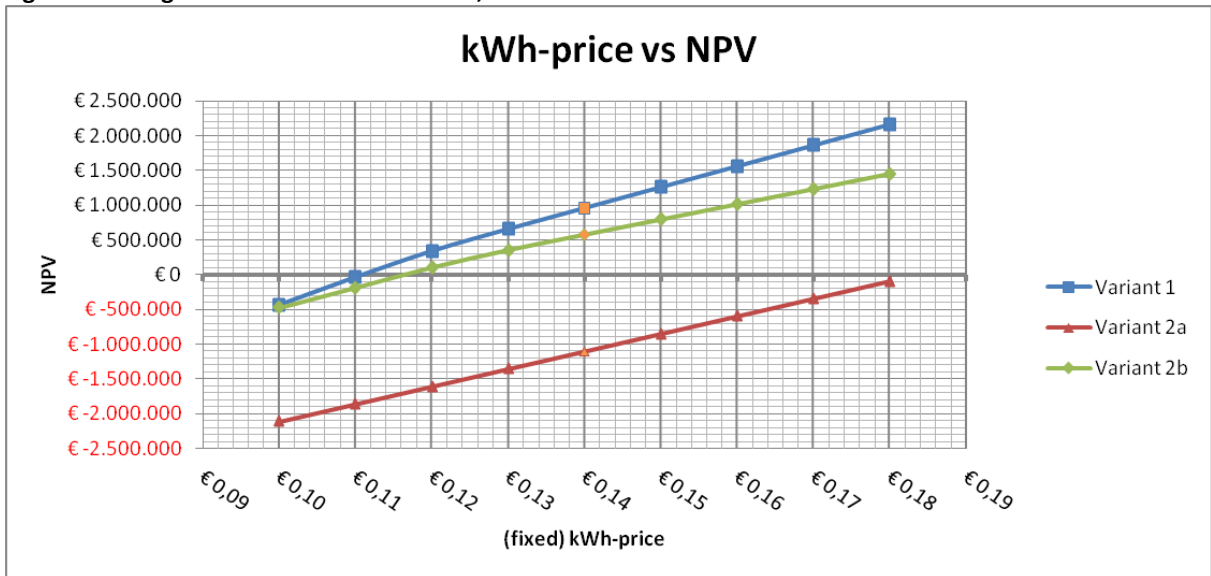**Figure 4: Change in NPV due to investment, for all variants.**
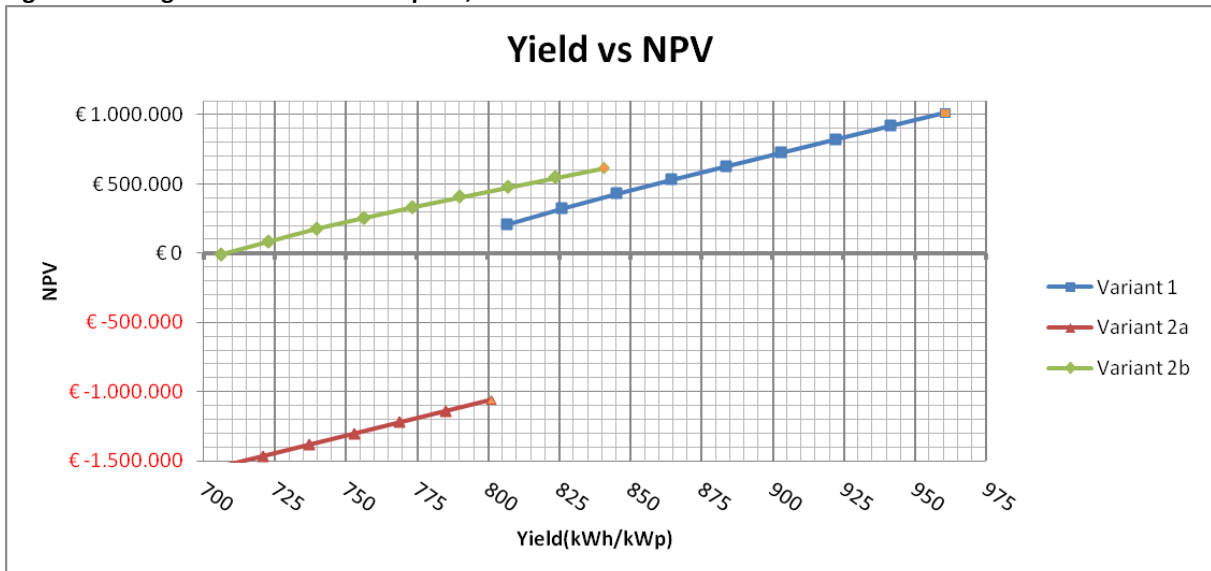

Figure 2: Change in NPV due to kWh-price, for all variants.

Figure 3: Change in NPV due to yield(efficiency), for all variants.

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CONCLUSION

From the sensitivity analysis some interesting conclusions can be drawn. The results of the sensitivity analysis indicate the investment for variant 2a has to drop significantly to become profitable. Thus, this won't happen in the near future and will take some years from now. Also the fixed kWh-price which is determined by Rijkswaterstaat has, as expected, a significant impact on the profitability. However, to make variant 2a profitable, the kWh-price has to become higher than €0,18, which is unlikely. For the other two variants, the kWh-price can drop with €[…] and still remain profitable. Since it is expected to encounter extra contamination since the PV panels are located near road infrastructure, it is useful to know the impact of this at the profitability. This impact is significant, but even with a 14% decrease in yield, variant 1 and 2b stay profitable(project evaluation).

Furthermore, the impact of subsidies per variant is determined. This shows that the SDE+ subsidy is more important than the EIA subsidy. The results also show subsidies are currently essential to make the investments in PV profitable. At most one subsidy application, whether it concerns the SDE+ or EIA, could be rejected in order to keep variant 1 and 2b still profitable.

Conclusively it can be stated PV panels can bring added value to the main road infrastructure in the Netherlands. This is demonstrated with the case study for one specific situation, a DBFM project. With the most important issue, which is financial feasibility, is complied. Variant 1 of the case study, which are PV panels in an open field configuration, is definitely interesting to investors since the NPV of the project and equity evaluation is positive. Furthermore, in this ownership situation regulation does not cause constraints. Due to developments regarding price and technique, the potential will grown since the profit of variant 1 will raise and also variant 2b becomes financial feasible with only a slight decrease in costs. Despite the large amount of square meters of noise barrier, it is not possible to cover the energy demand of the road with just photovoltaic noise barriers.

RECOMMENDATIONS

In this research, one case and thus one situation is studied. Thus only a small section of the broad infrastructural network in the Netherlands is considered. Parts of the conclusions are based on this case and the associated design, characteristics and specifications. For further research, it is recommended to consider several road sections at multiple locations in the Netherlands. When more cases are considered, stronger conclusions can be drawn about the technical and financial feasibility of PV panels near road infrastructure for the Netherlands as a whole. A comparison among different cases could result in useful insights. The financial model that is developed during this research could be used as the basis for further research. Besides studying multiple locations in the Netherlands, a second recommendation is advised. In this research, one case is considered and thus one ownership situation, but several situations are possible. For further research, it can be interesting to study the difference among these situations in order to draw conclusions which one is the most profitable.

Projects can bring more value other than financial. Since the projects are sustainable energy projects, it can bring added value when in addition to the economic analysis, which is the cost benefit analysis as described in this paper, an environmental analysis is performed. Although the need for an environmental analysis would be higher when the initiator and

owner is a public or governmental body, nowadays it could be even beneficial to private parties. Examples of benefits that may arise from an environmental analysis could be:
- extra goodwill from environmental or pressure groups towards the private party;
- in case of a contractor extra bonus points in tenders;
- improvement of environment-friendly image of the private party;
- fewer emissions of CO_2 into the environment.

ACKNOWLEDGEMENTS

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ing. P.M. Jochems (Paul)
I am very satisfied with the end result of my research. The topics road infrastructure and solar energy are very interesting subjects. During the process I realized the complexity of the energy market in the Netherlands, but therefore the challenge is bigger and it is more tempting to stay actively involved in the working field regarding PV panels near road infrastructure.

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THE MUNICIPAL LAND SUPPLY: RISK OR SUSTAINABLE OPPORTUNITY?

An explorative research on possible sustainable policy solutions in land use policy in order to create more financial continuity for municipalities in Noord-Brabant

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ABSTRACT

Dutch municipalities have an important role on the land market. On the one hand municipalities are an active stakeholder in land developments and on the other hand they set the rules for the land market. Municipalities in the Netherlands have the largest land supply of all stakeholders on the land market. In this paper the impact of the economic crisis on the municipal land supply and thereby financial situation of municipalities is discussed. All municipalities in the province Noord-Brabant are analysed by means of a Multi Criteria Analysis on the degree of financial danger they are exposed to due to their land supply. Furthermore possible sustainable policy solutions (PSPS) are discussed and tested among municipal, consultancy and academic experts. By means of the Fuzzy Delphi Method the results are analysed and the applicability and determining factors are ranked on importance. All in order to comprehensively stimulate financial continuity, sustainable use of space and sustainable forms of land use policy among municipalities.

Keywords: municipalities, land development, land use policy, sustainable land use, multi criteria analysis, fuzzy Delphi method.

INTRODUCTION

Land acquirement by municipalities

In the early 1990s the announcement of the locations of future *Vinex-wijken* by the *Ministerie van Volkshuisvesting en Ruimtelijke Ordening* made clear a residential construction output was wanted by the State. These *Vinex-wijken* were planned on the outskirts of cities, mainly on agricultural land. This governmental policy made the acquirement of land popular among commercial actors and municipalities. Also, the economic climate was very good whereby the available capital grew; a possible investment was land. Land was mainly invested in by municipalities but also on large scale by developers, housing associations, contractors and investors.

In areas where a high construction output was demanded by governmental policy, the municipalities searched for commercial partners to help them reach their construction quota. For the commercial actors it was helpful to secure their future construction output as with the ownership of the land also comes the right to self-realization on this land. Hereby, municipalities often bought the raw land and were responsible for the land development (transformation of raw land to building land) and commercial actors had the intention to buy the building land for the real estate development. The municipalities acquired the raw land with the expectation of future development; the acquirement price for this land is between the value in the current use (mostly agricultural) and the value in the future use (residential). After the transformation to building land and the change in land use the municipality sells the building land to the developer and gained profit from this increase in land value. This results in profit which can be used by municipalities to cover losses on other land developments: as example 1) the profit from these easy projects on outskirts of the cities can be used to cover losses on more complex, urban (inner city) developments or 2) the profit from the development of free sector dwellings can be used to cover the losses on the development of social sector dwellings in the same project (Segeren, 2007). When after this settlement still profit is made, this is used in the fund *Bovenwijkse voorzieningen* to finance the newly constructed infrastructure and sometimes also to finance social facilities as swimming pools, libraries or theatres (van Hoek et al, 2011).

Economic crisis
In the summer of 2007 a crisis in the financial markets arose and within two years the consequences revealed itself in the real estate market. A drop in demand and overplanning of spatial developments resulted in uncertainty about the scheduled plans; when will they be developed or will they be developed at all. The acquirement of the raw land is already partly done by developers, housing associations and municipalities. This is financed with loans; the delay results in increasing interest costs. In addition, the sale of the building land stays out because of the delay. It is uncertain how the price for building land will develop and if the projected revenues will be achieved. In some cases the profit is already evaporated and turned into losses on land developments. This uncertainty about the market value, projected revenues and the increasing interest costs result in losses on the land and a great strain on the budgets of municipalities. Due to these losses municipalities need to economize and thereby are shrinking in personnel, investing less in social facilities and postponing their ambitions on sustainability.

Problem definition
In the times of economic growth the municipality was an active stakeholder on the land market. Thereby invested extensively in land. Due to the economic crisis the financial risks are becoming more clear and result in losses on land developments. This resulted in the following problem definition:

Municipalities have bought much land with the expectation of area development. Because of the economic crisis area developments are delayed and in some cases even cancelled. The stay out of the allocation of building land and the uncertainty about the market value and projected revenues result in significant losses. Some municipalities are already in, while others are close to, financial danger due to the losses on their land supply.

Research Questions

The total problem (from a developers', housing association', investor' and municipal' point of view) of losses on land supply is too complex and extensive to research all. Therefore this research will limit itself to the financial problems of municipalities due to the losses on their land supply and the possible sustainable policy solutions to solve/minimize these financial problems. Throughout this thesis area developments on the outskirts of cities with (future) residential land use are subject of research. And the province Noord-Brabant is taken as research field to make the number of analysed municipalities a manageable size. Within this stated boundaries, and whereas the problem definition forms the basis, this resulted in the following main research question:*What possible sustainable policy solutions are applicable (and to what extent) to improve municipal land use policy in order to create a continuous healthier financial situation for municipalities in Noord-Brabant?*

Research Design

Generally, the research consists of four parts (figure 1): (1) theoretical framework, (2) different analyses to determine current municipal situation because of losses on land developments, (3) different analyses to determine the applicability of possible sustainable policy solutions to minimize the losses on the municipal land supply and look sustainable towards the future again, and (4) the conclusions and recommendations.
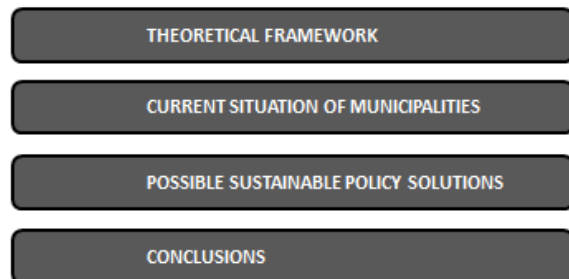

Figure 1: research design

1. In the theoretical framework the land market, spatial planning, municipal land use policy, area and land developments are explored by means of desk research.
2. In the current situation of municipalities the financial danger regarding their land supply of all municipalities in Noord-Brabant are analysed by means of multi criteria analysis. This analysis is done on the most recent quantitative data, the municipal balances and budgets of 2011 from their annual reports. Furthermore for the twenty municipalities most at risk of financial danger their situation is further explored with questionnaire 1 as indicator for the current problems and handling of these municipalities close to or in financial danger.
3. The possible sustainable policy solutions (PSPS) are determined by means of expert meetings and desk research. The PSPS are firstly presented in three case studies to define the determining factors for applicability. Furthermore the PSPS are evaluated with questionnaire 2 among municipal, consultancy and academic experts on determining factors and applicability. These results are analysed with the fuzzy Delphi method and result in the weighing and ranking of determining factors and the weighing and ranking of the applicability of the PSPS.
4. In the last part the conclusions and recommendations are determined and the research question (and sub research questions) is answered. The research is evaluated and recommendations for further research are done.

CURRENT SITUATION AT MUNICIPALITIES IN NOORD-BRABANT

Theoretical framework

In this research the municipal land supply of all municipalities in Noord-Brabant is analysed

in more detail from manually collected data from annual reports of 2011. The most important aspects which can be derived from the annual reports regarding land supply and the municipal financial situation are:
- The invested capital in land regards land which is in transformation and is documented in the municipal balance. The supply of a municipal balance consists of LNID, LID and other supply. In figure 2 the different characteristics of land not in development (LNID), land in development (LID) and other supply is given.

	LID	LNID	Other supply
Valuation based on	Future land use	Current land use	Current land use
Administrative status	All planning procedures finished (determined in zoning plan)	Council decision for future development	No council decision
Status of book value	Activated on municipal balance and financial estimate of land development is at least once a year updated	Activated on municipal balance and process and interest costs are annually added	Not activated
Actions when losses occur	A provision is arranged or amortized directly from book value when losses in land development occur	Amortized directly from book value or transferred to *LID* when book value is higher than market value	-

Figure 2: characteristics of municipal land supply in annual report

- The general reserves of municipalities are freely disposable and used to cover possible financial setbacks. In some municipalities a specific reserve for land development exists. This reserve specifically covers the risk of land development and can, when necessary, be supplemented by the general reserves. Other municipalities do not have a specific reserve for land development but cover possible losses directly from the general reserves.
- At least once a year municipalities update their land developments; in the annual report. When losses on land developments occur, as stated above, the municipality is obliged to cover this by the use of their reserves. This can be done in two ways:
  o by taking the losses by amortizing these losses from the book value with the reserves. With this solution the book value decreases with the size of the estimated losses directly.
  o by arranging provisions from the reserves to cover these losses. This way is most often used because these provisions can annually be adjusted and therefore it is possible to recover a certain book loss over time. Although the land development is estimated as best as possible it is variable over time and the result can change over time. With the arrangement of provisions the possible losses are covered and over time can be adjusted on the most recent developments.

Methodology

Multi criteria analyses (MCA) are used in a variety of forms and ways in qualitative and quantitative research. The basic definition is: "Multi Criteria Analysis is a decision-making tool developed for complex multi-criteria problems that include qualitative and/or quantitative aspects of the problem in the decision-making process (Voogd, 1983)." The MCA in the used form consist of the ranking of the financial situation of municipalities by means of different criteria. This results in an overview of the financial situation of all municipalities in *Noord-Brabant* regarding their land supply. Every municipality in Noord Brabant is scored

on every criteria based on the quantitative data from the annual report of 2011. The maximum score of every criteria is 100 and the minimum score is 0. In that way it is possible to compare these different criteria. On the level of one criterion the municipalities are compared mutually; it is aimed to determine the financial situation of a certain municipality in comparison to the other municipalities in *Noord-Brabant*. The maximum score of 100 is given to the municipality where the specific criterion has the most financial negative influence on the financial situation. The minimum score of 0 is given to the municipality where the specific criteria has the least financial negative influence on the financial situation. All municipalities in between are scored in comparison to the relative deviation from the absolute value of the maximum and minimum.

After the MCA on all municipalities in Noord-Brabant the ranking of the twenty highest scoring municipalities is validated with questionnaire 1.

Results

Results MCA

The total book value of land supply per inhabitant (criterion 1) in the municipalities of *Noord-Brabant* differs strongly. Veghel and Maasdonk have the largest land supply with a book value per inhabitant of respectively € 4.974,- and € 4.765,-. A significant share of 44 of all (67) municipalities have a book value of land supply of < € 1.000,- per inhabitant. The total book value of supply as share of the total assets (criterion 2) is in 29 of all municipalities < 20% and in 29 municipalities > 20% but < 40%. In Maasdonk (70%), Veghel (64%), Boekel (56%) and Heusden (55%) the total land supply represents the biggest share in value of the total municipal budget. The global resistance capacity (criterion 3) shows major dispersion. In total 53 of all 67 municipalities have more reserves than land supply. It is plausible these municipalities are more able to cover possible losses on land developments.

The twenty highest scoring municipalities in Noord-Brabant	Number of inhabitants	Total score
1 Veghel	37.303	391
2 Maasdonk	11.268	315
3 Heusden	42.995	290
4 Veldhoven	43.243	266
5 Nuenen, Gerwen en Nederwetten	22.213	216
6 Boekel	9.772	216
7 Gemert-Bakel	28.763	181
8 Bergen op Zoom	65.845	178
9 Uden	40.536	174
10 Halderberge	29.291	170
11 Dongen	25.061	161
12 Bernheze	29.655	158
13 Deurne	31.526	158
14 Gilze en Rijen	25.975	155
15 Best	28.953	151
16 Breda	173.299	148
17 Boxmeer	28.575	147
18 Geldrop-Mierlo	38.117	142
19 Bergeijk	18.061	137
20 Roosendaal	77.566	134

Figure 3: Highest scores MCA of twenty municipalities

However, to state this with enough certainty further research is necessary on project level, as the possible losses depend on many different variables. Of the 14 municipalities which have more land supply than reserves in book value the highest scores are for Heusden, Veghel, Maasdonk and Gemert-Bakel. These municipalities thereby have the least reserves in comparison to their total land supply. The total book value of the land supply (criterion 4) showed the relatively large municipalities with the highest scores. However, also other relatively smaller municipalities scored very high on this criteria e.g. Veghel, Veldhoven and Heusden. In figure 3 the twenty highest scoring municipalities are shown.

When looking at the outcome the score of the municipality Veghel is remarkable; a total

score of 400 is the maximum and this municipality scored 391. Furthermore many municipalities in the south east of the province of *Noord-Brabant* scored high. And the most municipalities are relatively small as to number of inhabitants except Bergen op Zoom (65.845 inhabitants), Roosendaal (77.566) and Breda (173.299).

As all municipalities are scored in comparison to the other *Noord-Brabantse* municipalities it is clear the twenty highest scoring municipalities are more at financial danger than the other *Noord-Brabantse* municipalities. In figure 4 all scores of Noord-Brabantse municipalities is shown whereas the threshold $S_j > 130$ for the twenty highest scoring municipalities is applied. However, due to the limited publicity of data on municipal finances the MCA is not comprehensive. Therefore more information on land supply and project level is needed. Questionnaire 1 is applied to validate the positions of the twenty highest scoring municipalities.

Results questionnaire 1

Due to the limited publicity of data on land developments and the sensitivity of this information for municipalities it was difficult to validate the positions of the municipalities. It generally gave more insight in the situation and handling of municipalities in Noord-Brabant. Based on the expert meetings, the interviewed municipalities and questionnaire 1 the current situation and handling of municipalities to minimize losses on their land supply can be summarized as:

Figure 4: All scores from MCA

- Municipalities are trying to monitor the risks of the land developments more constantly. In the past this was done only once a year; now municipalities update the land developments more times a year.
- Municipalities are reprioritizing and when possible cancelling developments. The *LIND* supply is more revaluated and when development is not possible in the near future the book value is devaluated to agricultural value.
- The phasing of land development is stretched and the making of land costs is postponed as much as possible in anticipation of better market conditions.
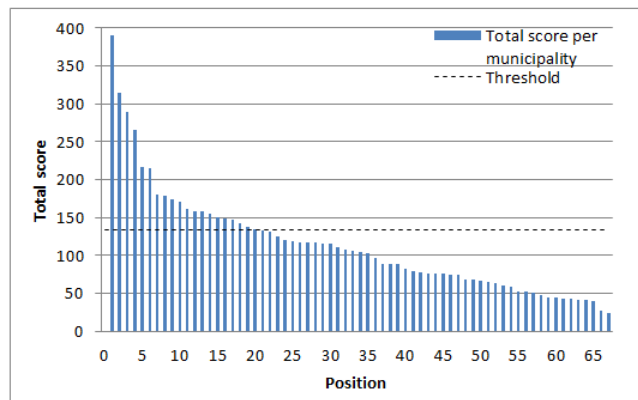- Active land use policy is only used for locations were municipalities have land; for new locations municipalities
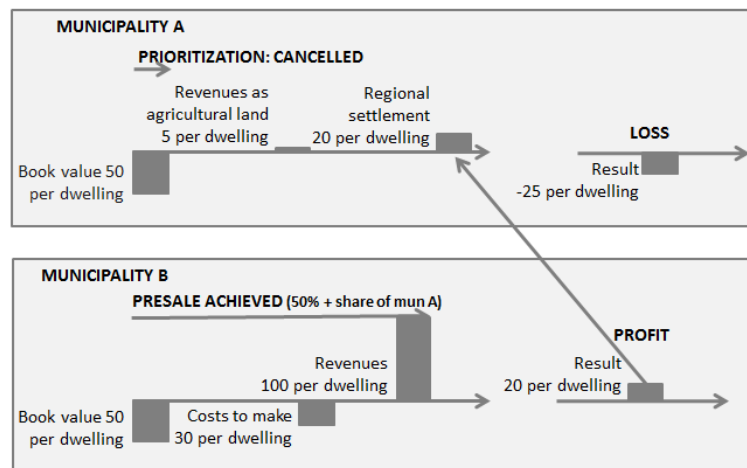

Figure 5: Regional settlement

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are shifting towards facilitating land use policy to minimize risks.
- Municipalities are trying to stimulate the land allocation by actively offer the available land to contractors, developers but also individuals. And some (3) municipalities have started to decrease the land prices.
- For industrial and office areas regional coordination is more and more applied to decrease the number of projects, but for residential areas this is in an early stage.

POSSIBLE SUSTAINABLE POLICY SOLUTIONS
In general, from the MCA and questionnaire 1, there can be concluded municipalities are solely minimizing the losses on land developments and are not looking for sustainable, innovative possible solutions. From scientific publications and expert meetings two possible sustainable policy solutions (PSPS) are derived:
1. *Regional and financial settlement:* due to the oversupply in planned residential development the projects do not reach the presale requirement and are thereby delayed (De Zeeuw et al, 2012). The different residential developments in a region need to be prioritized to induce realism in the number of residential developments; a decrease in supply to come to an equilibrium of demand and supply. In that way the number of residential developments will be more in balance with the number of (in the current economic climate) dwellings possible to sale.

   In this PSPS the assumption is made, a part of the developments in a region are cancelled and thereby the chance of achieving the presale requirement in the remaining developments is improved. Also, the profit from the completed residential developments is used to compensate the cancellation of the other residential development. This is schematically shown in figure 5. Municipality A cancels its development and municipality B achieves its presale requirement. Furthermore in figure 6 the payoff matrix in the different situations is shown. The assumption is made when no regional settlement is implemented the presale requirement is not achieved. It shows that for the region the regional settlement is the situation with the least losses.

		Municipality B			
		No regional settlement		Regional settlement	
Municipality A	No regional settlement	-50	-50	-50	-50
	Regional settlement	-50	-50	0 or -25	0 or -25

Figure 6: Payoff matrix of regional settlement

2. *Temporary use of the land by the placement of solar panels:* the temporary vacant land can be used for the placement of solar panels. For different scenarios the feasibility of the placement of solar panels is calculated. The investment in the panels is done by an energy cooperative therefore the municipality only gains a lease hold for the use of the land. This lease hold is residually calculated and can be €1,30 per m^2 up to € 3,30 per m^2 land and results thereby in at least two times and up to almost seven times more possible revenues than agricultural use. The annual lease hold per m^2 can be used to cover the annual interest costs on the book value. In this case the interest costs (with an interest rate of 4%) of a book value from € 32,50 up to € 82,50 per m^2 can be covered.

Methodology
The two PSPS as described before are tested on applicability and determining factors among two respondents groups. Among the municipal experts (expert group A) 13 of the contacted

26 experts responded thus making a 50.00 percent response rate. Among the academic and consultancy experts (expert group B) 15 of the contacted 21 experts responded thus making a 71.43 percent response rate.

There are three basic types of information uncertainty, namely ambiguity, discord and fuzziness (Klir & Yuan, 1995) that are covered by numerous uncertainty theories. Due to the human factor in evaluation, in this case the importance of a certain factor, a type of the uncertainty is present. That is the fuzziness resulting from the lack of definite or sharp distinction. Therefore, the fuzzy Delphi method (FDM) will help to give an overview of the factors relevant for the applicability of the PSPS. As recommended in Delphi literature, for homogenous groups, the expert groups should have a minimum response of 10-15 people to conclude reliable from the results. In both respondents groups (A and B) this minimum response is achieved. The steps taken are:

1) Validate predefined list of factors: this done by means of three case studies and resulted in the determining factors for PSPS_R (regional and financial settlement) and PSPS_T (temporary use by the placement of solar panels).
2) Collect opinions of expert groups A and B with questionnaire 2: the two PSPS are described and subsequently the experts are asked to score (ordinal scale 1 to 10) these factors and conclusively determine the applicability of each PSPS.
3) Analyse results of questionnaire with FDM: by means of the calculation of the trapezoidal fuzzy number and subsequently defuzzification of the experts' scores eventually the definite value (s_j) is derived per factor and per PSPS.

Results

Overall applicability of PSPS

There can be concluded the highest applicable is the PSPS of regional and financial settlement of residential developments (A=6.15, B=6.48) and less applicable is the PSPS of temporary use of municipal land by the placement of solar panels (A=5.56, B=5.78).

Figure 7: Applicability of PSPS

Determining factors for applicability of PSPS

For the regional and financial settlement the municipal experts see the administrative aspects such as political cooperation ($s_j = 7.27$) and certainty that all municipalities will cooperate ($s_j = 7.27$) as the most important factors for applicability. Among the consultancy and academic experts the most important factors for applicability were the financial aspects. The share of the profit that should be donated by municipality B ($s_j = 7.00$) and the compensation which is gained by municipality A for cancellation of the development ($s_j = 7.15$) are evaluated as most important. As threshold for this PSPS $s_j > 7.00$ is used and the other factors are scored lower and therefore less important.

For the temporary use by the placement of solar panels the financial factors are evaluated as important by the municipalities. The financial feasibility of the business case depends highly on legislation regarding collectively net metering and there is nowadays uncertainty about the development in legislation. The evaluation scores of the respondents, on legislation
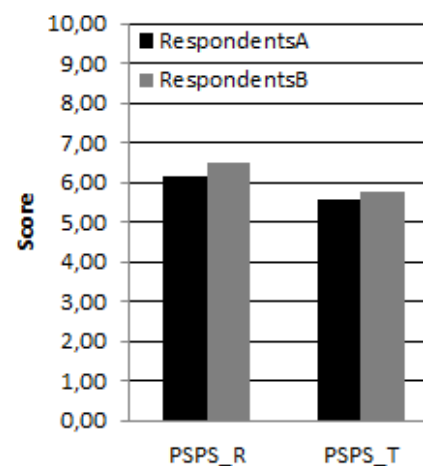
regarding collectively net metering ($s_j = 6.38$), endorse this. Furthermore the run-time period ($s_j = 6.43$) is evaluated as important, this is in line with the interviews where was stated that it can be difficult to put the residential development on hold for twenty years. The process of implementation of the temporary use may evoke resistance from municipal politics. Overall the dispersion in evaluations of the factors by the respondents is significantly higher (mainly $\sigma > 2.00$) than in the PSPS_R. The opinions of the experts differ more for this PSPS.

CONCLUSIONS AND DISCUSSION
Current situation
The MCA resulted in a ranking of Noord-Brabantse municipalities which are most at risk of financial danger to least at risk of financial danger. This resulted (with threshold $s_j > 130$) in twenty municipalities that are most at risk in comparison to the other municipalities. The losses on land developments have resulted for two municipalities in total evaporation of the general reserves over 2012. These municipalities, Nuenen Gerwen en Nederwetten (no. 5) and Gemert-Bakel (no. 7), are now under pre-emption of the province. These municipalities are thereby directly in financial danger. Furthermore the general opinion among municipalities, province and experts is when the current economic conditions continue (or worsen) the losses will only increase and more municipalities will come in direct financial danger. In conclusion especially the smaller, rural municipalities with relatively large land supplies and small reserves position are the most at risk of financial danger.

Thereby the municipalities are now mainly minimizing losses by short-term accounting measures. The need to look for sustainable, long term policy solutions is not present at municipalities. At the same time the number of municipalities in financial danger will only increase as the most recent forecasts do not show improvement in the economic conditions.

Applicability of PSPS
The experts are acknowledging that temporary use of municipal land is interesting and the generation with renewable energy sources is one of these uses but still see difficulties in the financial feasibility. Furthermore, regional settlement in residential developments, as is already done for industrial areas, should be the direction of future land use policy is the general consensus. This also resulted from the questionnaire among all experts as the regional and financial settlement is evaluated as the most applicable ($s_j = 6.45$) followed by the temporary use of the land by the placement of solar panels ($s_j = 5.68$). Both PSPS can minimize the losses on municipal land development but more importantly help using the land more sustainable. And additionally the applications in sustainability (e.g. renewable energy sources) can be part of that sustainable land use.

Recommendations
Further research can be done by modelling the PSPS in a game theory model and thereby explore the decision making process in more detail also among the other stakeholders. Also, to come to a comprehensive overview of the financial danger among municipalities different areas in the Netherlands can be explored (other research field) and in cooperation with provinces and municipalities more data needs to be collected to do the MCA in more detail.

This research mainly improved the awareness among municipalities for sustainable,

innovative ways of land use (policy). From this research can be concluded municipalities do not exchange views on this subject; the view is mainly limited within the own municipal borders. Therefore it is recommended to cooperatively, by sharing knowledge, learn from the different situations. It is necessary the municipalities share their knowledge to cooperatively limit the losses and look sustainable to the future again. This can be done by sharing knowledge in the first place on administrative level thereby excluding the influence of the municipal politics. And eventually come to a regional land use policy whereby the possibility of financial settlement needs to be further investigated.

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GIJS KANT

This master thesis is the result of a half year of hard work. It was interesting to see the actuality regarding the chosen subject in the media. Many municipalities are struggling financially with their acquired land at this moment. My research contributes to the awareness of the problems and stimulation of looking for new innovative and sustainable forms of land use policy.

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SPATIAL MODELLING TO ALLOCATE LOCATIONS FOR PUBLIC CHARGING STATIONS:

Determining the locations of public charging stations for the municipality of Eindhoven

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ABSTRACT

This paper is about the development of a location allocation model for public charging stations. Especially in urban environments a public charging infrastructure is required for further developments of electric mobility. The model is applied to the municipality of Eindhoven to find a solution for the location problem of public charging stations. A scenario for the year 2020 is created to determine the settings for the model. Scenario analysis will lead to recommendations on locations and quantities of public charging stations.

Keywords: public charging infrastructure, agent-based modelling, GIS, multi-objective optimisation, scenario analysis

INTRODUCTION

The development of electric mobility and electric vehicles has increased significantly over the last couple of years. Global awareness about the impact of human activities on the environment has become much greater over the past decades. Resources such as fossil fuels are getting more scarce and pollution, especially in densely populated areas, is threatening the quality of life. Global agreements on reducing emissions have been made, targets have been set and actions have been taken to achieve environmental goals. In order to continue the process towards a cleaner and more sustainable environment, innovation is needed. Urban areas can still improve significantly to become more sustainable. New developments in the field of electric mobility will contribute to reach sustainability goals. The use of electric vehicles in urban areas will decrease carbon emissions, increase the air quality and contribute to the overall quality of life within urban areas. The use electric vehicles largely depend on a supporting charging infrastructure for electric vehicles. Electric vehicles and a charging infrastructure are interdependent; the development of electric vehicle usage requires a supporting infrastructure and installing a charging infrastructure is only useful when a certain level of electric vehicle usage is reached. This interdependence results in a great challenge for the development of electric mobility. It is assumed that in order to disrupt this dependency circle a supportive charging infrastructure must be in place prior to the introduction of a new technology (Sovacool & Hirsh, 2009).

Research approach

It is desirable to develop a supporting infrastructure in order to stimulate the use of electric vehicles. However, the development of a public infrastructure is hampered because currently there is no profitable business case for public charging stations. Most of the developments for a public charging infrastructure are generally initiated as pilot projects by governments, network operators and research institutes. It is expected that after 2015 a profitable business plan for public charging station can be developed (PRC, 2013) and that the market for public charging services will grow from a developing market to a mature market (Innopay, 2011). A growing market for public charging services presents new challenges. This paper focuses on the spatial challenges that a growing market for public charging services entails.The problem definition for this research is phrased as: *"An integrated approach for allocating locations for public charging stations is lacking"*. The owner of this problem is for the majority of cases a local government or municipality and the problem is most relevant to urban areas.

The objective of this paper is to create a location allocation model for public charging stations. The municipality of Eindhoven will be used as a case study to apply the model to the real world. The objective is to create solutions for the location problem of public charging stations in the municipality of Eindhoven.
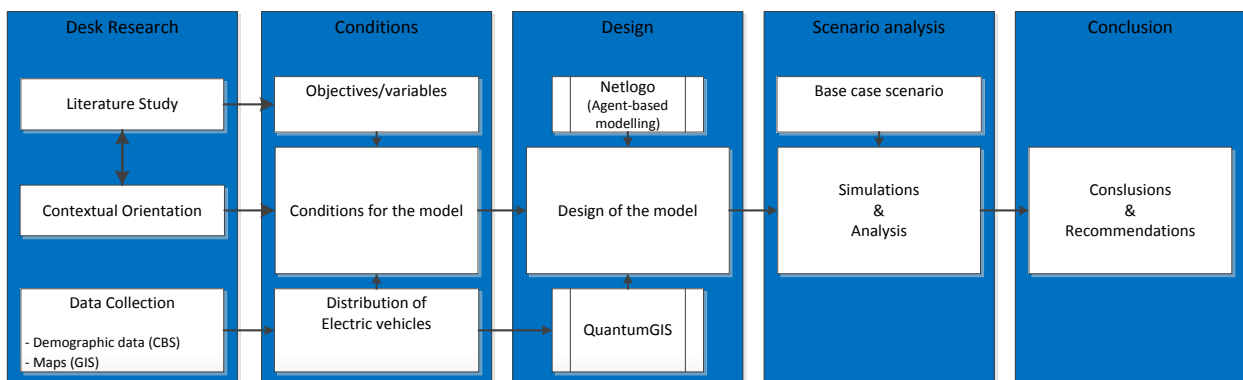

Figure 1: Research model

CONTEXTUAL ORIENTATION

Over the last couple of years, the development of electric mobility is growing rapidly. Although the global market for electric vehicles is growing, it is no guarantee for success. The development of electric mobility is facing a very mature market of conventional car manufacturers. Fortunately, existing car manufacturers are increasingly involved in the developments of electric mobility. Future developments of electric vehicles will be very important for the growth of electric mobility. Existing car manufacturers have an essential role in these developments because for the most part, they will eventually determine which electric vehicles and which technologies will enter the market. The performances and costs of batteries for electric vehicles is perceived as one of the greatest barriers for the development of electric mobility (JRC, 2010). A distinction is made between full electric vehicles (FEV or BEV) and hybrid electric vehicles (HEV). Full electric vehicles are solely driven by batteries while hybrid electric vehicles are driven by both a combustion engine and batteries. Plug-in hybrid electric vehicles (PHEV) are hybrids which can be plugged in for recharging. Since this paper focuses on a charging infrastructure for electric vehicles it only considers full electric vehicles and plug-in hybrid electric vehicles.

The development of electric mobility has received a lot of attention in the

Netherlands and is growing steadily. The E-Laad foundation, a cooperation of Dutch network operators, has realised approximately 2.500 public charging stations in The Netherlands. Due to limited budgets and interference by the national governance, E-Laad was forced to stop the deployment of public charging stations.

FIELD OF CHARGING STATIONS

The sole purpose of a (re)charging station is obviously to replenish batteries of electric vehicles. There is a wide variety of charging stations and applications of charging stations. Besides recognising all modes and types of charging stations it is most important to acknowledge the different applications of charging stations and usage patterns. This paper will focus on publicly accessible charging station using cables and plugs for recharging, other techniques are not within the scope of this paper. Publicly accessible charging stations can be divided in public charging stations, extended private charging stations and semi-public charging stations.

To further stimulate electric vehicle usage and to increase the deployment of charging stations, standards are essential. The main purpose of standards is to ensure that electric vehicle drivers can safely and conveniently enjoy the use of both electric vehicle and charging station which increases user acceptance and decrease costs (ACEA, 2012). The current business case for operating a public charging station has a financial gap. For a profitable business case local and national governments can actively facilitate operators by reducing costs for leaseholds, permits and applications. Network operators also play a crucial role in creating a profitable business case by reducing costs for the connection to the grid. Economies of scale and more sales of energy will also contribute to the viability of the business case. Both charging stations and electric vehicles come along with certain limitations, which have to be dealt with now and in the future. The (re)charging speed is determined by the capabilities of both charging station *and* electric vehicle. For electric vehicles the on-board charger determines the charging power of the vehicle. Charging station themselves also have limitations regarding efficiency in terms of utilisation. The practical capacity of a station will be significantly less than the theoretical output of the station because in practice the charging station will not be utilised 24 hours a day.

Matching electric vehicle usage patterns with types of charging stations will also stimulate the future development of a charging infrastructure. The "charging tree" (Ladder van Laden) presented by the Dutch Ministry of Economic Affairs and the Taskforce Formule E-Team is a guideline for the implementation of a charging infrastructure and matches the use of stations with types by prioritising the types of charging stations.

METHODS

For this research several research methods are used which are also shown in the research model. The used research methods are multi-objective optimisation, GIS, agent-based modelling and scenario analysis.

Multi-objective optimisation: With multi-objective optimisation a trade-off between divergent objectives exists which results in a number of solutions. If one solution is better in terms of one objective, it comes only from a sacrifice off other objectives because the objectives are not independent (Deb, 2005). The aim of multi objective optimisation is not to solve a single objective or to find an optimal solution corresponding to each objective function (Deb, 2005).

GIS: Geographic information systems (GIS) are used to gather, analyse, modify, manage and present all types of spatial information. GIS is an operational and supporting information

system where data can be related to a specific location or area. Combining data with geographic information such as maps, results in numerous forms of output. With GIS many products can be created such as maps, charts, tables and graphs. GIS is commonly used in planning, analysis of traffic, transport, environment, safety, earth sciences and many more applications.

Agent-based modelling: Agent-based modelling is a simulation technique for modelling complex systems. An agent-based model generally has three elements; a set of agents with attributes and behaviours, a set of relationships and methods of interaction and the agents' environment (Macal, 2010). The systems are modelled as a collection entities called agents. The main benefits of agent-based modelling is that is captures emergent phenomena, provides a natural description of a system and it is flexible (Bonabeau, 2002).

Scenario analysis: The use of scenarios stimulates strategic thinking and helps to overcome thinking limitations by creating multiple futures (Amer, 2012). Scenarios can be described as: "a set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points" (Kahn, 2000). Scenarios can also be defined as a description of a future situation and the course of events which allows one to move forward from the actual to the future situation. Scenario development creates a better understanding of plausible future developments by looking at trends on a macro level such as: socio-cultural, technological, ecological, political and economic developments. All the above described method will be used to develop a location allocation model for public charging stations. Agent-based modelling and GIS will be integrated to design the model while multi-objective optimisation is used to determine the decision space of the model.

OBJECTIVES & VARIABLES

A subset of two conflicting objectives based on reliability, availability, maintainability and costs (RAM&S) are taken into account; availability and costs or profitability. The objectives together with the constraints for the objectives will determine the decision space of the model.

Availability: The first objective for the model is to maximise availability $A(x)$. Among others, the availability of a public charging station determines the usefulness of a station. The availability of a charging station is determined by demand and supply; high supply and low demand will result in a high availability. The objective function for daily availability is:

$$f(x) = A(x) = supply - demand$$

The demand is determined by the charging output in kW and the effective charging time which is the assumed maximal capacity of charging station in practice. The demand for a station is determined by the energy consumption per vehicle and the number of vehicle within the surrounding of a stations. The constraint for availability is determined by the relation between demand and supply. If demand exceeds supply, a station will be overloaded which decreases the availability dramatically. When demand exceeds supply a station is more likely to be occupied which is not desirable for users in need of charging. The limit for the objective space is reached when demand exceeds supply. The constraint $g(x)$ for the availability objective is:

$$g(x) = Demand \leq Supply$$

Profitability: The second objective for the model is to maximise profitability. Currently, public charging stations do not have a profitable business case but for the development of a charging infrastructure a profitable business plan for public charging stations is essential. The profitability of a station depends on several variables such as the initial investment, interest rates, profits per kWh and utilisation. The latter is one of the most important variables

because the utilisation almost directly determines the profitability of a charging station. For a charging station to be profitable the actual daily utilisation has to be higher than the required daily utilisation for profitability. The objective function for the actual daily utilisation $U_a(x)$ is:

$$f(x) = U_a(x) = \text{Actual daily utilisation}$$

The actual daily utilisation in hours is determined by the energy consumption per vehicle and the number of vehicle within the surrounding of a stations divided by the charging output of a station in kW. The actual daily utilisation has to be higher or equal to the minimal required utilisation for a station to be profitable.

$$U_a(x) \geq U_r(x)$$

The daily required utilisation U_r (hrs) is determined by calculating the necessary hours of utilisation per day for generating the desired profitability. The most important variables used to calculate these hours are initial investment costs, desired rate of return on investment, selling and purchasing prices for electricity, and the charging output of a station.
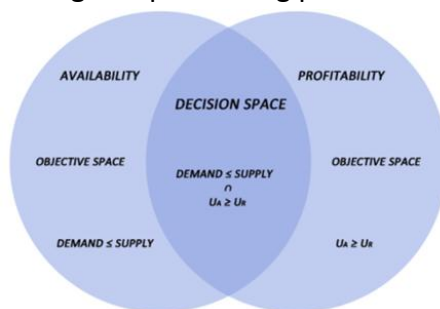

Figure 2: Decision space

Decision space: The above described objectives are divergent, meaning that if one solution is better in terms of one objective, it comes only from a sacrifice off the other objectives (Deb, 2005). Therefore the aim is not to find an optimal solution to each of the objective but to find an optimum compromise solution between the objectives. The two objectives combined, determine the decision space for the location allocation model.

In facility location problems, a facility agent deals with the problem of finding a location that provides services for a spatially distributed demand. Location allocation models, which deal with facility location problems, intend to find a spatial distribution of facilities that maximises or optimises objective functions within one or more constraints (Arentze, 2010). A distinction is made between two different location problems; median problems and covering problems. Median problems measure the effectiveness of a facility location by determining the average distance by those who visit it while covering problems regard a demand as covered when it can be served within a specific time or distance from a facility. Within covering problems set covering problems set out to cover all demand and maximal covering problems use given number of facilities to maximise the demand covered. The location problem considered for the model is neither exactly aligned with the definition of a median problem nor with the definition of a covering problem. For the model the maximum walking distance from destination to vehicle or charging station is considered to be a crucial factor determining whether a charging station will be used. If a destination is outside the catchment area of a charging station it is assumed that the destination is not covered and that the station will not be utilised. The location problem for the model can be described as a multi-objective partial covering problem. The problem is multi-objective because it has to deal with two conflicting objectives. Furthermore, the problem is not a set covering problem but a partial covering problem because it does not cover all demand but only the demand within the decision space of the objectives.

ENVIRONMENT

The environment for the model will be determined by a distribution of electric vehicle within the study area. The study area for the model is the municipality of Eindhoven. The distribution of electric vehicles within the study area is based on a forecast of electric

vehicles in Eindhoven in the year 2020. Based on the national objectives for electric vehicles in 2020, the national growth of car ownership and the proportion of represented cars in Eindhoven the number of electric vehicles in Eindhoven is assumed to be 2.000 by 2020. As mentioned before with electric vehicles only FEV and PHEV are considered. According to the function living, working and visiting three distributions are created for all 2.000 vehicles at neighbourhood level. For the three distributions the electric vehicles per neighbourhood are in proportion with the number of cars owned, the number of workplaces and the total floor area for sales.

The number of electric vehicles per neighbourhood, regardless for which function, will change over time because vehicles are used for transportation and the movements over the course of a day cannot be ignored. For the locations of electric vehicles during a day a distinction is made between at home, at work, at facilities and electric vehicles which are travelling. The three distributions per function and the movement of electric vehicles over the course of a day are combined to create snapshots of distribution for every hour of the day. With these 24 snapshots the movement of electric vehicles during a day is illustrated.
A final distribution is needed because in the real world charging stations are static and the model needs one distribution on which the locations of charging station can be determined. for all neighbourhoods presenting a substantial higher or lower amount of electric vehicles between the average number of electric vehicle during these periods is used. In other words, for all neighbourhoods that show a substantially higher or lower number of electric vehicles over a period of time, the averages of this period is used for a final distribution. For all the other neighbourhoods which show no substantial difference the average of electric vehicles over all 24 hours is used for a final distribution.

DESIGN OF THE MODEL
The model is designed with the program Netlogo. Netlogo is a programmable modelling environment for simulating natural and social phenomena, it is a relatively simple system but well suited for modelling complex systems.

The model has two buttons to run a simulation; the setup button and the go button. When the setup button is used the model responds by (re)setting the model to the initial state. The setup button also clears all previous settings and simulations. When the go button is pressed a simulation starts and charging stations will appear. When a simulation is run the algorithm first uses the minimum catchment area of a station and swaps all cells to determine if a location is in the decision space using. When no more locations can be found the maximum catchment area is used and again all cells are swapped to determine if a location is within the decision space. When no more locations can be allocated the simulation stops.

The interface which is shown below, is used operate the location allocation model and it shows all the buttons, sliders and monitors for running simulations. Besides these elements it also has a view which shows the map of Eindhoven and the locations of the charging stations. The monitors which are coloured beige, display the number of electric vehicles, charging stations and the number of electric vehicles which are covered or serviced by a station. The last monitor displays the average number of covered electric vehicles per charging station. The sliders in the interface are coloured green and they represent the variables mentioned in chapter 5. The user of the location allocation model can set the variables to the preferred or expected values. By altering the values of the variables the decision space of the model will be altered accordingly.
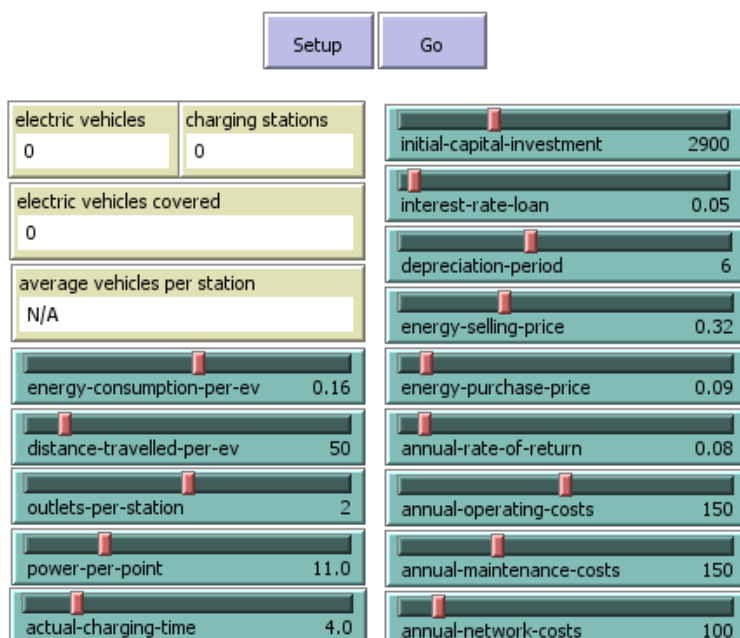
Figure 3: Interface of the model

The scenario created to determine the values for the variables in the model is a base case scenario. The scenario will present an outlook for the year 2020 and the general assumption for this scenario is moderate growth of electric mobility in The Netherlands. It is assumed that the average electric vehicle is no longer limited to 3,7 kW charging but that the average charging capacity of electric vehicles will be 11 kW. On the charging infrastructures side, it is assumed that the types and techniques used for charging stations in 2020 are comparable with the charging stations used by E-laad. Communications between electric vehicle drivers and charging stations have also not improved significantly meaning that the efficiency of charging stations will remain relatively low. To find a solution for the location problem the model is used to analyse the base case scenario. In total ten random distributions of electric vehicles are created and for every random distribution twelve simulations are run with the model, which resulted in 120 simulations. All of these simulations present a solution to the problem but with the use of different criteria final solutions are selected. The used criteria are maximal facilitation, maximal profitability, maximal availability and minimal amount of charging stations. In total three solutions can be identified because the criteria minimal amount of charging stations and maximal profitability result in the same solutions.

CONCLUSION

The simulations run with the model provide a set of solutions for the location problem. It must be realised that the solutions provided by the model are not ultimate solutions to the problem. The model itself and the scenario analysis do not use exhaustive calculations to find the ultimate solution. Instead near optimal solutions are provided by the model. To analyse the set of solutions different criteria are used. According to each criteria a different solution can be selected from the total set of solutions which is shown in table 1.

	Maximal facilitation	Maximal profitability	Maximal availability	Minimal charging stations
Charging stations	724	687	741	687
Ev's serviced	1.995	1.963	1.974	1.963
EV's/station	2,756	2,857	2,664	2,857

Table 1: Solutions according to criteria

The table reveals that the criteria maximal profitability and minimal charging stations result in the same solution, this can be explained because profitability is determined by high utilisation which implies a minimal amount of charging stations covering a maximal amount of electric vehicles. In terms of electric vehicles serviced, all solutions are relatively close to

each other. However when considering the amount of charging stations for every solution, the differences are substantial. Especially when the number of charging stations are expressed in cost. In the base case scenario it is assumed that the initial investment costs for realising a single public charging station is € 2900,-.

Since municipalities are in most cases the owners of the location problem, they can use this model to gather information about how many charging station are needed and where to place them. The outcomes of this model do not specify precise locations for charging stations at street level. On a micro level the exact location of public charging station still has to be determined which depends on the policy of a municipality.
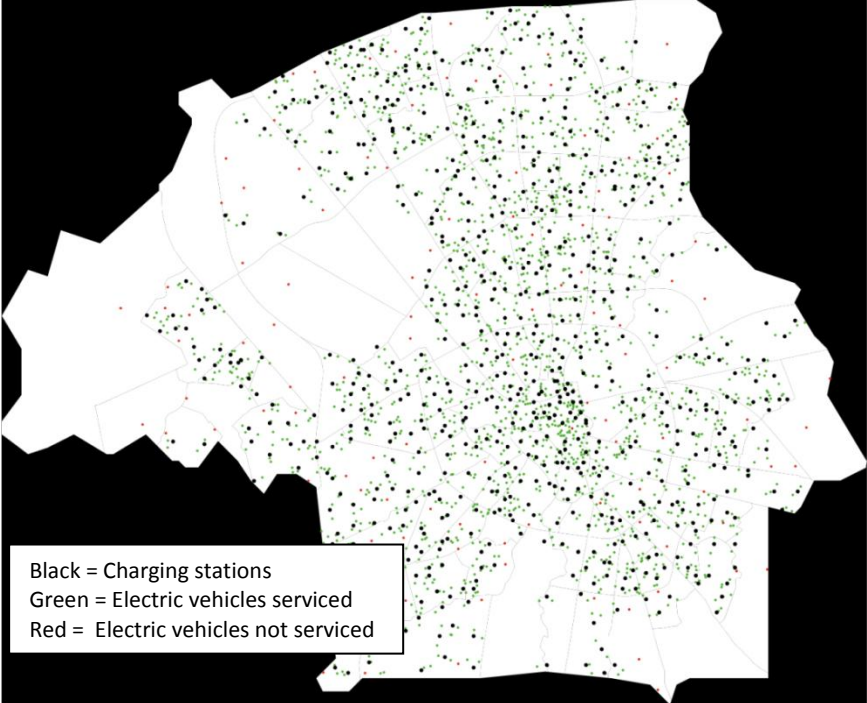

Black = Charging stations
Green = Electric vehicles serviced
Red = Electric vehicles not serviced

Figure 4: Map with charging station for maximum facilitation

Black = Charging stations
Green = Electric vehicles serviced
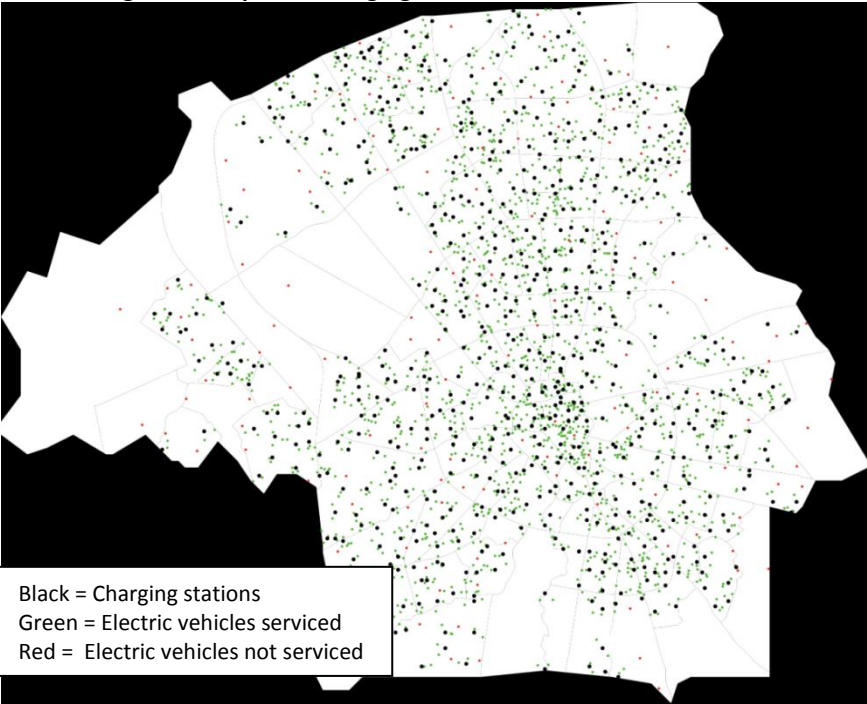Red = Electric vehicles not serviced

Figure 5: Map with charging stations for maximum profitability & minimal charging stations
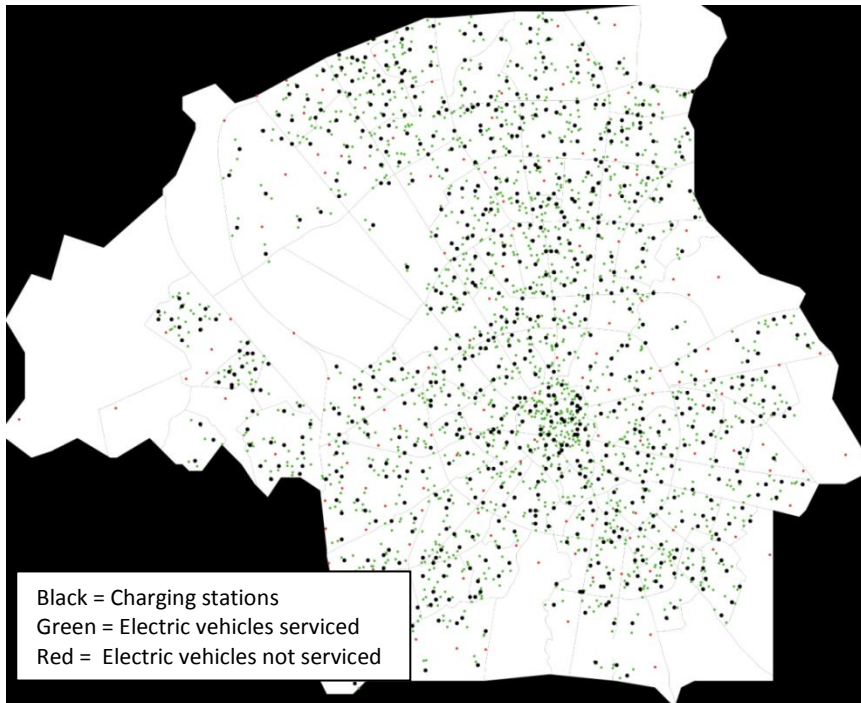
Figure 6: Map with charging station for maximum availability

FURTHER RESEARCH

For further research it is recommended to refine the model. First of all the location is defined as a partial covering problem but instead it could also be defined as a maximal covering problem. In case of a maximal covering problem the number of public charging stations is known upfront and the model will allocate location to achieve maximal coverage. If the model is constructed like this it is more suitable when the amount of public charging stations to be created is limited. Secondly, the current model does not use distances between electric vehicles and a station directly. The only way distances are used is by setting the maximum radius of a charging station. The distances between vehicles and station could be incorporated in the model. With the use of average distances the model would solve a median problem or a combination between a median and a covering problem. Thirdly, the location problem is approached as a static problem. This is obviously true because both parked vehicles and charging stations are static but vehicles can also be considered as dynamic elements in a model. This will transform a static problem into a dynamic problem which has dramatic consequences for the construction of the model. This approach will include flows of electric vehicles and queuing components. Especially for fast charging stations this approach might be very interesting because in most cases they are situated along major exit roads or high ways.

The created environment in GIS can contain more details and in Netlogo candidate locations can be indicated. This way policies can be integrated in the model because in most cases policies of municipalities provide information about locations for charging stations at street level.

Furthermore it is extremely important to monitor the developments of electric mobility very closely. The future of electric vehicles is unknown and even within the relatively short period of this graduation projects radical changes within the field of electric mobility have occurred. The field of electric mobility offers great challenges but also changes. It is recommended to respond to these changes adequately and effectively. For

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now, electric mobility is still growing and perhaps the electric vehicles in our streets will be the standard instead of the exception in 2020.

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MODELING THE RELATIONSHIPS EXISTING WITH THE PERFORMANCE OF NON-REVENUE WATER

Using structural models to link the performance of non-revenue water and its components with the variables that can be obtained

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ABSTRACT

To manage drinking water more efficiently, non-revenue water should be reduced, which can only been done after analyzing non-revenue water. The current process of analyzing the performance of non-revenue water or its components should be more efficient in time. To take a step forward to a more time sufficient approach it is proposed, in cooperation with Royal HaskoningDHV, to examine the relationships between the performance of non-revenue water or its components and the variables that influence or are influenced by the performance. The performance of non-revenue water is expressed in liters/connection/day. The variables included in the model are the connection density, the pressure, the night-peak factor, the number of connections and the sector type. The relationships are shown in structural equation models created using the path analysis; the equations evolving from the models are analyzed using the multiple backward elimination analysis. An important relationship which is proven by the analysis is the influence of the performance of the real losses on the night peak factor. The model also shows that the pressure does not influence the performance of the real losses. The results from the 95% confident intervals, the variance and shrinkage in the model show that the structural equations are too inaccurate to be used for predictive purposes.

Keywords: Performance non-revenue water, multiple regression analysis, prediction models

INTRODUCTION
Currently the world population is growing, the increase in world population leads to an increase in water demand, putting a growing pressure on water as a resource. Water must be managed more efficiently since there are already regions where water is a scarce resource. Water can be managed more efficiently by reducing non-revenue water (NRW) (Gonzalez-Gomez, et al., 2011). "*Non-revenue water is the portion of water that a utility places in the distribution system that is not billed and, therefore, recovers no revenue for the utility*" (Thornton, et al., 2008). NRW can effectively be reduced, when a reduction plan is made. This reduction plan can be made when the performance of non-revenue water and its

components (apparent losses and real losses) is analyzed based upon the measurements performed in the system. The current process of gathering these measurements should be more efficient in time, so no time will get lost. To take a step forward to develop a more time sufficient analysis it is proposed, in cooperation with Royal HaskoningDHV, to analyze the relationships between the performance of NRW or its components and the variables that are influenced or are influencing this performance. Royal HaskoningDHV recognizes this as an opportunity to link one of their respected products with NRW to create a new business opportunity. The product that will be linked to the performance of NRW is OPIR (Optimal Production through Intelligent Control). Some of the variables will be obtained from OPIR, the other variables are data that can be obtained at the beginning of a project.

LITERATURE REVIEW

Non-revenue water and its components

NRW can be divided in three components (1) unbilled authorized consumption, (2) apparent losses and (3) real losses. Unbilled authorized consumption is the water that is used by utilities for operational purposes. The unbilled authorized consumption should be less than 1% of the system input volume, thus the volume of NRW consists mainly of the real losses and the apparent losses. The apparent losses are often the result of influences on the company, which are usually beyond the scope of the day-to-day operation practices. The real losses are caused by leakages in all parts of the systems and overflows at the utility reservoirs. The volumes of the components can be derived from either conducting measurements in the system or by verifying the numbers that are used by the administration, when both are not possible rules of thumb are used to determine the volumes of the components (Thornton, et al., 2008).

Analyzing performance of non-revenue water

The performance of NRW is analyzed using the performance indicators (PI). The PI helps utilities to understand the water loss better, to measure and compare the performance and to be able to define and set targets for improvement. Royal HaskoningDHV has determined that the PI that will be used in the analysis should be able to determine the performance of NRW, the real losses and the apparent losses and that it is not important whether the PI can be used to compare systems with each other. The PI that will be used in this research is the PI liters/connection/day, which satisfies the requirements posed by Royal HaskoningDHV. The PI is well-known by water utilities and can easily be transformed in a more detailed PI by dividing it by the average pressure in the system. The PI liters/connection/day is chosen, because it is assumed that the greater portion of the losses occurs on the service connections (Thornton, et al., 2008), since most of the projects are introduced in urban areas.

OPIR

Some of the variables from which the relationship with the performance will be analyzed can be obtained from OPIR. OPIR is a real-time software package that is used to optimize the operation of drink water systems, by predicting the future pattern. This intelligent control is established using the measured daily water demand patterns to predict the future patterns using statistical algorithms. The OPIR package can be expanded with a pressure model, this module controls the pressure for the weakest point in the system; the pressure in this point should never be lower than the minimum allowable pressure (RoyalHaskoning DHV, -).

The measured daily water demand patterns and the measured and controlled pressure values are the elements that are used to link OPIR with the performance of NRW. To variables can be created from the daily water demand pattern, the day peak factor (DPF) and the night peak factor (NPF). These two variables are estimated by dividing the maximum day consumption or the minimum night consumption by the average consumption of the day (Trifunovic, 2006). The pressure can directly be used as one of the variables.

Variables

The performance of NRW and its components will be expressed in liters/connection/day. The variables DPF, NPF and pressure will be obtained from OPIR, while the variables that can be obtained at the beginning of a project are the sector type, the number of connections and the length of mains (km), the connection density can be estimated using this data.

Thornton, et al. (2008) discusses the influence of the pressure, the number of connections and the length of mains on the real loss volume. Since the performance of the real losses is determined by dividing the volume by the size of the area (specifically the number of connections), it can be concluded that there is no relationship between the performance of the real losses and the number of connections or the length of the mains. It is assumed that there will be a relationship between the pressure and the performance of the real losses. By analyzing the relationships with the performance of the real losses another variable can be included as well, this is the connection density. Fantozzi, et al. (-) describes a nonlinear relationship between the real losses (l/con/day) and the connection density. The nature of the relationship between the real losses (l/con/day) and the pressure is undefined. Since the real losses (l/con/day) is a component of NRW (l/con/day), it is expected that the same variables have a relationship with NRW (l/con/day).The same variables will be used to test whether these variables have an influence on the apparent losses (l/con/day), since there is little known about the variables that influence the performance of the apparent losses.

The DPF and NPF are influenced by the real losses (l/con/day) and thus NRW (l/con/day). Zhang (2005) proves that the DPF has a relationship with the PI NRW (%) (in which only the real losses are used), therefore it is assumed that a relationship exists with the real losses (l/con/day). The relationship between the NPF and the real losses is proven since they are both needed to determine the minimum night flow (Thornton, et al., 2008). Since it is unknown whether the apparent losses (l/con/day) influences the DPF or NPF, these relationships will be analyzed as well.

The DPF is also influenced by the number of consumers (Zhang, 2005), the consumption category, the water price/income, the weather variables, the resident population per account (Arbués, et al., 2003) and the cultural differences (Blokker, 2010) and the NPF by the number of consumers and the type of connections (Thornton, et al., 2008). The relationship between the DPF and NPF and the number of connections will be analyzed, instead of the number of consumers. The number of connections is administrated by the water companies and thus can be accessed easily. Zhang (2005) shows that a nonlinear relationship exists between the number of consumers and the DPF, it is assumed that the same relationship exists with the number of connections. The nature of the relationship between the NPF and the number of connections is undefined. The influence of the sector type on the DPF and NPF will also be analyzed. The sector type replaces the variables consumption category, the income and the household composition for the DPF; it replaces the variable type of connections for the NPF. All these variables differ for the different sector types and thus it is expected that the sector type will influence the DPF and NPF. The sector types are (1) formal urban neat, (2) township, (3) informal-untidy and (4) rural. The remaining variables influencing the DPF are the weather variables and the cultural differences, these can be neglected since the data will be collected from one region.

METHOD

Choice of method

A path analysis will be used to create a structural equation model from the found relationships. Structural equations will evolve from this model. The regression analysis or the machine learning technique can be used to analyze the structural equations. The machine learning technique outperforms the regression analyses in modeling a short-term water demand forecast model (Bougadis, et al., 2005), but needs at least a hundred cases to train a network (StatSoft, -) Since the data set dispose of a hundred cases, the regression analysis is chosen.

With the help of a regression analysis the structural equation, shown in equation 1, can be determined. The relationships between the dependent and independent variables are expressed with the β_n estimates.

$$Y = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n \qquad 1$$

The multiple linear regression method will be used to analyze the structural equations. A backward elimination will be used to find the best combination of independent variables for the structural equation. This method is least likely to miss an independent variable that does predict the outcome. Variables are eliminated when they are not contributing statistically significant ($p>0.1$) to the prediction of the dependent variable. The final model will be accepted when it has a significance level of $p<0.05$. The variable sector type is a nominal variable; dummy variables will be used to be able to use this variable in the multiple regression analysis (Field, 2009). To determine whether the multiple regression analysis can be used the following assumptions must be met: (1) outliers must be examined, (2) there should be linearity in the dataset, (3) homoscedasticity must be present in the data, (4) as well as normality, (5) no independent errors should be present, (6) as well as no multicollinearity.

Application of regression analysis in water demand management

The regression analysis is used for many disciplines; one of the disciplines is water demand management. The regression analysis is used to forecast the water demand in certain areas or in general. The methods that are used are time series analysis, but also multiple regression methods which determines the most suitable variables for forecasting the water demand (Bougadis, et al., 2005). The regression analysis is never used to analyze structural equations involving the performance of NRW, though the practice of the regression analysis in the water demand management shows that it is possible to use this technique to analyze the performance of NRW, since NRW is a component of the total water demand.

RESULTS

Data collection

The collected data is made available by the company JOAT. JOAT is a South-African company that specializes in all aspects of water management, one of their specializations is NRW. Two datasets are provided; the datasets are from the areas of West and South Durban, South Africa. Each dataset consists of several sectors for which a water balance is determined and for which the characteristics of the sector are described. Both dataset consists of various types of sectors, though overall South Durban is more developed than West Durban. The values in the water balances are an approximation determined by the engineers, each area has their own engineer that determines the water balances of the sectors. Even though the engineers of JOAT have a lot of field experience and there are company standards on how the water balance must be determined, it can happen that incorrect values are displayed in the water balances (Pena, 2013). The data is cleaned for sectors that are too small or too big, sectors that experienced out-of-range values in their data are also excluded. Since the data set does not provide all values of the maximum day flow, the DPF will not be analyzed. The type of sector is for some sectors not provided, but this variable can be determined using the internet.

Structural model

Figure 5 shows the structural model determined from the relationships. Three models will be analyzed the model of the performance of NRW, the second is the model for the real losses (l/con/day) and the last is the one for the apparent losses (l/con/day). The NPF and DPF are shown in the same structure, because they are both influenced by the same variables.
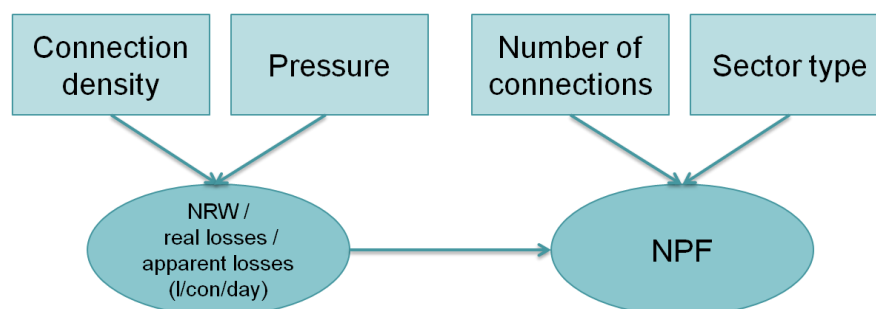

Figure 5: Model specification with dependent variables performance indicator (l/service connection/day) and the night peak factor and the day peak factor

Results regression analysis

The relationships are examined using the results from the literature and the scatter made for the relationships. The relationship between the connection density and the performance of NRW or any of its components is nonlinear (Fantozzi, et al., -), the log function is used to express this nonlinear relationship. The relationship between the NPF and NRW (l/con/day) is also nonlinear, but here an exponent function is used to express this relationship. The other relationships are all linear.

Whenever the assumptions are violated, robust techniques will be used. When the assumption of homoscedasticity is violated, the weighted least squares regression is used and when the assumption of normality is violated the bootstrap technique is used.

The first structural model that is analyzed is the NRW (l/con/day) model; the resulting model is shown in Figure 2. The values displayed in the model are the β-coefficients, these show how much influence an independent variable has on the dependent variable. The value refers the number of standard deviations the value of the dependent variable will change, per standard deviation increase of the value of the independent variable. The β-coefficient can vary between the -1 and 1 (Field, 2009).
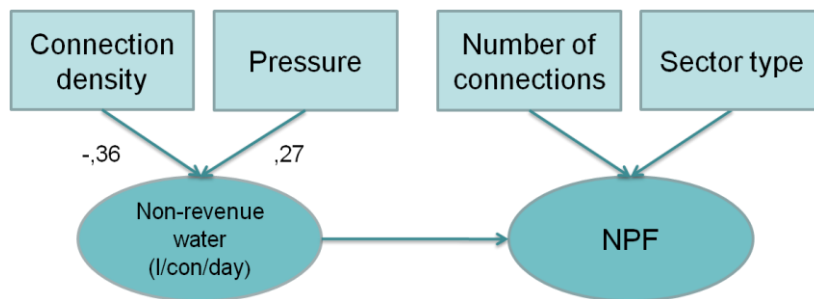

Figure 2: Results of the regression analysis on the model of non-revenue water (l/con/day)

The model shows that a structural equation is determined to predict NRW (l/con/day) using the connection density (β=-0.36, p<0.001) and the pressure (β=0.27, p<0.05). The two independent variables explain 17,7 % of the variance (R^2=0.18, F=9.25, p<0.001) of the variance in the NRW (l/con/day) value. The structural equation is shown in equation 2.

$$NRW\ (l/con/day) = 3390.10 - 2574.23 \log(Connection\ density) + 37.31\ Pressu\ 2$$

The model also shows that the structural equation for the NPF is not determined, both the variables NRW (l/con/day) (β=.12, p=.23) and the number of connections (β=.12, p=.13) do not contribute significantly (p>.1) to the variance in the NPF. The regression analysis is not used any further, since the resulting structural equation would only be able to determine an average NPF for each sector type.

The second structural model analyzed using the regression analysis is the real losses (l/con/day) model for which the results are displayed in Figure 3.
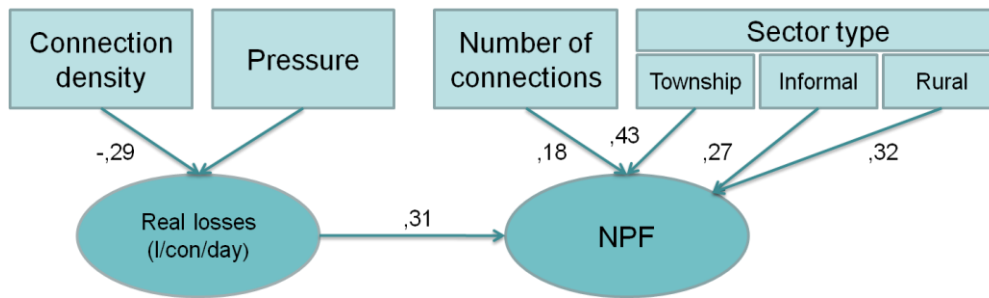
Figure 3: Results of the regression analysis on the model of the real losses (l/con/day)

The model shows that the real losses (l/con/day) can only be predicted using the connection density (β=-.29, p<.05), since the contribution of the pressure (β=.06, p=.52) is not statistically significant (p>.1). The connection density is accounted for 8,4% of the variance (R^2=0.08, F=7.96, p<0.01) in the dependent variable. The independent variables predicting the NPF in the real losses (l/con/day) model are accounted for 30,8% of the variance (R^2=0.31, F=6.84 and p<.001). It is found that the number of connections significantly predicts the NPF (β=.18, P<0.05), as does the real losses (l/con/day) (β=.31, p<0.01). Dummy variables are created to be able to analyze the nominal variable sector type. The urban formal neat sector type is used as the baseline sector type. The results show that the urban formal neat vs. township significantly predicts the NPF (β=.43, p<.01), as does the urban formal neat vs. informal untidy (β=.27, p<.05) and the urban formal neat vs. rural (β=.32, p<.05). Equation 3 and 4 show the structural equation belonging to the model in Figure .

$$Real\ losses\ (l/con/day) = 1802.38 - 739.86\ \log(Connection\ density) \qquad 3$$
$$NPF = -.242 + .237 * Township + .167 * Informal\ untidy + .177 * Rural + .417 \qquad 4$$
$$* Number\ of\ connections^{0,00004483} + 9.847E^{-05}$$
$$* Real\ losses\ (l/con/day)$$

The last analyzed structural model is that of the apparent losses (l/con/day), the results are shown in Figure 4.
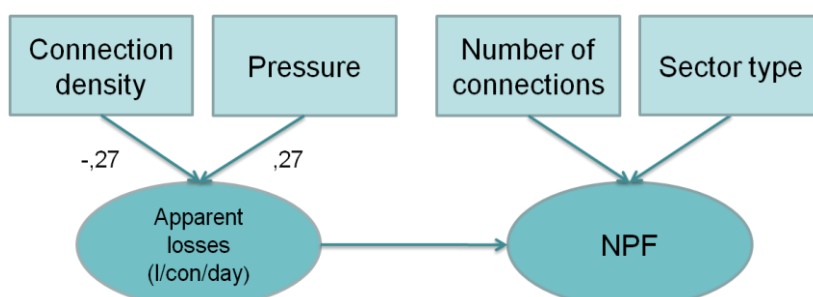

Figure 4: Results of the regression analysis on the model of the apparent losses (l/con/day)

Both the connection density (β=-.27, p<0.05) and the pressure (β=.27, p<.05) significantly predict the apparent losses (l/con/day), the variables explain 13% of the variance (R^2=0.13, F=6.42, p<0.01) of the apparent losses (l/con/day). Equation 5 shows the structural equation for the apparent losses (l/con/day).

$$Apparent\ losses\ (l/con/day) \qquad 5$$
$$= 943.69 - 955.07\ \log(Connection\ density) + 19.24\ Pressure$$

The structural equation for the NPF is not determined using this model, since both the number of connections (β=.11, p=.15) and the apparent losses (l/con/day) (β=-.03, p=.73) do not contribute significantly (p>.1) to the NPF. The regression analysis is not used any further, since the resulting structural equation would only be able to determine an average NPF for each sector type.

Table 1 displays the range between which the predicted value lies using the 95% confidence interval resulting from the regression analysis and the average values from the collected data.

Table 1: Boundaries non-revenue water (l/con/day) model

	Predicted value	Lower bound	Upper bound
NRW (l/con/day)	672.98	-5921.27	11763.38
Real losses (l/con/day)	423.74	-1680.29	2441.42
Apparent losses (l/con/day)	236.44	-2891.86	3741.25
NPF using real losses (l/con/day)	0.239	-0.575	0.974

Validation

The internal validation is performed by examining the R^2 as well as the adjusted R^2. Two adjusted R^2 are estimated, Wherry's adjusted R^2 and Stein's adjusted R^2. Wherry's adjusted R^2 estimates the level of variance in the dependent variable that is accounted for if the model was derived from the population from which the sample was taken. Stein's adjusted R^2 estimates the level of variance in the dependent variable that is accounted for if the model was derived from an entirely different data set. The outcomes are shown in Table 2.

Table 2: Adjusted R^2 estimation

	R^2	Wherry adjusted R^2	Stein adjusted R^2
Non-revenue water (l/con/day)	0.177	0.158	0.128
Real losses (l/con/day)	0.084	0.073	0.052
Apparent losses (l/con/day	0.130	0.110	0.079
NPF using real losses (l/con/day)	0.308	0.213	0.266

DISCUSSION, CONCLUSSION AND RECCOMENDATIONS

The following relationships are shown using the literature study and the regression analysis:
- The model NRW (l/con/day) shows that the NRW (l/con/day) can be predicted using the pressure and the log function of the connection density. No structural equation is developed to determine the NPF;
- The model real losses (l/con/day) shows that the real losses (l/con/day) can be predicted using the log function of the connection density. A structural equations is also made for the NPF, using the real losses (l/con/day), the sector type and an exponential function for the number of connections as independent variables;
- The model of the apparent losses (l/con/day) shows that the apparent losses (l/con/day) can be predicted using the pressure and the log function of the connection density. No structural equation is developed to determine the NPF;

Some remarkable facts are shown in the model results, these are:
- The non-existing relationship between the real losses (l/con/day) and the pressure, since the relationship between the real losses (kl/day) and the pressure is defined by the

literature. The cause of this non-existing relationship could be the size of the data or the reliability of the data;

- The relationship between the apparent losses (l/con/day) and the pressure is not defined by literature and thus it is unknown whether the relationship is causal;
- The relationship between NRW (l/con/day) and the pressure is expected resulting from the relationship between the real losses (l/con/day) and the pressure. Since this relationship does not exist, the relationship between NRW (l/con/day) and the pressure is caused by the relationship between the apparent losses (l/con/day) and the pressure, thus it is unknown whether this relationship is causal;
- The results show that there is a relationship between the NPF and the real losses (l/con/day). This relationship is expected, because both variables are used to determine the minimum night flow. This proven and now analyzed relationship gives opportunities for future research and to link OPIR with NRW;

The regression analysis also shows whether the models can be used for predictive purposes:

- The proportion of the variance explaining the performance of NRW or its components using the independent variables is in all cases smaller than 25%, except for the equation predicting the NPF (30,8%);
- The shrinkage levels are all smaller than 25%; two of them are even below the 10%;
- The boundaries, determined using the 95% confident interval, are really broad.

The independent variables do not explain a large part of the variance of the dependent variable and the boundaries are really broad even becoming negative. When the equations resulting from the structural models are used to predict the dependent variables, they will be imprecise. The predicted values will not add any knowledge about the performance of NRW or its components in a new project area.

For future research it is recommended to:

- Identify more variables that influence the dependent variable, this may explain a larger proportion of the variance of the dependent variable;
- Use larger datasets and verify the data that will be used, this may lead to closer boundaries and thus a more precise structural equation. It should be noted that it is difficult to verify water balances;
- It is recommended that the machine learning techniques will also be used, when a large enough dataset is available;
- For future research it is recommended to examine the relationship between the real losses (l/con/day) and the NPF over a time-period in one area. The changes in the NPF value over a time-period can be examined to determine the influence of the real losses (l/con/day).

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ENERGY SERVICES IN THE DUTCH SOCIAL HOUSING SECTOR
A benchmarking study on housing corporations' in practice performance

Author: B. Kroon

Graduation Program:
Construction Management and Urban Development 2012-2013

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ABSTRACT
The energy efficiency of most social housing dwellings does not meet current norms, which unnecessarily increases the total housing costs of the tenants. Housing corporations must invest in improving energy efficiency to improve performance, but come across several barriers that prevent them from covering their costs. An often mentioned solution is bringing energy services, which has to distinct approaches and business models, aimed at lowering energy demand and fulfilling the remaining energy demand. This research assesses twelve projects in the Dutch social housing sector, in which these energy services have been applied, on energy performance and project finances. Especially small-scale, decentralized energy delivery by housing corporations has the ability to improve energy performance, while using the earnings potential of energy delivery. Given these advantages, outdated rules and legislation should be changed to facilitate this development.

Keywords: Energy services; Housing corporations; Energy efficiency; Energy Performance Contracting; Energy Supply Contracting.

INTRODUCTION
An increasing energy demand and decreasing availability on fossil fuels has driven up prices of the last few years. Since the increase in energy costs for Dutch households has increased at a faster rate than the income, the share of household-income that is spent on energy-related expenses is rising. Research shows that three groups are especially vulnerable for this development (Nibud, 2009): The lower incomes; the lower educated; and tenants.

Most of the lower income households in the Netherlands are not able to buy or rent a home on the private market and are reliant on the social housing sector, which in the Netherlands exploits 34% of all the 7.2 million Dutch homes. These dwelling are exploited and maintained by housing corporations: a private organization with the public goal of providing qualitative and affordable housing to those that cannot themselves. The target group for social housing has been determined by European law to be households with an annual income up to € 34.085 (price level 2012). Housing is considered to be social housing when the monthly rent is lower than € 664,66.

The main task of housing corporations is stated in the main national legal document for the social housing sector 'Besluit Beheer Sociale Huursector', or BBSH (VROM, 2005), in six main performance fields:
- To accommodate the target group;
- To ensure quality of living;
- To involve tenants in policy-making and exploitation;
- To provide financial continuity;
- To provide quality of life;
- To provide housing and care.

Given its size and the financial vulnerability of its tenants, the sector plays an important role in reducing the energy-related expenses by improving the (energetic) quality of their housing stock. The sector has made agreements on improving this energy efficiency with the national government (BZK, 2012). Most of the social housing was build in a period in which few to none attention was given to energy efficiency. The room for improvement is therefore large. Despite of the goals, the investments of the sector in the existing housing stock is decreasing (CFV, 2012).

Due to several developments en new political decisions, the financial position and investment possibilities of housing corporations has decreased. The prognosis on new building projects therefore shows a decreasing trend and many projects have been postponed. This makes investments in the existing housing stock and in improving energy efficiency even more important. However, the speed and number of such projects is falling behind.

This is an concerning development, since several experts point out the necessity of investing in the energy efficiency of the existing social housing stock (Renda, 2012). They argue that without these investments, the vast majority of the social houses, 80%, will no longer be within financial reach for the target group of the corporations by the year 2030, due to the increased total housing costs, see figure 1. This makes it necessary for housing corporations to expand their focus and offer social housing with an affordable, long-term housing costs prospect.
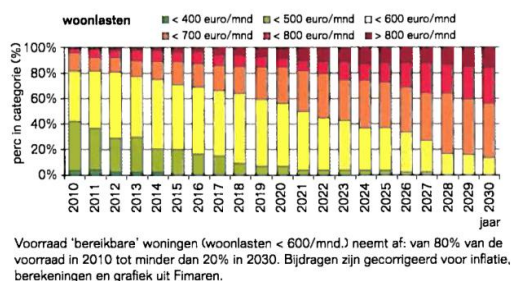

Figure 1: Percentage of rental dwellings within Financial reach of the target Group. Source: Renda (2012).
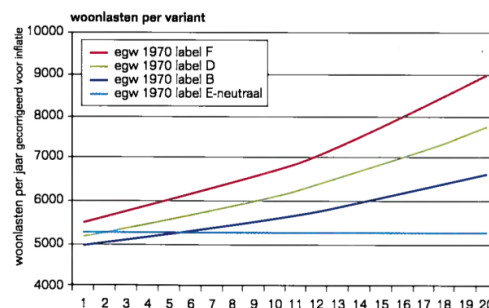
Figure 2: Development of housing costs for different energy labels. Source: Renda, (2012).

Figure 2 shows that steady housing costs on the long term are only reached by energy-neutral houses. Energy neutral dwelling are dwellings that use as much energy as they generate over the net period of one year. Since bringing real estate up to energy neutral standards means additional investments in energy generating installations and measures in a

time where housing corporations are already struggling financially, the implementation of such measures is minimal.

SPLIT INCENTIVE

An explanation for the low investments in energy efficiency and the slow implementation of such measure is the split incentive. The capital investments for improving the energy performance of the dwellings is done by the housing corporations, but the (financial) benefit of these improvements are experienced by the tenants in the form of lower energy costs. This imbalance in costs/benefits makes it unattractive for housing corporations to invest in improving energy performance and thus forms an important obstacle for the sector.

A possible solution for this problem of housing corporations could be found in bringing energy services: A package of energy efficiency improving measures, concerned with maximizing efficiency and cost effective supply and end-use of energy for their customers (GEA & EESI, 2009).

Several opportunities are addressed to such energy services: It lowers the housing costs for the tenants; generates additional income for housing corporations and thus lower the split incentive; and it could provide for the financial boost to bring dwellings up to energy neutral standards by implementing durable energy generating solutions.

ENERGY SERVICES

Energy services has been stated as a multi-purpose instrument, which will help to overcome market-barriers for energy efficiency (Bleyl-Androschin, 2009) Two distinct approaches to energy efficiency exist in the energy services: energy performance contracting, EPC, and energy supply contracting, ESC. EPC is aimed at reducing the energy demand of a dwelling and thus on establishing energy savings, whereas ESC is aimed at efficiently fulfilling the remaining energy demand, and thus on energy supply.

These contracting types are not about any particular technology or energy carrier, but rather must be seen as a modular efficiency tool. Although they both strive for efficient energy use, their business model and type of implemented measures differ.

Energy performance contracting

Energy performance contracting's main goal is to reduce energy consumption by implementing demand side efficiency measures. This includes high insulation values for facades, floors roofs and windows. The business model is based on delivering savings compared to a predefined baseline. The investment, or capital expenses, of the EPC-measures, is covered by the avoided energy costs, or a decrease in the operating expenses. In the Dutch social housing sector, a similar approach is used. The implemented EPC-measures lower the energy costs of the tenant and the housing corporation increases the rent. As long as the rent increase is lower than the savings on energy costs, this results into lower housing costs for the tenant.

Energy supply contracting

Energy supply contracting's main goal is to provide maximum efficiency of the energy supply and to provide the security of supply. The subject of the contract therefore is not the

avoided energy costs, but the delivered units of energy. Within this contract innovative, high-efficient and renewable technologies such as bio-mass plants, solar, wind and water energy, thermal systems and local heating networks have been implemented. In the Dutch social housing sector however, the implementation of ESC-measures is minimal and only performed by a handful pioneering housing corporations, which show promising results.

RESEARCH STATEMENT AND RESEARCH QUESTIONS

The research statement is as following: 'Most housing corporations are hesitant to become fully active in the energy services, despite positive results and experience of their colleague corporations. The decision-motives underlying these hesitation and their interrelationship are not known. Also, a clear view on the effects of energy services on important energy efficiency targets are not known.'

The main research question is formulated as:
'What are the effects of energy services on energy efficiency targets of energy efficiency projects in the Dutch social housing sector?'

METHOD

The effect of energy services on energy efficiency targets is assessed by benchmarking projects that have been performed by housing corporations with the intention to improve the energy efficiency of the dwellings.

This research uses the formal benchmarking technique Data Envelopment Analysis, which is applied to perform both a best practice and a performance benchmark of these energy efficiency projects in the Dutch social housing sector.

Data envelopment analysis

Data envelopment analysis is a data-oriented approach for evaluating the performance of a set of a relatively homogenous set of peer entities, called Decision Making Units or DMUs. It is a relatively easy mathematical programming method, which identifies efficiency frontiers for a peer group of entities and has been proven particularly useful for estimating multiple input and multiple output production correspondences.

DEA opens up possibilities for use in cases which have been resistant to other approaches because for the complex and often unknown nature of the relations between the multiple inputs and outputs involved with many of these activities. (Cooper et al., 2004). DEA has also been used to supply new insights into activities and entities that have previously been evaluated by other methods.

DEA assesses the relative efficiency of a peer group of entities by using the efficiency ratio, output divided by input, of each individual DMU. The DMU with the highest efficiency ratio is thus the most efficient and serves as an example for the other DMUs. However, the exact combination of inputs and outputs can differ between DMUs due to different approaches and decisions. The aspects on which a DMU can be called efficient can thus also differ. DEA enables the researcher to assess these DMU-specific combination by implementing a variable weighting scheme.

DEA assigns weight to each input and output variable for each DMU's transformation process. It determines which weighted combination of input and output results into the highest input-to-output ratio for a DMU, when the same weight-combination would have been applied to all DMUs. By doing so, the relative strong points of a DMUs transformation process become clear

Variables

The input and output variables on which the DMUs are assessed have been determined by literature study, experts' opinion, national agreements and ability to assess the two energy service approaches. The input and output variables of this research can be seen in table 1.

Table 1: Input and output variables.

Input	Output
Costs per dwelling	Savings on total housing costs
	Energy Index
	Present value of additional income

Costs per dwelling (X_1)

The costs per dwelling only cover the costs of the energy efficiency measures. Often, such measures are applied during a renovation, in which sanitation and kitchen appliances are replaced. These costs however are not taken into account as only dwelling improving measures may legally results into a rent increase. (BZK, 2012)

Savings on total housing costs (Y_1)

The savings on total housing costs measures the monthly financial benefit for the tenant, after the measures have been applied. In the agreement 'Convenant Energiebesparing Huursector' (BZK, 2012) it is stated that energy efficiency measures must lead to lower housing costs for the tenant.

Energy Index, EI (Y_2)

The Energy Index, EI, is the obligated index that measures the energy efficiency of existing dwellings. Two values of the EI are obtained per DMU: EI_{after} to capture the EI-score after renovation, and ΔEI to capture the added quality of the improvements.

Present value of additional income (Y_3)

The present value of the additional income is taken into account to express the financial benefit of the energy efficiency project for the housing corporation. It holds all the expected additional positive cash flows related to the renovated dwelling during its extended exploitation period.

FINDINGS

Data Collection

Twelve DMUs have been assessed in this research. Eight of these implemented EPC-measures, the other four implemented both EPC- and ESC-measures. The DMUs were visited and the responsible project leaders were interviewed. The obtained data collection can be seen in table 2.

Table 2: Data collection.

DMUs	Input		Output				
	Costs		Savings on Housing costs	Energy Index Before	Energy Index after	Present Value	
1	€	3.800,00	€ 7,00	2.38	1.20	€	2.745,70
2	€	60.000,00	€ 16,50	1.99	1.09	€	6.666,94
3	€	50.000,00	€ 28,00	2.32	0.88	€	7.778,10
4	€	77.000,00	€ 28,02	1.91	0.38	€	15.802,79
5	€	14.320,75	€ 8,00	2.31	1.49	€	9.736,95
6	€	20.881,60	€ 60,00	2.13	0.96	€	0,00
7	€	5.592,00	€ 30.58	1.87	1.25	€	1.020,93
8	€	45.000,00	€ 9,00	2.21	0.85	€	9.228,81
9	€	130.000,00	€ − 40,00	2.21	0.15	€	45.553,39
10	€	14.416,67	€ 63,00	2.38	1.16	€	3.073,35
11	€	40.000,00	€ 30,00	2.01	0.95	€	0,00
12	€	27.437,50	€ 7,00	2.31	1.02	€	5.000,20

Analysis

Two DEA analyses have been performed. One on the actual performance, using the data of table 2, and one on the potential performance, using recalculated data to represent the DMUs' performance unhindered by rules and legislation. This second analysis more accurately represents the true strong points of EPC- and ESC-projects and shows the influence of rules and legislation on the direct performance of these projects. The results of this second analysis can be seen in table 3 and 4.

Table 3: DEA results for the potential performance on dataset 1 (EI_{after})

ES	DMU	θ	Reference set	v_1	v_2	v_3	u_1
ESC	2	0.37	DMU$_5$ (0.02); DMU$_9$ (0.39); DMU$_{10}$ (0.59)	0.32		1.01	1.32
	4	0.65	DMU$_1$ (0.04); DMU$_5$ (0.08); DMU$_9$ (0.55); DMU$_{10}$ (0.34)	0.07	0.34	0.21	0.70
	5	1	-			0.90	1.21
	9	1	-		0.24		0.28
EPC	1	1	-		1.90	1.07	2.26
	3	0.59	DMU$_9$ (0.25); DMU$_{10}$ (0.75)	0.56		0.34	
	6	0.99	DMU$_9$ (0.03); DMU$_{10}$ (0.97)	0.32	0.24		
	7	1	-	0.74			4.88
	8	0.53	DMU$_5$ (0.54); DMU$_9$ (0.27); DMU$_{10}$ (0.20)	0.27		0.85	1.10
	10	1	-	0.30			
	11	0.57	DMU$_9$ (0.17); DMU$_{10}$ (0.83)	0.54	0.41		
	12	0.52	DMU$_5$ (0.20); DMU$_7$ (0.57); DMU$_9$ (0.16); DMU$_{10}$ (0.08)	0.19	1.09	0.46	1.97

The θ-value shows the relative efficiency of a DMU on a scale from 0 to 1. The reference set is determined for the non-efficiency DMUs as an indication of improvement possibilities. v_1, v_2, v_3 and u_1 represent the individually determined weights per DMU, corresponding with Y_1, Y_2, Y_3 and X_1, respectively.

Table 4: DEA results for the potential performance on dataset 2 (ΔEI)

ES	DMU	θ	Reference set	v_1	v_2	v_3	u_1
ESC	2	0.58	DMU$_1$ (0.23); DMU$_9$ (0,42); DMU$_{10}$ (0.35)	0.01	1.38		0.31
	4	0.91	DMU$_1$ (0.21); DMU$_9$ (0.56); DMU$_{10}$ (0.23)	0.01	0.81		0.18
	5	1	-			0.90	1.21
	9	1	-			0.20	0.27
EPC	1	1	-		1.06		0.24
	3	0.96	DMU$_1$ (0.24); DMU$_9$ (0.33); DMU$_{10}$ (0.43)	0.01	0.86		0.19
	6	0.96	DMU$_9$ (0.00); DMU$_{10}$ (1.00)	0.15	0.64		
	7	1	-	0.49	0.68		4.74
	8	0.91	DMU$_1$ (0.59); DMU$_9$ (0.32); DMU$_{10}$ (0.09)	0.01	0.92		0.21
	10	1	-	0.33		0.20	
	11	0.75	DMU$_1$ (0.15); DMU$_9$ (0.23); DMU$_{10}$ (0.62)	0.01	1.16		0.26
	12	0.96	DMU$_1$ (0.79); DMU$_9$ (0.18); DMU$_{10}$ (0.03)	0.01	0.97		0.22

The θ-value shows the relative efficiency of a DMU on a scale from 0 to 1. The reference set is determined for the non-efficiency DMUs as an indication of improvement possibilities. v_1, v_2, v_3 and u_1 represent the individually determined weights per DMU, corresponding with Y_1, Y_2, Y_3 and X_1, respectively.

Results

The efficient DMUs are the DMUs that have scored a θ-value of 1. The DMUs that have received lower θ-values are thus inefficient. For the efficient DMUs, it can be said that they receive their full efficiency score mostly because of their financial variables, which have been awarded the highest variable weights. Either the DMUs kept their costs relatively low (DMU1, DMU7), or kept their income relatively high (DMU5, DMU9). DMU10 was able to achieve very high savings on total housing costs.

Also, most inefficient DMU's receive a far higher θ-score for dataset 2 than for dataset 1. This indicates that they are more successful in achieving big improvement on the Energy Index (ΔEI), than they are in reaching high end-value (EI$_{after}$).

Regarding the differences in type of applied energy service, important differences can also be found.

Energy Performance Contracting projects are able to achieve a reasonable Energy Index after renovation. This Energy Index meets current the norms, but will not surpass an average A-label. The affiliated costs of the projects are lower than those of Energy Supply Contracting. However, the ability of EPC to cover these costs are lower than those of ESC and a split incentive remains. The savings on total housing costs are directly related to the present value. The more savings on total housing costs for the tenants, the lower the potential present value of the project and vice versa.

Energy Supply Contracting has the ability to achieve a much higher Energy Index, up to almost energy neutral standards. The costs of these projects are often higher than EPC-projects, but by utilizing the earnings potential of the energy supply measures, they are able to achieve a relatively high present value and cover a relatively larger part of their costs. This lowers, but doesn't entirely removes, the split incentive for housing corporations. However, the higher present value means that the savings on total housing cost for ESC-projects isn't a strong aspects.

Overall, projects with ESC's characteristics will perform better on energy efficiency, indicated by a lower energy index, while the earnings potential of the energy supplying measures improves their present value. They are still able to generate savings for the tenants, albeit a small benefit. EPC projects perform lower on energy efficiency, but meet the energy efficiency norms with lower costs and with the ability of high savings for the tenants, yet lower added income for the corporation.

DISCUSSION & RECOMMENDATIONS
Housing corporations
The performance of the assessed DMUs, EPC and ESC, all comply with the current energy efficiency norms. The ability of combining Energy Supply Contracting with the Conventionally adopted approach of Energy Performance Contracting to achieve a lower – thus better – energy index, while utilizing the earnings potential of its energy supply installations, is therefore not perceived as an immediate necessity by most housing corporations. Corporations seek a balance between their societal objective and their financial arguments regarding their investments behavior. The practical implementation of the sector's societal goal is thus dependant on the financial possibilities. This explains why the cheaper energy performance contracting is still the conventional approach of the sector.

Housing corporations exist under the societal condition to provide high quality, affordable housing. Although many of them see the possibilities of energy delivery regarding this condition, most of them choose not the take the step. By doing so, the possible quality of the dwellings is compromised: by only doing what is necessary, a permanent solution is denied and problems are postponed instead of solved.

Apart from the intrinsic motivation of housing corporations to strive for the highest energy efficiency norms, rules and regulations should facilitate innovative energy efficiency initiatives. Here lies an important role for the Dutch national government.
National government

Short-term market barriers must not become long-term business obstacles that prevent housing corporations from fulfilling their main goal of providing high quality, yet affordable housing for the lower incomes. To prevent this, the current legislative framework and energy efficiency norms need revision and take in a more facilitating character, instead of the barrier that it is perceived as today.

First, the current ambition of the sector to reach an average B-label or EI of 1.25 in 2020 (BZK, 2012) will not guarantee long-term affordability. Renda (Renda, 2012) shows that this ambition will not stabilize the total housing costs of households and only energy neutral houses will. Under more ambitious norms, ESC will have to be applied given its ability to reach higher EI-norms, as shown by this research. This is even stated in the same agreement (BZK, 2012), maintaining the ambivalent stance of the sector towards energy services and managing total housings costs.

Explicitly mentioning energy services or managing total housing costs in the BBSH as one of the performance fields of housing corporations could provide them the security and policy space regarding the implementation of ESC-measures especially. Simultaneously, such

activities should fall under the activities of housing corporations eligible for state-aid, opening up opportunities for more beneficial financial funding for the high capital expenses on ESC-measures.

This would be a logical step, following the reasoning that long-term affordability of the social housing sector is only assured by taking into account the total housing costs, and thus the implementation of ESC-measures.

Structural solutions are called for by the Dutch government, creating opportunities for housing corporations in laws and legislation, by facilitating small-scale decentralized energy generating solutions.

ACKNOWLEDGEMENTS

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This summary is the result of my graduation thesis on the performance of Dutch housing corporations on the implementation of energy services to improve the energy efficiency of their housing stock. The research was performed in collaboration with Innovation in Building & Maintenance in Eindhoven. With this report, I end my Masters education Construction Management & Engineering at Eindhoven University of Technology.

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MAINTAIN A DYNAMIC OFFICE REAL-ESTATE MARKET IN THE PROVINCE NOORD-BRABANT, 's HERTOGENBOSCH CASE STUDY:

The office real-estate market, what are the effects of policies to bring back the equilibrium in the real-estate office market and vanish the structural vacancy?

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ABSTRACT

The economical growth and eagerness to develop out of the past decades has caused the present overstock off office real-estate. By the use of System Dynamics this research predicts the effects the effect of futures measures in future scenarios (within the real-estate office market of 's Hertogenbosch). The most important factors within this process of Urban Development are: plan capacity release, employment development, office withdrawal, and quality improvement. At the end of the end of the research the future scenarios are judged by the responsible policy makers out of the BrabantStad region by the use of Game Theory.

Keywords: real-estate office market, urban development, System Dynamics, Policies, Game Theory.

INTRODUCTION

'The dynamics of the office market', the previous sentence could be a description of the whole real-estate office market, but it finally means nothing. It only indicates the complexity of the market. In general the office property market is clearly characterized by a succession of cycles, with expansionary and recessionary stages emerging as direct response to monetary and fiscal policies, to economical parameters, and trends in the use of offices. The game between demand and supply of offices is interactive with always a form of tension, which it makes it interesting. To give the market 'space' (literally and figuratively) there need to be a small oversupply (if not the market is locked). A healthy vacancy rate should be 5% till 7% of the stock. There is no need for extra scientific research to demonstrate the structural vacancy in the office real-estate market in the Netherlands. But to indicate how big this problem is, some facts and figures: The office stock in the Netherlands consists of 41 million m2 in use and 7,6 million m2 in offer, this means a vacancy rate of +/- 15,6%. This overall rate could be divided in cyclical vacancy (the dynamics of the market) and structural

vacancy (over stock, mismatch between demand and supply).

PROBLEM DESCRIPTION
In the past decades lots of new offices are built at mostly formal locations. Because of the race for the most attractive office, the available capital, the eagerness to do land development by the municipalities and the drive for developments of offices was high. Finally possible future developments of the economy are not taken into account. This has led to too much office stock, where there is a possible skewed distribution of office quality.

Research question: 'What are the effects of policies to bring back the equilibrium in the real-estate office market and vanish the structural vacancy?'

Research objective: The aim of this research is to investigate if different measures could bring back the equilibrium in the office real-estate market. This aim is tried to be achieved with the construction of a System Dynamics model. The real-estate office market in the province Noord-Brabant (especially the municipality 's Hertogenbosch) is modeled to understand the different cycles in the market and to predict the effect of future behavior (especially the behavior of policy makers).

Research boundary
- The province of Noord-Brabant, Especially Brabant Stad (5 biggest municipalities);
  - The System Dynamics model is focused on 's Hertogenbosch.
- The willingness to cooperate by a collective solution will be reviewed, mostly measured by the responsible municipalities (Brabant Stad);
- The focus of the measurements is at the 'collective tax', 'development credits', and a 'governmental payment ' (hierarchical approach by the government);
- The willingness to take an office out of the market will be measured, if it will be transformed to another function of use or demolished will be not taken along;
- The change in land position which could arise after the demolishing of offices will be disregarded.

THEORETICAL FRAMEWORK
Financial structure of investment funds, investment behavior of office owners
The aim of real-estate investments is important to notice. In the past decades real-estate is often used to secure money. Because of a growing economy during the last decades two important developments have made the (office) real-estate market 'hot' to speculate and invest. First the stabilized growth and stability (inflation secure), and second the scarcity of development space (Kummerow, m., 1999). Because of this, different players occur at the real-estate market, each with a different aim. An important phenomenon during the last decades in the real-estate market is the debt-driven financing. By the use of the leverage effect, lots of office real-estate portfolios are financed with a substantial high part of debts. With a growing economic and scarcity this portfolios will giving interesting revenue percentages. Which the portfolios are based on static valuation methods based on growth (Millington, A.F., 1994). By a growth disturbance portfolios with too much risks will go bankruptcy. By the above stated properties of the real-estate market structural office vacancy is a big threat for the present office real-estate market. In this research the development of vacancy in relation with urban development quantities will predict the future development of the office real-estate market (vacancy) by the use of different influence factors, the aim is to bring back the market in an equilibrium.

Vacancy influence factors
As mentioned, vacancy is a dangerous threat for the (risk geared) office portfolios. To steer the market and vanish the overstock, influence factors of office vacancy are important. The last years there are produced several researches which determines these factors in the

Dutch office real-estate market. The most important are presented in Table 1, (EIB, 2011, DTZ, 2011).

Vacancy influence factor	Categories		
Geographic location*	Central location	Remaining locations	Formal locations
Quality category**	Attractive offices	Deprived offices	No chance offices

Table 1: Vacancy influence factors * EIB research ** DTZ research

Of course there are several more factors which influence vacancy, e.g. price level, quality, operating cost, highway distance, accessibility, etc. In this research is chosen to pick out the most consistent factors to model (with complete information), and which obviate the most vacancy influence factors. Hereby are the factors out of Table turned into measurable factor these are visualized in Figure.
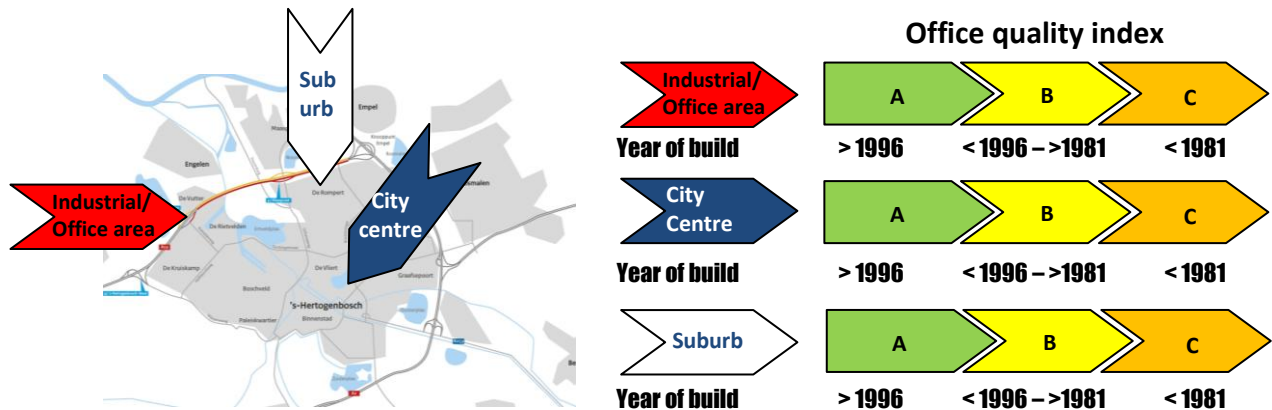
Figure1: Influence factors geographical location and quality index

The geographic location is static and will not quick shift towards another location (only by a gigantic urban revitalization). The quality on the other hand will quick shift towards another category, these is called ageing, in the next paragraph these ageing part will be explained.

The life cycle of real-estate, the ageing part

Technical ageing: The technical life cycle of an office building could be defined in several ways, in different units. The latest one is the carbon footprint, determined by Agentschap-NL (Anink, 2010). Out of the research of Agentschap-NL the next important findings about technical ageing can be filtered out. The general (technical) life cycle of a building is mostly estimated around 50 years. To extent this life cycle there could be intervene by a renovation to consolidate the technical quality. The next variables are important to judge this renovation:

- Replacement or preserve ratio;
- Achieved lifespan extension;
- Long- or short cyclical components in the building;
- The present lifetime;
- The year of build
- Energy label.

Economical ageing: Economical ageing is related to the different valuation methods, namely static or dynamic, which the last gives more price input. To overcome the ageing part of office real-estate at field (area) level. The economical institute of construction (EIB) developed an 'office model' which should create an equilibrium in supply and demand. This 'office model' determines not the age, but the difference between quantitative supply of offices and qualitative supply of offices. Which the demand of offices in the office market could be described in a quantitative and a qualitative way, which:

- The quantitative aspect is the absolute size of the office demand, this can be determined by the employment and the office space use of each employ.
- The qualitative aspects are the users' preferences with respect to the offices. Relevant are: trends, changing preferences, technical possibilities, and location preferences.

Stock movement: In the previous paragraph there is stated a technical and economical

depreciation in qualitative way. The technical depreciation means the ageing of building techniques (building physics and materials) and the economical depreciation has the best relation with the functionality (layout of the building), which both has relation which each other. To translate these facts to the 'free-market-system' of the office real-estate market, the economical institute of construction (EIB, 2011) has expressed the economical ageing in hard factors, namely the shift towards lower (price) segments, divided in the different locations:

Central locations	Remaining locations	Formal locations
0,5%	0,6%	0,9%
% of stock movement towards a lower quality segment		

Governmental policies

Lots of research can be done and is done in the field of governmental policies in relation with urban (re)development. In this paragraph the major highlights of the policies and legislation which influence vacancy will shortly be discussed, According to the publication of (Hobma & Schutte Postma, 2011). Passive and active government, difference between legislation and policy: First of all a difference should be made between legislation and policy, which will prevent misunderstandings. Legislation (laws and regulations): Legislation creates boundaries which the different entities may act or may deviate from (public and private parties as well as individuals). There could only be deviate conform a special set up procedure. Policy: A policy rule regulates the policy which need to be preformed, Policy rules are intend to give a consistent and systematically substance to the power of an authority.In the past the boundaries of the legislation (spatial planning act) are used to create possibilities for growth in urban development in the Netherlands. The policy of most of the municipalities was to facilitate the growth active by planning lots of plan capacity, which they prefer to buy greenfield locations, because these are the most easy to develop. Some municipalities chosen a passive attitude instead of the active, they did not bought lots of greenfield locations, they just facilitate different development companies. In the Netherlands there is a difference between hard (already a zoning plan), and soft planning capacity (No zoning plan, mostly agriculture destination). _Plan damage:_ The previous active or passive way of acting by different municipalities has fed different development companies and real-estate investors to develop the office overstock. For this the (already bought) plan capacity could be shrunken down. The disadvantages of these measures are the financial disadvantage for the land owners. If this land is owned by the municipality they lose financial resources, if not the land owners could reclaim plan damage if they own hard plan capacity. This fact makes the adjustment of plan capacity a difficult instrument to steer.

RESEARCH METHODS

In this research the next research methods are used because of their proposed outcome:

Determination of research method		
Proposed outcome	_Type of data_	_Research method_
Vacancy determination	Quantitative	Geographic information system (GIS)
System of supply and demand	Quantitative	System Dynamics
Willingness to take measures	Qualitative	Game Theory

Table 2: Involved research methods

Just the proposed outcome is not enough to determine why the different methods will be used in succession. All the methods are giving input to the subsequent method, practically the next relationships are there between the research methods in this research.
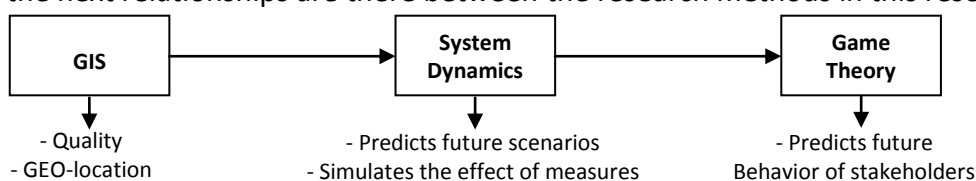

- Quality   - Predicts future scenarios   - Predicts future
- GEO-location   - Simulates the effect of measures   Behavior of stakeholders

Figure 2: Research relationships

Geographic Information Systems

GIS allows to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

The above standing quantity of a GIS-model directly defines why it is involved in this research. It helps to give easily insight in the data do determine office vacancy.

System Dynamics: System Dynamics is a research method which is useful to simulate different scenarios in complex systems; it is the simplification of a complex world (Sterman, J.D., 2000).

Game Theory: Game Theory has the aim to find the best solutions of all parties involved. This can only be achieved by an interactive analysis between two or more parties. Game Theory is a way to analyze interaction among a group or rational agents who behave strategically. Game Theory games mostly are played in a normal (simple) form or an extensive form.

DATA COLLECTION

Just collecting data and doing an analysis will not give the right insight. To achieve the aim of the research out of the research proposal the steps out of Figure are taken.

Data inventory	Data	Data assessment	Data modeling	Modeling
First (general)	boundaries	Field research/	GIS-analysis	decisions
check	Literature	trial and error	System Dynami	
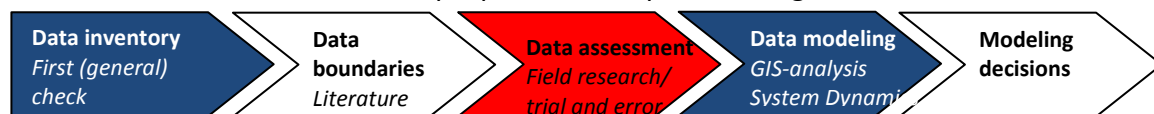
Figure3: Data modeling approach

Different parties have contributed to this research, in short their share:

- *Kadaster,* (Dutch land registry) has provided the most extensive datasheet. These serve as basis for the research (GIS-analysis). This is because they add the geographic coordinates to the remaining information (e.g. size of the office). Because the datasheet also contains the address including postal code, the other datasheets could be combined by the address.
- *Jones Lang LaSalle*, (international brokers' agency) has provided a total survey of the total office vacancy in the B5 region on postal code and address level.
- *Province Noord-Brabant,* The Province Noord-Brabant has provide a total survey of the employment development of the past 15 years.
- *Plan capacity of the municipality 's Hertogenbosch,* To determine the future plan capacity of the municipality 's Hertogenbosch the policy document 'kantoren en bedrijventerreinen beleid (2010)' is reviewed. This gives insight in the future supply of newly built offices.

At the end the combination of the datasheets of the Kadaster and Jones Lang LaSalle determined the vacancy and the deviation of the office stock. The datasheet of the Province Noord-Brabant and the Kadaster determined the past employment development in relation to built office stock. These input helped the valuation of the real-estate office model.

In the next paragraph the construction of the System Dynamics office model will briefly be explained, for this the previous described data gave input, which the data is based on the municipality of 's Hertogenbosch.

RESEARCH MODEL

The main part of this study is the built of a System Dynamics model to predict the future. Out of literature research the different relationships within the office real-estate market are filtered out. Within the research the effect of all the exogenous and endogenous variables is fully explained. In this article just the most important variables and input will briefly explained. After this the different scenarios which are simulated will be brief explained.

Real-estate office model: Figure gives a simple figurative representation of the stock and

flow model, the most important relationships and flows are shown. Which the most important exogenous and endogenous variables will be explained below.
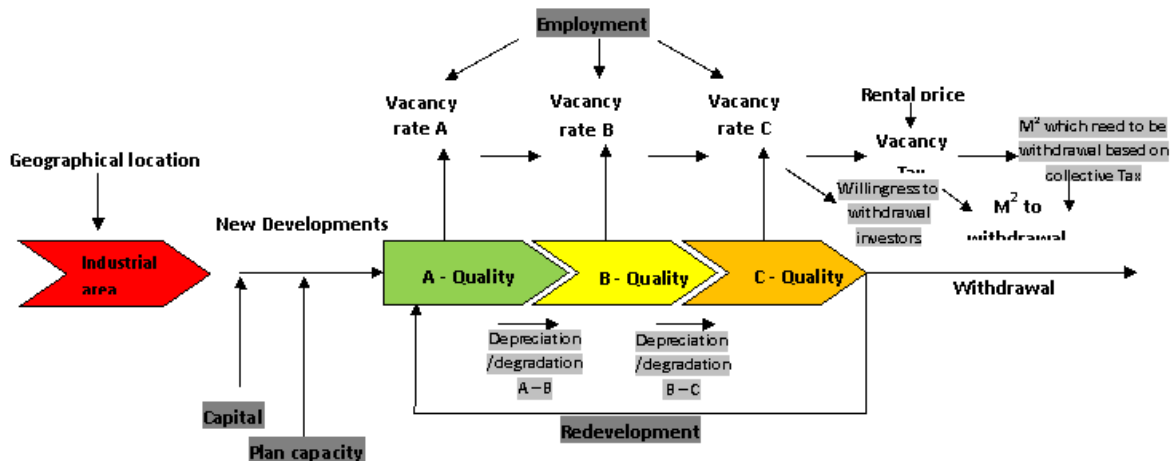
Exogenous variables:

Figure 4: Simple representation of the System Dynamics model

Employment: The employment development influences the demand for office space. An increase in employment means an increase in demand for office space and the other way around. The basic input for this variable are the WLO-scenarios (welvaart en leefomgeving), the next developments are modeled depending on the scenario, *Strong Europe* +1,01%, *Transatlantic Market* +1,01%, *Regional communities* -3,18%, *Global Economy* +5,9%.

Plan capacity: The inflow of newly built office depends of the available plan capacity. For this the hard plan capacity (the least), the soft plan capacity (the most), and no plan capacity can be modeled in the System Dynamics model.

Redevelopment: An office could be at the end of the economical and/or technical life cycle. This not direct mean a withdrawal out of the market, a renovation/ redevelopment could take place. Out of the numbers of the NEPROM (2012) the city of 's Hertogenbosch has a redevelopment of 1% each year.

Endogenous variables:

Withdrawal: To model the effect of different kind of interventions by taken office out of the market different possibilities to 'withdrawal offices' are modeled. An office withdrawal not directly mean a demolishing or the transformation to another function, it could be one of them. In this research only the effect of: 'what happen when an office is out of the market will be investigated'. In the model there are three possible withdrawal methods. Namely: 1) The government buys the structural vacant overstock; 2) A collective Tax will gain financial resources to take office out of the market; 3) A system of development credits restricts the new plan capacity to office which will be taken out of the market (exchange system).

Depreciation: The numbers of depreciation determined by the EIB are modeled in the System Dynamics model. Each time period a percentage of the office stock will shift from A-quality towards B-quality, and from B-quality towards C-quality (the office users/ tenants, will shift simultaneously). Beside this depreciation percentage there could occur a depreciation acceleration effect if there is a high percentage of vacancy at a certain location. For this some numbers are estimated, in the future this could be investigated more detailed.

The above standing adjustable variables can be modeled on a certain way. For this it is tried to simulate the most realistic scenario by the use of a power-versus-interest grid analysis, which the government and the office owners both has got advantages and disadvantages. The first 3 scenarios determining the possible present situation, the last 3 scenarios tried to give insight in different intervention possibilities. The model starting points are added by the results of the System Dynamics analysis. After the System Dynamics analysis the preference to execute one of the scenarios is measured by the different responsible policy makers with the use of Game Theory.

RESULTS

Because all the methods are used successive, the results will be presented separate. Within

the conclusion all the results will be combined.
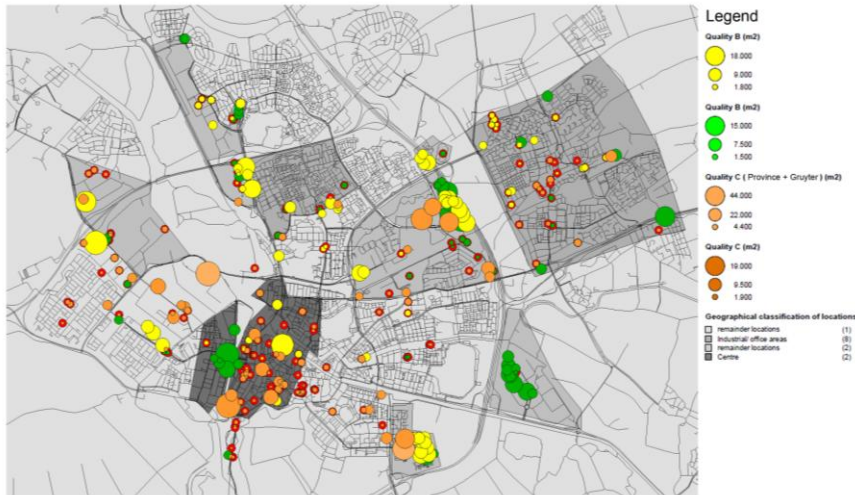
Geographic Information Systems results

Figure 5: Representation of the different quality groups in 's Hertogenbosch

Location	Vacancy A-Quality	Vacancy B-Quality	Vacancy C-Quality	Overall
City Centre	14,15%	12,35%	12,34%	12,74%
Remaining locations	7,81%	4,95%	1,21%	3,43%
Formal locations	17,11%	18,05%	7,12%	15,04%

Overall at the whole municipality of 's Hertogenbosch deals with 12,42% vacancy. In short there occur direct problems at centre locations and at formal locations. By reviewing the quantitative distribution of the stock lots of threats occur in the formal B-quality and C-quality. Both has got a big share in the total market, and will shift in the future towards a less attractive one. These problem areas can also be found at the visualization of the GIS-analysis Figure. The more the location occur yellow and orange dots, the less the qualitative good buildings. The size of the dot indicated the size of the building.

System Dynamics results: The results will be discussed by first indicate the present situation, after this the possible feature scenarios will be discussed.

The present situation

Scenario	Employment development		Willingness to invest	Plan Capacity	Tax-ation	With-drawal	Governmental influence
	Year 1-5	Year 5->					
1	5,9%	5,9%	Depends off vacancy %	Soft	As Usual	None	Present Method
2	1,01%	1,01%	Independent off vacancy %	Soft	As Usual	None	Present Method
3	-3,18%	-3,18%	Independent off vacancy %	Hard	As Usual	None	Present Method
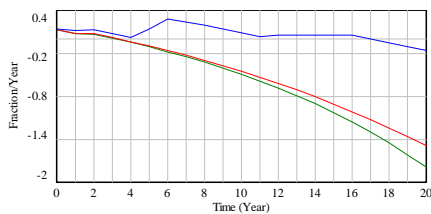
Figure 6: Vacancy development in the city, scenario 1,
(A, B, C – Quality stock)

*Scenario 1: Global Economy, years of growth (before the crisis).*This scenario should prove the model of spatial planning works well by economical growth. Out of the System Dynamics graphs there can be conclude a fast decline of vacancy, this result in a negative amount of vacancy (after approximately 4 (2015) years), Figure 6. This means the planned capacity works well if there is economical growth.
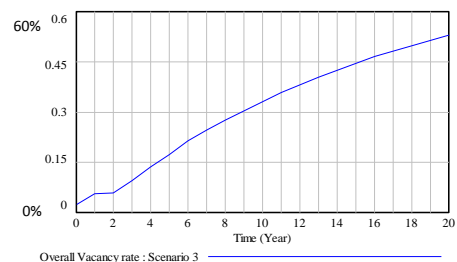

Figure 6: Overall vacancy development scenario 3

Scenario 2: Transatlantic market/ Strong Europe (present situation). This scenario expose the impact of stabilized growth and release of all plan capacity. The model assume a moderated growth (+1,01%). This should reduce the vacancy at all the locations. In general this decline will be achieved in the first 2/3 year (2013/ 2014) at the centre and remaining locations. Because the proposed big amount of soft planning capacity at the centre and the remaining locations

the vacancy will increase once again. This means too much plan capacity by a economical stabilization.

Scenario 3: Economical contraction, combined with hard planning capacity. In this scenario the effect of scraping the soft planning capacity is not visible. The ecomical shrinkage overrules the releasing of just the hard plan capacity. A huge increase in vacancy is visible Figure.

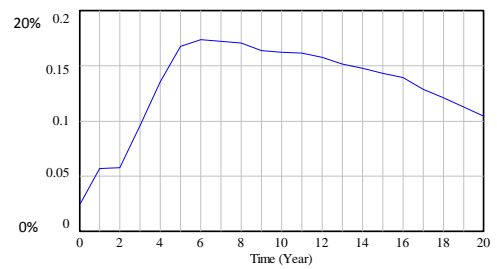## The reaction on different governmental policies

Scenario	Employment development		Willingness to invest	Plan Capacity	Tax-ation	Withdrawal	Governmental influence
	Year 1-5	Year 5->					
4	-3,18%	1,01%	Depends of vacancy %	None	Obliged	Governmental payment	Hierarchy
5	-3,18%	1,01%	Depends of vacancy %	Soft	As Usual	Collective Tax	Present
6	-3,18%	1,01%	Independent of vacancy %	Hard*	Obliged	Development credits	Present

*Plan capacity will be exchanged, 60% of an office withdrawal can be rebuilt!

Scenario 4, Governmental coordination. This scenario directly provides insight in the stop of plan capacity and a direct withdrawal by the government. First the vacancy will increase (this because the negative employment development in the first 5 years). After this the vacancy quick return back into an equilibrium. There will even occur a scarcity for offices around year 10. The disadvantages of this scenario is the capital distruction by buying office out of the market, which there is no certain future value for the offices.

Scenario 5, Model collective Tax. This scenario gives interesting insights in proposed solution concepts (vacancy Tax). Advantages of this scenario is the gradually market adoption. In the model the overall vacancy (Figure) is going towards an equilibrium and it will not fluctuate or go into a huge unbalance. Beside this the costs for this solution will be jointly supported by the office owners in total, there is made no difference if an offices is occupied or not. The disadvantage of this scenario is the negative spiral which the extra Tax could cause.

Figure 8: Overall vacancy development scenario 5

Scenario 6, Model development credits/ construction claim. The effect of this scenario has the aim to create 'scarcity', this because there first need to be taken more offices out of the market, whereupon there only can be redeveloped 60% at another (better *suitable) location.* The withdrawal stops by a vacancy percentage of 5%, Figure shows a negative vacancy percentage at year 20 (2031), this is because of the pipeline effect which often occurs in System Dynamics models. In this scenario there can be remarked a double effect, which can be created by development credits (construction claims). Namely by the coupling of the withdrawal of offices with the release of plan capacity, this scenario locks the model (office real-estate market) with two valves.

Figure 9: Overall vacancy development scenario 6

> **Consistency note:** The statistic consistency cannot be fully proven. This is because of the time period of this research. Nevertheless the approach of this research gives interesting results in the mode of operation of the office real-estate market. Because the current respondents are policy makers out of B5 region an extreme value test could be passed. Beside this a bigger sample size, should give more detailed information.

Game Theory results: In this part of the research the BrabantStad policy makers are approached by a Game Theory survey. Because the outcome out of scenarios 4/5/6 are the most relevant only these are represent in this article.

Dominant strategy government	Frequency	Percentage	Cumulative
Active	11	53,8%	52,4%
Passive	5	23,8%	76,2%
None	5	23,8%	100%
Total	21	100%	

Table 2: Governmental strategy (within the solution scenarios 4/5/6)

The government is purposed to participate active in 53,8% of the games, passive in 23,8% of the games and with no stratey in 23,8% of the matrixes (Table 2). In comparison with the governmental strategy in all the scenarios the government seems to act more towards an active role by the solution scenarios. Within the first judgment of the governmental strategy (passive/ active) in Table 2 there is remarket a more active strategy (53,8%) instead of the passive strategy (23,8%) by the government. These discrepancy can be explained by

the next phenomena: The dominant AP strategy (active participating investor and passive participating government) never occurs by the 3 scenarios with solutions. This means the government prefers to do both nothing (PP) or to have a dominant role (A,A), (P,A).

CONCLUSION
'Which governmental policies are the most beneficial to take offices out of the market or improve it sustainable?'
The office market is stuck, it is like a difficult domino game, the market depends off different chains which all influence each other, a missing link could let collapse the total market. The present problems can be the best described as a wrong system. The inflow is too high (plan capacity), the present stock has a wrong quality distribution, and there is a low outflow. This could be simple adjust by change the inflow of new quality offices and the outflow of less quality offices. Hereby there are 3 important stumbling blocks, namely, the political issue, financial depreciation, and renewal of quality. To answer the research question of this research, I conclude on the basis of the System Dynamics analysis, Game Theory analysis and expert interviews the use of the scenario of the development credits as the most beneficial. Not only because of the quick result, but also because of the most fair trading system. The construction claim will shortly be explained.
Best solution: Construction claim model to trigger both office owners and government
The basics of the construction claim is simple. If office owners will take their office out of the market they could take their present tenant along to a new office development at a better suitable location. At this location 60% of the left offices can be rebuilt, in this solution the office owner is fully responsible for the withdrawal of the left office. Here it is not important whether the old office will be demolished or transformed to another function.

By comparing the Game Theory results with the System Dynamics results together, an extra advice need to be formulated. Out of the municipalities behavior there also occurs a passive participating role by passive acting of office owners in this construction claim scenario. Out of this viewpoint there should be add an extra dimension within this scenario to make the municipalities more eager. The municipalities are probably not eager to shrink down their plan capacity and couple it to the existing stock. To solve this passive acting there should be add extra triggers within this concept. Which there could be an interesting role by the province. If the construction claim model will be restricted by the province, the municipalities could be more eager to active participation in this scenario, in order to stimulate the withdrawal of offices, hereby can the municipality release more plan capacity.

The last problem what you cannot to afford to miss is the qualitative renewal off office stock. In this respect if the equilibrium is reached after approximately 10 years there only will take place redevelopment (1% of the stock will improve in quality). The total cycle in case of the technical (quality) life cycle would be 100 years. With this fact in mind there is a major challenge for the redevelopment of offices (quality improvement). The government should construct resources to urge office owners. For this an obliged energy in combination with an obliged renovation after a certain cycle (for example 25 years), could bring the market in an equilibrium of a qualitative good stock.

DISCUSSION AND RECOMMANDATIONS
You can stop to create an end, but investigating something could be never ending. This almost philosophical sentence give researchers an open end, this to always have improvement possibilities. I think an investigation ends if the purposed aims can be satisfied.

In this research I think I created an interesting System Dynamics model which is helpful to predict the future behavior of the office real-estate market, and even more interesting the mode of operation of the model. The investigated case, 's Hertogenbosch was helpful, because it first is representative for the B5, beside this the growth of the municipality was just perfect to model it in the timeline of this research.The last part of the research, Game Theory, was interesting to review but could be investigated deeper. Nevertheless it is giving interesting insights in the behavior of policy makers concerning the office real-estate market policies. At the end there are two important things to achieve in the future. First the labeling of all the offices, this is to create a tool for the quality measurement of an office, this to stimulate the qualitative renewal of office stock. Second the System Dynamics model could be used to calculate the (financial) break-even point of let an office be vacant for several years, or demolish it directly.

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Ing. G.L.J.J. Lamers

During this research I started a bit naïve by a very wide approach. The interviews with experts helped me too constructed a good research boundary, despite they all had a small different opinion about the office real-estate market and the solutions.

Beside this I want to thank my graduation committee to bring this research to the next level. Last but not least I want to thank the Brabantste Ontwikkelings Maatschappij to give me the opportunity to use their knowledge, knowhow, and network.

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THE EFFECT OF MACRO ATTRIBUTES ON THE CHANCE OF IMPLEMENTATION OF AN ENERGY SERVICE COMPANIES (ESCo) IN THE INTRAMURAL CARE SECTOR

A system dynamics approach towards the effect of macro attributes on micro decision behavior of intramural care facility owners

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ABSTRACT

The intramural care sector is facing many difficulties. Since the introduction of the "Wet Toelating Zorginstelling" (WTZi) financial efficiency and "leaning" the care process have become daily issues. The ESCo concept compromises great benefits for this sector, resulting in decreasing distractions, improving the focus on the core business, decreasing costs and increasing comfort during this process. However, ESCo's remain unknown. This research identifies macro-economic, political and social factors influencing the development of the ESCo market, resulting in a System Dynamics model displaying the development of the ESCo market, showing the initial required steps in the field of marketing and ESCo deployment, acting as a guideline for different stakeholders aiming to improve the development of the ESCo market in the intramural care sector.

Keywords: Intramural care, System Dynamics, Decision Behavior, ESCo, energy efficiency

INTRODUCTION

Intramural Care facilities constitute an important part of today's society. The Netherlands houses 713 social healthcare concerns such as healthcare for mentally and physically disabled people, nursing and retirement homes, housing a total of 150,000 people divided over almost 1700 locations (CBS, 2010). This number is expected to increase in the next twenty years due to aging of the population. Research done by CBS in 2007 indicates an increase in demand for nursing homes of 40%.

A single care facility (e.g. retirement home) currently uses enough energy to power 151 houses. (Neve, 2009). Looking at current trends concerning energy costs, one can easily conclude that energy costs will increasingly rise in the coming years. (Ministerie van Economische Zaken, Landbouw en Innovatie, 2011). However, research done by AgentschapNL in 2011 shows great potential in implementing energy saving techniques, resulting in over 12 to 25% of possible energy savings in care and cure companies. when considering the saving potential of all care and cure facilities in the Netherlands at this

moment, saving 6.34 PJ/y is enough to power 78,000 households. (CBS, 2011)(Table 1) Due to the developments in energy prices and aging population, the energy issue in this sector will inevitably become more important.

Table 1; Energy Use in Care

Cluster	Gas (*1000m3/y)	Electricity (MWh/y)	Total (PJ/y)	Possible Improvement (%)	CO2 emission (Kton/y)	Possible Improvement (%)	Energy costs (M€/y)	Possible Improvement (%)
Nursing homes	213,000	518,300	12.3	25.9	672	24.7%	130	24.7%
Retirement homes	210,000	511,000	12.1	26.1	662	24.8%	128	24.8%
Total	423,000	1,029,300	24.4	26.0	1344	24.8%	258	24.8%

Currently, Care facilities are in a transition from being government controlled to government regulated. Traditionally, intramural care facilities were given budgets for their expenses, resulting in a low awareness towards energy saving. Nowadays, the sector is being budgeted based on their performances and quality, resulting in non-core activities being outsourced or disposed. Due to the high energy consumption level, the energy service industry is especially interesting for this market segment. (de Boer, 2011).

This research aims to identify and quantify attributes on macro level which can influence the implementation of ESCo's in the intramural care sector.

THEORY

- *Definition*

For this research, care is defined as follows; "Care has the goal to minimize the negative effects of illness through nursing, nurturing and support, done by properly qualified people. Care aims to help the chronically and prolonged ill and can do so in nursing homes, both intramural and extramural"

- *Status Quo Care Sector*

Since January 1st, 2006, the "Wet Toelating Zorginstellingen" (WTZi) was implemented by the Dutch government in order to reform the healthcare system by stimulating a regulated market. This implies that care and cure facilitators need to conform to the demands stated in the WTZi in order to receive financing through the "Algemene Wet Bijzondere Ziektekosten" (AWBZ). The goal of the WTZi is to transform care facilitators into entrepreneurial, but social aware parties, which are regulated by the government on a basis which takes care of the public interest. The WTZi aims to increase the freedom and responsibilities of the intramural sectors in healthcare, resulting in these sectors to carry the risks and responsibilities for their own facilities. (Vereniging Huisartsenpost Nederland, 2006)

Facilities that satisfied the demands stated in the WTZi, have the right to obtain financing through the "Algemene Wet Bijzondere Ziektekosten" (AWBZ) and the "Wet Maatschappelijke Ondersteuning" (WMO). This financing is organized through ZorgZwaartePaketten (ZZP) and is provided through "Zorgkantoren". These "Zorgkantoren" are part of the Health Insurance companies. Each year, Health Insurance companies buy a predetermined amount of care from an intramural care facility. This is done based on the expected amount of care consumption (Care Consumption), the number of subscriptions at the health insurance company (Health Insurance Market) and the quality of the care provided at this facility (Care purchasing market).

A part of the ZZP is the "Normatieve Huisvestings Component" (NHC), which is reserved for the hotel function of the intramural care. The height of this financing is an indexed yearly fee which is sufficient to finance during the entire lifecycle of a new WTZi approved facility, which is 30 years, based on 97% occupancy. For each ZZP which is

consumed at the care-facility, NHC is calculated. (HHM, 2009). The NHC is also used for energy costs and maintenance. However, when looking at annual reports for different care-facilities, energy costs are a small portion of the total expenditure of these facilities.

- ***Definition of an ESCo***

"Companies providing energy services to final energy users, including, but not necessarily, the supply and installation of energy-efficient equipment, building refurbishment, maintenance and operation, facility management and the supply of energy, accepting some degree of financial risk in doing so".

ESCo's can provide energy solutions by;

1. Guaranteeing the energy savings and/or provision of the same level of energy service at a lower cost by implementing an energy efficiency project.
2. Being remunerated, at least partially, based on the energy savings achieved.
3. Pre-financing or assisting in arranging financing for the implementation of the energy project by providing a savings guarantee.
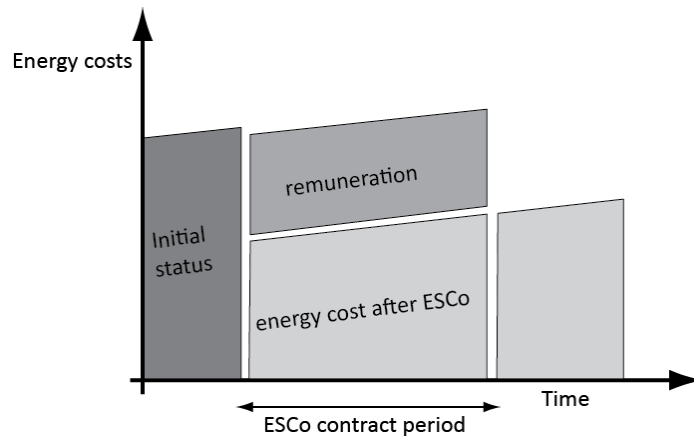
Figure 1; ESCo principle

As stated by De Boer, the term ESCo can compromise several different aspects. The basis lies within the principle in of guaranteed energy savings and remuneration through energy savings, which is shown in figure 1.

- ***Benefits of ESCo's for the intramural Care Sector***

When implementing an ESCo in a care-facility, several aspects are improved

1. Energy costs; the goal of the implementation of new energy techniques is to minimize the amount of energy used, resulting in less expenditure on energy.
2. Maintenance costs; when upgrading energy services, the proper use of new materials and machinery will result in lower maintenance costs. This works twofold. First, better quality energy equipment will result in less maintenance of this equipment. Second, through the use of proper materials, cleaning costs for these materials can decrease as well, resulting in lower maintenance costs for both hard and soft maintenance
3. Comfort; with the implementation of new energy techniques, the quality of these energy services increases, resulting in an increase of comfort. This increase will in turn result in a better proffer towards potential clients, increasing the amount of clients and thus increasing the amount of ZZP and NHC received through AWBZ.
4. Financial Profit; Care facilitators are depending on income through NHC, which is intended for the intramural care of patients. With the implementation of an ESCo, the money required for the intramural care will decrease, resulting in a profit from NHC. (e.g. if normally 90% of the NHC budget is used, and after ESCo implementation only 60% is used, 30% is saved, resulting in financial profit).
5. "Ontzorgen"; the implementation of an ESCo will result in less distraction by non-core issues like energy savings and maintenance due to the outsourcing to an external

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party. Facility services will change from a maintenance oriented organization to an operation oriented organization. resulting in an increase of focus on the core-business of intramural care facilities.

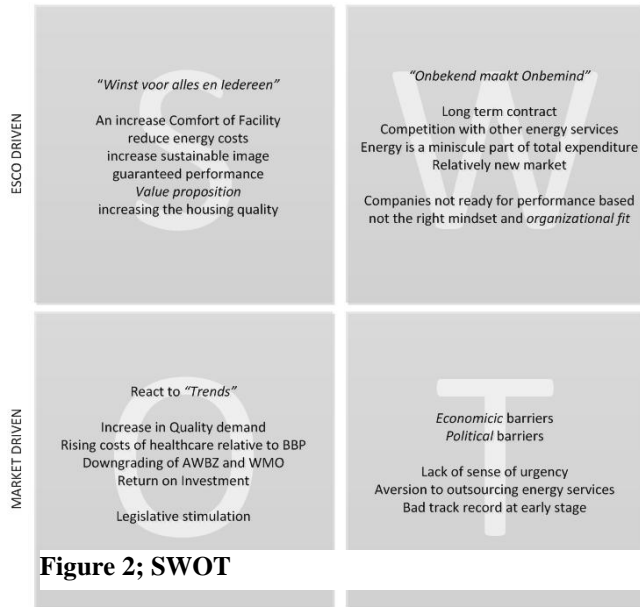## IDENTIFICATION OF MOST IMPORTANT ATTRIBUTES

Figure 2; SWOT

Through SWOT analysis, the most important attributes have been identified:

1. Familiarity
2. Organizational Fit
3. Value of the proposition
4. Quality of Care facility
5. Trends
6. Political Climate
7. Economic Climate

METHODOLOGY

Research done by Capelo in 2011 gives a description of the implementation of ESCo's in Portugal, Capelo describes a system dynamics approach towards this problem, identifying several factors on macro level which influence the national development of the ESCo market. This article is used as a guideline, aiming to adjust the SD model to fit the implementation of ESCo's in the Dutch intramural Care sector. System dynamics (SD) is a model which represents reality and aims to simplify it in a matter that can be comprehended.

MODELING PROCESS
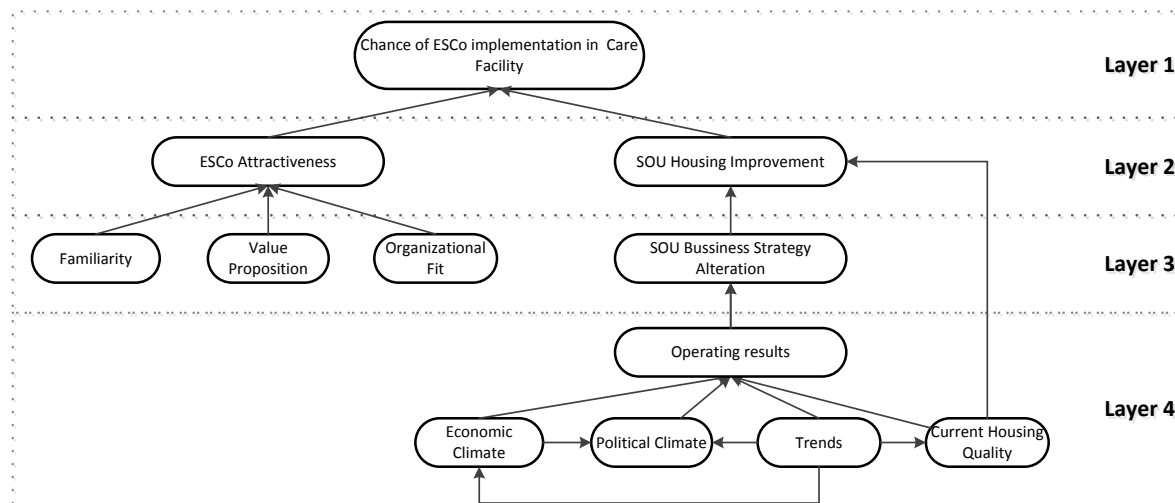
Figure 3: Layer model

In order to organize the modeling process, a breakdown of the real world system is made, resulting in the layer model in FIG X. These layers represent the goal in layer 1 and influential attributes in the layers below, increasing the complexity the real world abstraction with each consecutive layer. The implementation of an ESCo is influenced by two factors; [ESCo

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attractiveness] and [Sense of Urgency (SOU) for Housing Improvement] (SOU). The SOU building improvement is triggered by the [current housing quality] and [SOU business plan alteration], which is triggered by the [Operating Result]
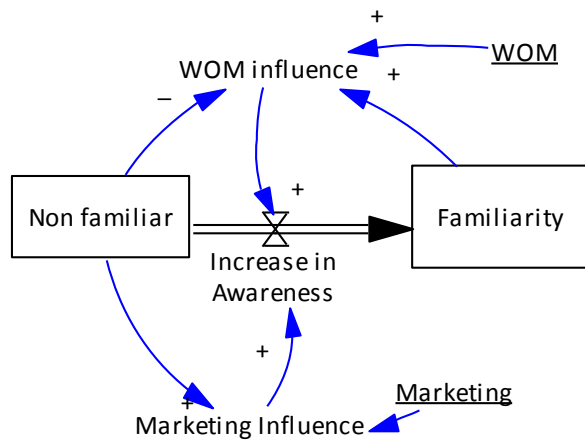

Figure 4; Familiarity

Familiarity

Familiarity is the level in which intramural care facility owners are familiar with the ESCo concept. This familiarity is driven by two factors. First, marketing by (non)governmental organizations increases the familiarity, once people become familiar with the ESCo concept and the first ESCo are being implemented, they start discussing the ESCo concept amongst each other, resulting in Word of Mouth (WOM) influence on the increase in awareness.
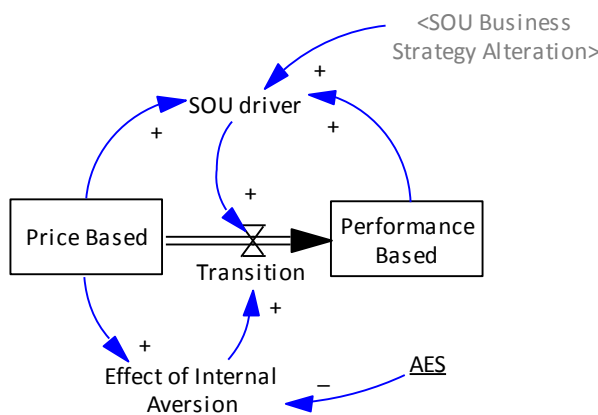
Figure 5; Organizational Fit

Organizational Fit

The organizational fit embodies the level in which intramural care facilities are suited to implement an ESCo. This Fit is a broad concept, first, the mindset of all stakeholders involved needs to be suitable, since implementing an ESCo involves a high mutual trust. Second, involved stakeholders must be ready to implement a performance based service, where they engage in a long term contract instead of a price based contract which is more traditional. Third, within the organization of the stakeholders, a sense of urgency needs to be present, allowing the company to alter their business strategy to meet the requirements for implementing an ESCo. This could mean reorganizing the company, changing different roles within the company
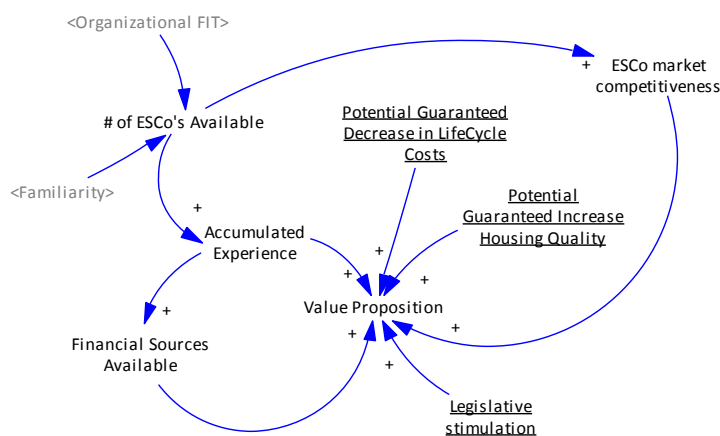

Figure 6; Value Proposition

Value Proposition

The value of the proposition is influenced by the competitiveness of the ESCo market, more competition requires a better proposition to stay competitive. The experience with the ESCo concept, along with the financial sources available also contribute to Value of the proposition. Last,

several micro factors influence the value of the proposition for that specific intramural facility. Not every facility has the same potential guaranteed decrease in lifecycle costs
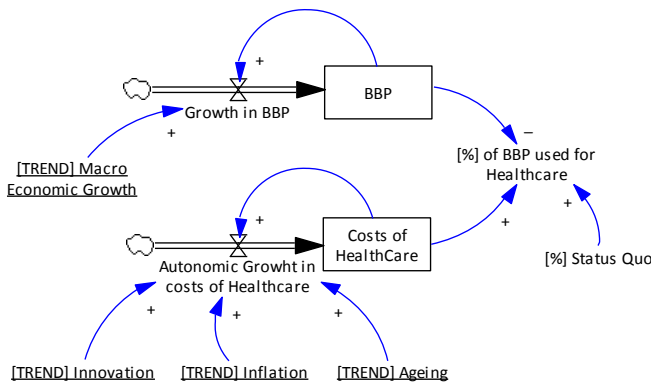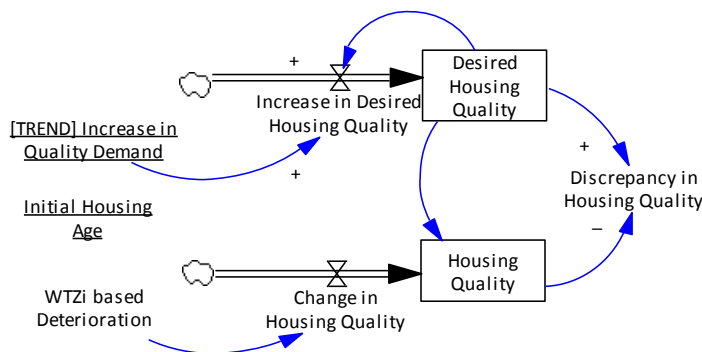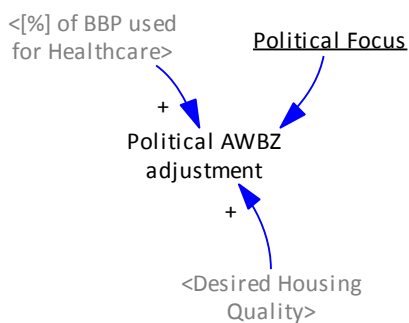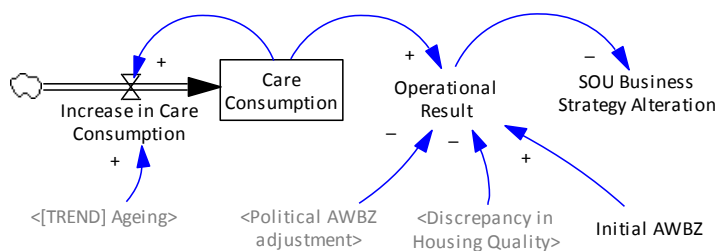

Figure 7; Economic Climate

Since [Trends] influence the economic climate, political climate and discrepancy in Housing Quality, this attribute is incorporated in the following models.

Economic Climate
The economic climate is influenced by several macro level attributes, resulting in a change in [BBP] and [Costs of Healthcare]. The government reacts to the ratio of [[%] of BBP used for healthcare].

Current Housing Quality
The current housing quality plays an important role in the business strategy of an intramural care facility. The quality needs to be sufficient for the health insurance companies and WTZi in order receive ZZP. It also needs to meet the demands set in the business plan. Calculations indicate the average lifecycle of an intramural care facility to be 30 years. The quality demand is influenced by several trends which see an increase in quality demand. This has effects on both the individual care facility and the governmental policy in the field of healthcare.

Figure 8; Housing quality

Figure 9; Political Climate

Political Climate
As stated in literature, the influence of the government is large since they determine the rules set in the WTZi and the height of the AWBZ. They do this based on the quality and affordability of intramural care. The focus on which is the most important attribute, changes with every election

Operating Result
In the end, the operating result of an individual care facility will determine if the applied business strategy is sufficient. When the operating result is low, a change in business strategy might be needed in order to increase the operating result to

Figure 10; Operating Result

meet the required standard to stay "financially healthy". A change in strategy also means a change in applied housing strategy, with this change, the chance of implementing an ESCo will increase.

RESULTS

Table 4 shows the result of the sensitivity analysis, indicating [Housing Age] and [Political Focus] as most influential attributes

Variable	MAX influence	*Ranking*
Marketing	0.1041	*6*
WOM	0.0637	*7*
AES	0.1228	*5*
Initial Situation Familiarity	0.1897	*3*
Initial Situation FIT	0.1771	*4*
Potential Guaranteed Decrease in Lifecycle Costs	0.0500	*9*
Potential Guaranteed Increase in Housing Quality	0.0500	*10*
Legislative Stimulation	0.0500	*11*
[TREND]Growth in Care Consumption	0.0190	*14*
Initial Housing Age	0.5414	*1*
[TREND] Innovation	0.0071	*16*
[TREND] Inflation	0.0267	*13*
[TREND] Ageing	0.0180	*15*
[TREND] Increase in Quality Demand	0.0599	*8*
[TREND] Macro Economic Growth	0.0286	*12*
Political focus	0.2538	*2*

Table 4; Sensitiviy analysis

For this research, several scenarios described by Idenburg (2010) (Table 2) have been implemented in order to investigate the development of ESCo in different cases (table 3), which are set by Strukton.

	Virus (V)	Chronically sick (U)	Breach (WL)
	Positive	Neutral	Negative
Political Focus	Quality [0.2]	Medium [0.5]	Affordability [0.8]
Legislative Stimulation	High [8]	Medium [5]	Low [2]
Marketing	0.05	0.03	0.01
[TREND] Macro-Economic Growth (BBP)	2,6%	1,8%	1,0%
[TREND] Inflation	2,0%	1,5%	0,5%
[TREND] Innovation	1,4%	1,2%	1%
[TREND] Ageing	1,1%	1,05%	1%
[TREND] Growth in Care Consumption	5,5%	4,2%	3,1%
[TREND] Increase in Quality Demand	1%	0,5%	0,1%

Table 2; Scenario Input

	New Innovator	Mean Majority	Old Laggards
	Facility X	Facility Y	Facility Z
Initial Housing Age	5	15	25
Potential guaranteed increase in Housing Quality	Low [2]	Medium [5]	High [8]
Potential guaranteed Decrease in Lifecycle costs	Low [2]	Medium [5]	High [8]
Initial Situation FIT	High [0.8]	Medium [0.5]	Low [0.2]
Initial Situation Familiarity	High [0.8]	Medium [0.5]	Low [0.2]
AES	Low [2]	Medium [5]	High [8]
WOM activity	High [0.5]	Medium [0.38]	Low [0.3]

Table 3; Case Input

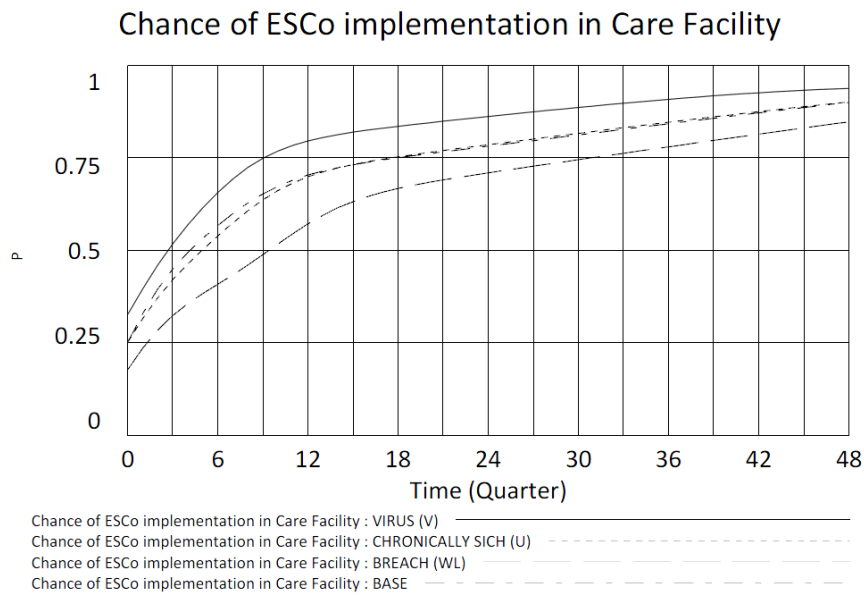The scenarios in comparison to the base scenario can be seen in figure 2.

Chance of ESCo implementation in Care Facility

Chance of ESCo implementation in Care Facility : VIRUS (V)
Chance of ESCo implementation in Care Facility : CHRONICALLY SICH (U)
Chance of ESCo implementation in Care Facility : BREACH (WL)
Chance of ESCo implementation in Care Facility : BASE

Figure 2; Scenarios compared to BASE

This graph shows the positive effect of the most positive economic scenario. The breach scenario (most negative) shows a clear negative effect. This difference is the result of slow economic developments and a low increase in costs of healthcare. Figure 3 shows the chance at different cases, the large drop in Facility Z is explained by the initial age of the facility. The higer guaranteed potential effect of an ESCo is responsible for the difference between facility X and Y.
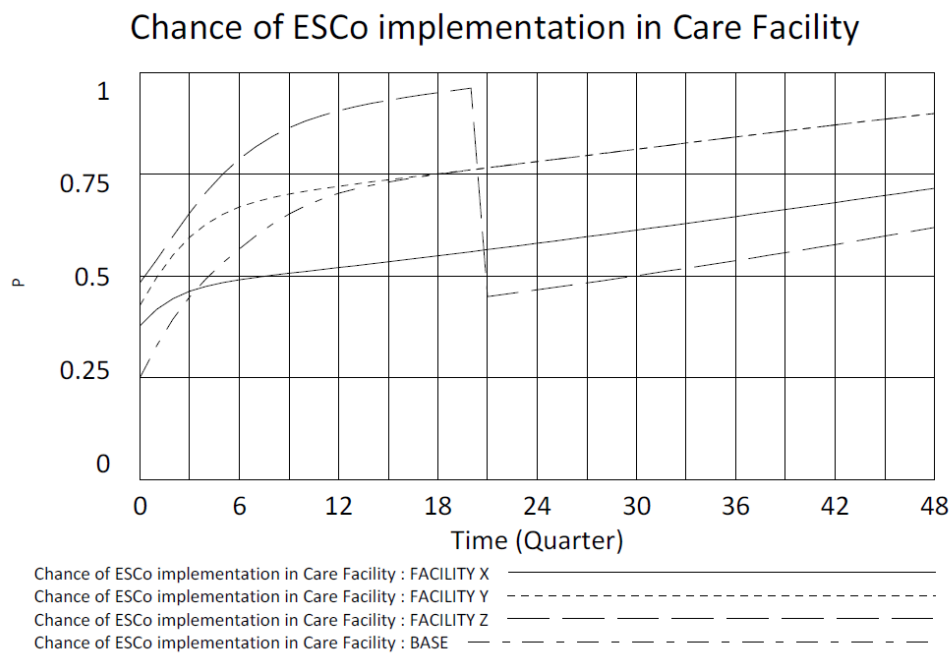

Chance of ESCo implementation in Care Facility

Chance of ESCo implementation in Care Facility : FACILITY X
Chance of ESCo implementation in Care Facility : FACILITY Y
Chance of ESCo implementation in Care Facility : FACILITY Z
Chance of ESCo implementation in Care Facility : BASE

Figure 3; Facilities influence on Implementation chance

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CONCLUSIONS

This research identifies the effect of different macro developments on the growth of the ESCo market in the Dutch intramural care sector and describes the causalities that bind them. The effect of the age of the facility is greatest, therefore, the start for this market development should be with the facilities near the end of their lifecycle. Once ESCo's are setup at these facilities, the value proposition and effect of word of mouth will increase, increasing the development of the ESCo market. At this moment, it is important to reach that group, not forgetting the positive effect of marketing at this stage of the ESCo market development.

DISCUSSION

The greatest limitation of this research lies within the SD modeling. SD requires a thorough quantification of attributes, which is difficult in a new developing market. The weights of different attributes is not quantified, resulting in a model which identifies different relations, but is not able to exactly measure the effect of different attributes on each other and the end result. It is therefore questionable if the model truly represents reality. It is advisable to perform additional research in the causalities described in this research, aiming to properly quantify the causalities, making them suitable for SD modeling.

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This thesis is the result of the 2 year program of "Construction Management and Engineering". I never expected and realized the complexity and causality which influences daily decision behavior in the field of construction management. This thesis gave me some insight in the process of developing a new market within a segment that is constantly changing. The challenges today's business development face interest me, the process of satisfying all stakeholders, formulating the optimal solution is a challenging and interesting one.

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SUSTAINABILTY OF STATIONS
An assessment of the sustainable station scan

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12-03-12

ABSTRACT

The Sustainable Stations Scan is an assessment tool which measures the sustainability of a railway station. It was developed for NS and ProRail, the two largest companies in the Dutch Railway sector. The tool gives a quick yet extensive overview of a station but currently it is too multi-interpretable and therefore the reliability can be questioned. This is because, questions are ambiguous so assessors are too much able to include their own insights. The questions in relation to 'energy', 'environment' and 'health' are usually completed uniformly. The items related to 'quality of use' and 'future value' show more variation in scoring. Improvements for the tool should be made for (a) the tool itself, (b) the process and (c) the manual. These improvements will significantly enhance the tool whilst keeping it user friendly and straightforward.

Keywords: Sustainability, Railway Station, Assessment tool

INTRODUCTION

Sustainability is becoming an important issue nowadays and also the Dutch railway sector has picked this up. NS (Nederlandse Spoorwegen/Dutch Railways) and ProRail (Dutch railway infrastructure provider) are the biggest enterprises in this sector. A couple of years ago the NS and ProRail stated requirements regarding the sustainability of railway stations. In order to have an instrument to measure this, the so called Stationscan Duurzaamheid was developed (in this report mentioned as Sustainable Station Scan). This was done based upon GPR-gebouw, a program developed by WE advisors to assess the current state of a railway station for various important topics regarding sustainability (see figure 1). The main topics, which are assessed, are so called themes or modules. The scan assesses the following themes: energy, environment, health, quality of use and future value. Other topics in a module can be found in sub-modules so for the energy module the sub-modules are energy consumption, light, heating and cooling and transportation (see figure 1).
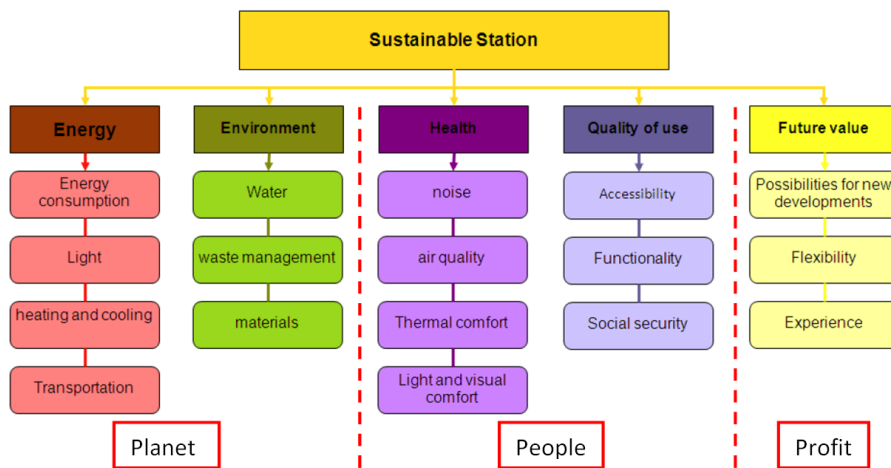
Figure 1: The (sub)module in the assessment tool and the relation with the triple bottom line

Currently there are a few uncertainties. The first one is the results, in the scan, are sometimes attained in unclear way and therefore the scan can act as a black box. Another uncertainty is the possibility of multi-interpretation for various items. Therefore it is necessary to examine the problems of the scan and its questions, which can be improved. The research question is formulated as follows: which improvement measures are required for a higher reliability of the Sustainable Station Scan, without changing its main characteristics?

SUSTAINABILITY

In our modern society efforts need to be made to increase sustainability. This is necessary because resources are depleting, population and consumption are growing which all cause more pressure on our environment and society (Cohen 2007). In the long run this could make it impossible for the earth to accommodate future generations. The triple bottom line (people, planet, profit) provides a starting point to get a better grasp of the term sustainability. Extending this principle towards assessment methods makes it possible to evaluate the sustainability of buildings. Passenger rail transportation plays an important role since it is one of the transportation forms that is effective in terms of sustainability according to Bouwman and Moll (2002). Railway stations could be considered as emblematic places for urban sustainability (Conticelli, 2011), and there is still much to gain in terms of sustainability. This is illustrated by the first promising attempts to design and construct sustainable stations (French & Watts 2012). However the scale is still limited. The Sustainable Station Scan can help to asses and improve the sustainability of current stations and therefore make a difference. The Sustainable Station Scannor the underlying GPR-Gebouw are however not very often mentioned in scientific sources.

THE SCAN

The Sustainable Station Scan, does not provide a highly detailed building assessment (as for BREEAM). It is however specifically aimed at rail stations, hence the importance of "quality of use", from planning of high level objectives through to maintenance (French & Watts, 2012). The tool is currently in the early stages of development (French & Watts, 2012).

Development

The Sustainable Station Scan manual by Olde Monnikhof & Maltha (2010), describes the development and the use of the tool. ProRail and the Dutch Railways (NS) are enterprises related with passenger rail transport in the Netherlands, who want to perform sustainable and social responsible business. Therefore they set goals with stakeholders, clients and most of all themselves. Since stations are important properties or assets for both companies. Both ProRail and NS strive to improve the sustainability of stations. To gain insight they developed a measurement instrument; the Sustainable Station Scan. The Scan is developed by ProRail, NS Poort and W/E advisors and it is based upon the assessment method GPR-gebouw (Version 3.6). This was done after a careful selection. Other methods were analyzed but the GPR method proved most suitable. Important considerations like costs and an acceptable degree of subjectivity played a role in the selection. The tool defines sustainability in a wide range by selecting five themes. Underneath the themes are three or four subjects (see fig 1).

The themes reflect the People, Planet, Profit philosophy which widely supported to implement and describe sustainability. The interests of Planet are displayed in the themes *Energy* an *Environment*, those of People with *Health* and *Quality of use* en Profit can be found *in Future value*. The scan is a tool that measures the current sustainability of a station or a proposed design (also for renovation). It indentifies strong and weak points in relation to the different themes. This opens the possibility to improve "the quality" of a station with building related measures. The Sustainable Station Scan is an assessment tool that helps to make choices in designing, constructing and maintaining stations and realizing sustainability ambitions. The Scan can be used with Microsoft Excel, or a web based version; duurzaamstation.nl. This makes it possible for the user to interact with the five themes, but also to access the general input sheet, the results sheet (with proposed improvement points) and the page that shows the scores. The scan calculates based upon the inputted data, a sustainability score of a station. There is an overall score which ranges from 0 till 5 stars (from very bad till very sustainable). Every theme obtains an individual score from 1 till 10 (very bad – outstanding). The scores are conformed to the in 2009 applying legislation and regulations set by ProRail and NS Poort. In case when a station exactly follows the standards and is build according to the current energy requirements in the building decree, the station scores approximately a 6 on all themes. There are five themes in the Sustainable Station Scan which are described shortly in table 1.

Table 3: Themes and descriptions in the Scan

Theme	Description
Energy	Selected characteristics regarding the first theme environment are energy use, sustainable energy, lighting, heating and cooling.
Environment	Selected characteristics regarding the second theme environment involve; water, waste management, maintenance and materialization.
Health	Selected characteristics regarding the theme health as, the presence of sources for air and noise pollution, provisions for limiting air draft overheating and glare play a role in the third module.
Quality of use	Selected characteristics regarding the theme quality of use are, accessibility, access, functionality and safety of the station
Future Value	Selected characteristics regarding the theme future value as, how well the station is able to adapt future changes, flexibility and the experience (monumental status, recognition etc.)

Scoring system

In every module a grade ranging from 1.0 till 10.0 can be reached. The module performance is calculated by a weight summation based upon several separate sub-module performances. In the figure 2 below this can be seen. A station can score for a module maximal 1000 points. The points are divided between sub-modules (so in fig 2: 0, 200, 600 and 200 in the third column). When something is not applicable the points are distributed among the other questions. Based upon the filled in options every sub-module obtains a score and so a grade ranging from 1.0 till 10.0. With the help of an allocation key, the score for each module (or theme) is determined. The scores of the themes result at the same time to an overall score, which is represented in stars. Here all the themes are weighted the same. The basic score for a (sub)-module is related to 6. This 6 represents the conventional score for a station or the required level according to underlying policy.
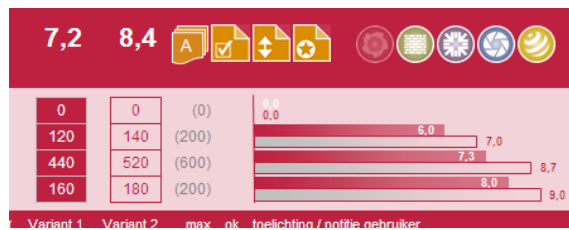

Figure 2: Calculated performances for the sub modules (Olde Monnikhof & Maltha, 2010)

The GPR-gebouw software is basically a spreadsheet and checklist in one. For every sub module, building related items can be selected. An example can be found in figure 3; when we look at point 2.1.2. "waterbeheer" in the sub-module water (2.1), here the relevant building related items relate to water management. Most measures in the scan are building related, so the items of the sub-module correspond with building components or systems.

Figure 3: Example of the sub-module water in the Scan. (Source: excel version 3.06)

The corresponding characteristics or properties of this item are selected and this results in a score for the item. When all items in the (sub)module are assessed a total score is calculated which determines the final score of the module. These final scores give an indication how the (proposed) station performs. When it is unclear how to assess a certain item the manual can be consulted. For most items five possible answering options are possible. The middle score is "neutral" and corresponds with a 6. For the other options points are added or removed from the "6". Not Applicable can also be used then the points are redistributed among other items.

RESULTS
In this part the results of the analyses found in research are summarized.

Scan Analysis
There are a number of interrelations between items. Positive relations result in double counting. Negative relations make that minimum and maximum scores (i.e. 1 and 10) cannot be obtained. Another remarkable point is that scores not always range from 1-10. There are also some bugs in the scan regarding; sub module sound and the item oversight and lighting level the bugs need to be fixed. The not applicable option is also odd; more explanation will be given later why this is strange. Currently it is possible to add bonus or minus points but this option could also be improved. The fact that some answering options are unavailable makes sense, however this results in an unbalanced spread of the points. The middle score, six for this test, means that scoring below average is punished slightly harder than scoring above average. Since the intentions of some questions are not clear then the guide helps to create a clearer definition of the questions. The information sources that can be obtained are not always the same for all assessments this results into different views and assessments.

Policy
The analysis of the policy showed that for the modules quality of use and future value most questions are relevant. The scan provides a fairly complete overview of a station. However some additions can be made. Missing items can be incorporated in an improved scan under by extending current questions or including them in the bonus and minus points this can be seen in table 2.

Table 2; Possibilities for the incorporation of missing items in the current scan
+ good option   ± possible option   - not an option

Missing Item	Relation with policy documents	Proposal		
		Extend normal item	**Add as bonus/minus**	**New item? In:**
Emergencies	2/6	-	+ 4.1.6 Accessibility	-
Music	1/6	-	+ 5.3.7 Amenity Value	-
Plinth	1/6	± 5.3.2 Identitiy	± 5.3.7 Amenity Value	-
Human scale	2/6	± 4.2.2 Dimensions	-	± 5.3 Amenity Value
Furniture/outillage	4/6	± 4.2.5 Facilities	± 5.3.7 Amenity Value	± 5.3 Amenity Value
Entrance	3/6	± 4.1.1/4.2.3/4 a+b	± 4.1.6 Accessibility	± 4.1 Accessibility
Signposting	5/6	± 4.2.3 Logic	± 4.2.7 Functionality	± 4.2 Functionality
(travel)information	6/6	± 4.2.5 Facilities	-	± 4.2 Functionality
Meeting point	2/6	± 4.2.5 Facilities	± 4.2.7 Functionality	± 4.2 Functionality
Gates	2/6	± 4.2.5 Facilities/1.3 energy use	-	± 4.1 Accessibility
Supply of stores	1/6	-	+ 4.1.6 Accessibility	-
Time indication	3/6	± 4.2.5 Facilities	± 4.2.7 Functionality	-

Process

The data sources that are being used for an assessment could be very diverse. The effect is that no fast en clear overview of a station can be developed. This results in more time to do an assessment and mistakes. Therefore improvements need to be made in this field. The involved persons have always their own views and interests. The validator for instance is never totally objective. The more an assessor is trained the better, an assessment will be. Therefore all assessors should have training to form a better understanding of the Scan. The technical advisor provides important information to the assessor, he should do this as objective as possible. The delivered data should be objective and unambiguous so the assessor is able to make the assessment individually.

Not applicable analysis

In the Sustainable Station Scan sometimes questions not are applicable. This is illustrated by figure 4, here the questions that are not applicable (n.v.t. in the scan) for Helmond are shown. These percentages related to the number of questions questions are not applicable for Helmond since the station does not have a transfer zone with elevation points and an inter-area connection. Whereas the scanned stations of Amersfoort and Alkmaar have no questions that are automatically not applicable. Since Helmond misses one main station part the percentages for smaller stations will be larger. It is disturbing that 14% of all answers are not applicable just because one station part is missing, for smaller stations this is even more.
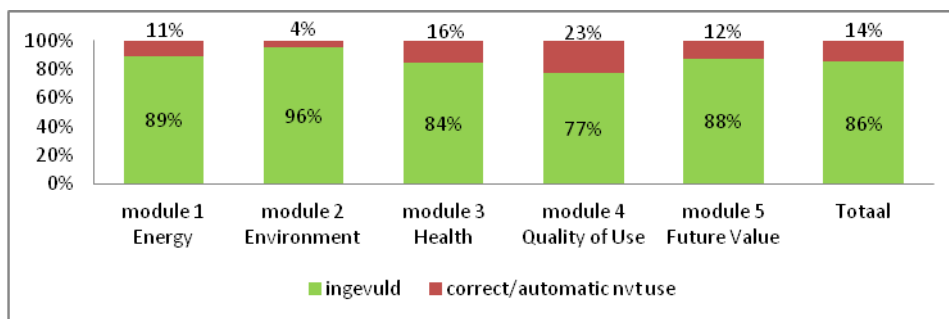

Figure 4: Percentage of questions where not applicable applies for Helmond

The points that are redistributed, because of the use of n.a., as percentage is not as big for the questions (as presented in figure 4). The points are redistributed among other (sub) items. the effect of this point redistribution is smaller (around 5% per main station part) then the not applicable questions.

Assessment analysis

When comparing all filled in options and the deviations between various assessors can be obtained, figure 5 shows the results of the assessment analysis. The trend is that the white areas (no deviation for compared stations) in the bars decrease for the later modules. The light grey areas grow bigger, and for the third module there is a peak. The light grey areas display the questions where one of assessors had a slightly deviating assessment compared with the others. A light grey assessment is still acceptable. For the dark grey bars the highest percentages can be found in modules four and five that support the claim that those are difficult or more subjective to assess. The black areas are caused by very large deviations these occur most in module five but also in two and three. N.a. also can be found in the graph (vertical white/grey); here the option not applicable is automatically filled in. Since this

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was only the case for Helmond and not for Amersfoort and Alkmaar the percentages are relative small. The diagonal whit/grey option shows the incorrect use of nvt. Here one or two assessors disagreed in the use of n.a., since points are redistributed to other items this is a severe deviation problem and it is most dominant in modules one and two.
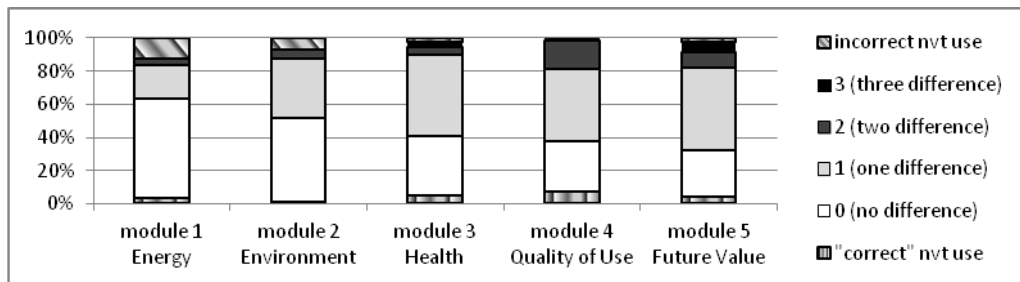

Figure 5: Percentages of deviations for the stations Helmond, Alkmaar and Amersfoort

To obtain a better oversight where the assessments could be improved for the modules figure 6 summarizes the needs for improvements. For modules one till three the assessments are in more than 80% of the assessments; good or acceptable (the white and grey areas as in figure 5). The area's where improvements could be made can be found in solving the incorrect use of n.a. this is for modules 1 and 2 a large component, for module three deviations play a slightly bigger role. For the modules four and five the problems are bigger when considering the percentage and/or the earnest of the deviations. The good or acceptable answers are for module five almost the same as module one but the deviations of three or more options occur here the most. Module 4 has clearly the most possibilities for improvements.

Observations from review
In the review process where an assessed scan is reviewed by another expert, it became clear that the scope was not always seen the same. This leads to arguments what to include or exclude. By simply displaying the scope, it will be immediately clear what is included or excluded in the assessment. The information sources that are used are also sometimes out dated or wrong. To be able perform a good assessment actual and correct data should be available.

Improvement priority
The assessment analysis was based upon an older version of the manual. This manual was used since this was the most recent one during the assessment. The updated manual is later used since, some n.a. problems are solved and some deviations will be smaller because of more clear instructions. These items were considered in the improvement analysis in chapter 6. The results are summarized in the graph below (fig 6). Compared with figure 5 the some changes become clear since the areas have changed. The orange parts have grown due to some validation issues that resulted in an increased improvement priority. From this picture it becomes clear that for all modules improvements are required. In the first three modules improvements such as clear use of n.a. and using the right sources from the IV'er will make improvements. The last modules' questions need to be objectified, since here the questions are generally more open for personal interpretation. The possibility of multi interpretation is clearly indicated by the smaller green areas compared with the first three modules.
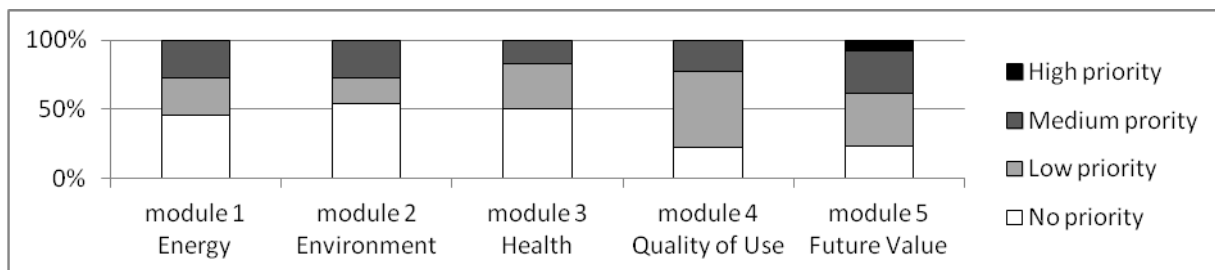
Figure 6: Percentages of items with and the improvement priority

Improvement proposal

Ten points to improve the Sustainable Station Scan, are presented in this part. These points were selected since they are implementable and easy to apply. For this proposal also input came from the current users (ProRail, NS and NPC). Validation also has taken place by NS and ProRail. The proposal is based upon ten points and they connect with three elements of the Sustainable Station Scan; the (content of) the tool itself, the process and the guide. A short summary of the improvement points is presented in table 3. During the improvement process of the tool all these issues need to be addressed. However there are a lot of relations between the tool, process and the guide, therefore an iterative process should be executed to ensure all improvements are incorporated well and enforce each other.

Table 3: improvement points per theme

a) Tool	b) Process	c) Guide
1) Include clearer scope definition	5) Train Assessors	8) Objectify subjective items
2) Solve not applicable issue	6) Standardize information	9) Explain Bonus/minus points
3) Fix found bugs	7) Minimize role validator	10) Extend guide
4) Discuss (and add) missing items		

DISCUSSION

Discussions will always exist about the measurement and weighting scales. This is because various stakeholders have other (contradicting) priorities and interests but also geographical, climate, social and legal issues play a role in tools. The Sustainable Station Scan has chosen other methods, so this makes it difficult to compare it with other assessment tools. Assessment tools will always be based upon subjective choices with as result that discussions will always remain. Being transparent and providing explanation about the choices that are made (and by whom), will give more insight in the tool (10). The use of the not applicable option in the tool is remarkable (2). When an item is not present one could use the option; not applicable in the tool. This means the related points are redistributed amongst other items in the sub-module. However this is very strange, because when an item is not available the points should be lost since it is not applicable. If something is unavailable it should receive minus points since it is not available and the points should not be redistributed.

In the tool there are some positive links between items, this could be considered as double counting since points can be obtained twice for one issue. This amplifies the effect of an item, and it will therefore attract more attention. Other problems caused by links are; the minimum and maximum scores, cannot be obtained for all questions, and odd scoring ranges. This only takes place for a few items and impacts on the scores are also limited. To make an assessment for a large station more tradeoffs need to be made and more information needs to be obtained. Finding a good trade off is easier for smaller stations.

Huge stations however, require more and are harder to assess. This is also relevant for the smaller stations where more components are missing. This amplifies scores and the results should not be compared with "normal" stations

CONCLUSION

About sustainability tools always discussions will remain. This is because they always are established from particular choices, The sustainable station scan tries to provoke this discussion. What has become clear during the research is that the current scan works reasonable. However, there is room for improvements to make the tool more reliable and less multi interpretable, for discussions. The Scan however has some problems that need to be solved; the not applicable issue (2) and several bugs (3). In the process of assessing also improvements can be made; a focus should be on, gathering more objective information before the assessment (6). The requirements, relationships and tasks for the scans users could also be defined better so responsibilities and performance issues are more explicit (5, 7). If the questions in the tool are considered; those in modules one, two and three (energy, environment and health) are already quite objective. To increase the objectivity further more motivation, data or information needs to be added and the not applicable option should be limited (2). Objectification of modules four and five (quality of use and future value) should be improved. This could be done with reference pictures, extended descriptions in the guide and motivations (8). This are however not fundamental improvements of the scan. A fundamental restatement of the questions is required to come to a far less multi-interpretable tool. The result will be that far less expertise is required for an assessment, since lesser (specific) interpretation is required.

RECCOMENDATIONS

My first recommendation is of course to improve the Sustainable Station Scan. The main points where improvements should be made are; (a) the tool itself, (b) the guide and (c) the process. When these points are incorporated in an updated version of the scan, validation needs to take place. This to investigate if the tool has become less multi-interpretable. The results of the (improved) tool should also be used by (more) sub-organizations of ProRail, the Dutch Railways (NS), municipalities and other stakeholders. The simple and user-friendly character of the tool makes it a very good instrument for communication and discussion. Currently one hundred stations have been assessed with the Scan. From the resulting database it would be interesting start indentifying correlations and relationships as well as tradeoffs and interrelations between items scores and station properties (such as; size, age, users, location, etc). Especially the interrelations and tradeoffs might lead to constructive improvement options to further sustain railway station. As this was one of the original objectives of the scan.

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SMART GRIDS ON INDUSRTIAL AREAS
Business models to enhance the implementation of renewable energy

Author: F.S. (Simon) Lubach

ABSTRACT

The use of energy from renewable sources is growing, and a transition in the energy supply is expected. Yet, this renewable energy is uncontrollable and can cause unbalances in the electricity system. To implement renewable energy, smart grids are required to match supply and demand. Although the industrial sector is already involved in management of the power system, a large potential can be found here. Flexibility in the consumption of energy can have economic value; concepts for flexible energy consumption are given and business models for smart grid applications are investigated. In a case study, an example is given of a smart grid application for a collective heat/cold network on an industrial site. An agent based simulation model optimizes the energy use, resulting in increase of the use of renewable energy and a vast reduction in costs.

Keywords: Smart grids, renewable energy, demand side management, industrial energy use, agent-based simulation.

INTRODUCTION

Currently, the most energy used in the world comes from fossil fuel sources such as oil, coal and gas. Yet, the use of these fossil fuels has negative environmental consequences, such as global warming. Scarcity of these resources is a growing problem, and increases the costs for energy, which demands are ever growing. Moreover, gaining these fossil fuels has been a major cause for conflicts in history: Instable regions hold vast shares of fuel resources and our cravings for energy results in undesirable dependencies and warfare. Taking this in mind, a transition towards renewable energy is a necessary and responsible step. Most countries have ambitious targets on clean energy. The European Union targets with its 20/20/20 goals for 20% reduction of CO_2, 20% increase in energy efficiency and 20% renewable energy in 2020. The Intergovernmental Panel on Climate Change (IPCC, 2012) states a CO_2 reduction of 80-95% compared to levels of 1990 is required for developed countries in 2050, in order to avoid disastrous climate change.

Transitioning to energy from sources as wind and solar requires improvements in the energy infrastructure: Development of smart grids is essential for the success of clean

energy. The random, intermittent, and the unbalanced nature of renewable energy require such a smart grid, which is capable of matching the supply and demand of energy.

Industrial areas consume vast amounts of energy for their production activities. In 2004, the industrial sector consumed 41,4% of electricity globally (IEA, 2006). They are confronted with the rising prices of energy; in order to be competitive in the global market, companies should take measures to reduce their energy costs. When companies are able to purchase energy at times of the day that it is cheaper, they can have great benefits and consequently contribute to the implementation of renewable energy. Therefore, smart grids in industrial areas seem to have a great potential. Summarizing, the problem in this research is: A transition from an economy based on fossil fuels is emerging towards a renewable energy economy. Yet, the random and uncontrollable nature of renewable energy and the rising energy costs for industries threatens the availability of energy! The central question in this research is: "How can smart grids contribute to the integration of renewable energy on industrial areas?"

A vast share of literature on smart grids focuses on applications in households. The general idea is that appliances such as freezers, washing machines and air conditioners can be flexible in their use of energy. In other words, the time when they use the energy can be varied to some extend, in order to control the energy demand to match the varying supply of energy. In literature, smart grids are rarely linked to industrial energy use, however the terms demand side management or load management are used more often. This research focuses on industrial users; this group has a very high demand, yet the number of consumers is much smaller. Moreover, demand management and hourly varying energy prices is already seen in the sector, which is described by Albadi et al (2008). Paulus (2011) investigates potentials of demand side management in energy intensive industries. A top-down analysis is made on industries with high electricity demand and high costs for electricity in order to find achievable and economic flexibility. Grein et al (2011) and Hovgaard (2012) investigate potentials of demand management for refrigeration systems. Significant cost reductions are shown, yet also barriers are indicated.

Although demand management is common in energy intensive industries, it is often used to reduce peak loads, rather to integrate renewable energy supply. Gaps in literature are present on smart grids on industrial areas and business models to exploit flexibility in energy usage. In this study, activities that are flexible in energy consumption are investigated and business models to develop smart grid applications are explored. In a case study on an industrial area development, the potential for a smart grid application is investigated and the economic benefit is assessed.

METHOD

A number of research methods have been used in this study. A literature study is performed on smart grids and on industrial energy use. Application of demand side management and varying prices of energy is investigated. To better understand the problems related to the integration of renewable energy, the electricity system and markets are studied as well. A case study has been preformed where an application for a smart grid is investigated. For this case, an agent based simulation (ABS) model has been developed. ABS models can simulate complex behaviour of individuals or devices, and their interaction. The developed model simulates the production and consumption of energy in a process, which is optimized in the smart grid. By using scenarios, the most beneficial case could be determined. The ABS model is developed using Netlogo.

SMART GRIDS

Wind and solar power are a major source of renewable energy. Yet, it is generally accepted that the integration of intermittent energy resources like wind energy and photovoltaic into an electricity system cannot exceed a limit of around 20% to 25% (Stadler, 2008). The reason for this is that the current electricity system is demand driven. Customers, small and large can, to some extend consume energy as much as they want whenever they want. Electricity generators follow the demand, and supply energy accordingly. Intermitting renewable sources cannot be controlled and can cause unbalances in the energy system. If the supply of energy deviates from the demand (figure 1), problems can occur and the electricity supply is threatened to a blackout, since it has to be in balance at all times.
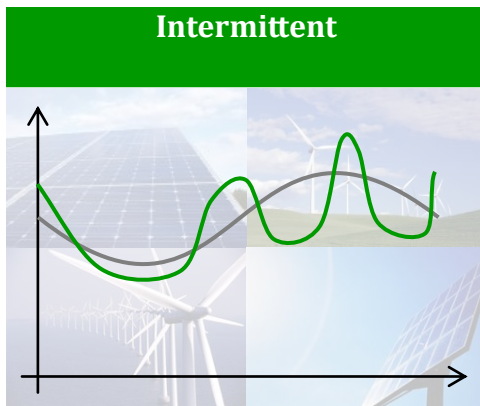

Figure 1 intermitting energy sources (green line) can cause unbalances if the supply differs from the demand

To be able to integrate a larger share of renewable energy in the electricity system, a solution should be found in controlling the demand for energy; demand is flexible and can follow the supply of energy. This is a radical different approach, and is the main objective of smart grids. Although the literature on smart grids is widespread, no uniform definition of a smart grid is made. Within the e-harbours project, a smart grid is defined as: "An electricity network that is adapted to the introduction of renewable energy sources." The European Technology Platform (smartgrids.eu, 2006) defines a smart grid as "An electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both, in order to efficiently deliver sustainable, economic and secure electricity supply."

The smart grid is a modern electricity network that covers all parts from production, transmission and consumption, which is optimised by the use of information and communication technology. The market for energy is complex; production and trade in energy is done by numerous actors, who trade on different markets. Energy distribution takes place tree levels: The transmission side operator regulates the high voltage level. Distribution side operators (DSO), deal with electricity distribution on medium- and low-voltage levels. To maintain the crucial balance in the electricity system, balance responsible parties (BRP) coordinate supply and demand in advance. A market system for unbalances is used to correct unbalances in the production. All actors can experience benefits of the flexibility of smart grids, yet this flexibility is in the hands of the energy consumers, who have to adapt their energy usage by means of smart grid technology.

FLEXIBILITY IN ENERGY DEMAND

Controlling the energy demand to maintain balance in the energy network is applied for decades. Large industrial plants can control their energy demand by switching on and off large electric loads within a few minutes, or schedule production processes on times when energy supply is cheap. Yet, the fraction of energy use that is responsive to price changes or is controllable by the network operator is really low. In most cases, load shedding is applied, which affects the primary process of the company and resources as labour or material are get lost when plants have to shut down temporarily. In a smart grid, the goal is to adapt energy consumption in a more automated way, without resulting in lost labour or resources.

This flexible energy consumption can be characterized by two determinants: the amount of flexible loads (in kilowatts or megawatts) and the flexibility over time, which can reach from minutes to hours, or in some cases even days. These determinants of flexibility can describe single devices or entire properties. Flexible loads that can be subjected to load management can be divided further into independent loads, process interlocked loads and storage space constrained loads (Ashok and Banerjee, 2001). Independent loads can be subjected to load management by taking into account constrains that are related to them, such as the time span that the loads can be switched on or off. Process interlocked loads form a part of a production process where the different loads are dependent. Such loads can only be controlled together. A storage space constrained load can have dependencies in a production line, but can be controlled individually.

A number of processes in the industry include thermal applications, which can be seen as independent loads. These processes all have a general principle, which is similar. Products or spaces have some sort of window in which the temperature should remain. If the temperature exceeds certain thresholds, heating or cooling applications are activated to restore temperature to the desired level. These processes have potential flexibility: Without exceeding the temperature thresholds, the energy use can be optimized to the availability of energy. Stretching the limits of temperature a little can increase the available flexibility. This is often possible without disturbing the process. Cold storage facilities or climate systems for buildings can be controlled 'smart'. An example is given for a cold storage facility in the e-harbours project; when abundant energy from windmills is available, the products are cooled down a few degrees more. Afterwards, the cooling system can be switched off for up to 24 hours. In this example, a costs reduction of 15% could be achieved.

Processes that have a storage space constrain are part of a production line that can be operated individually but are linked to a shared storage space for material. In figure 2 process 1 and 2 have a storage space constrain; the handled material from process 1 is placed in the storage, afterwards it will be an input for process 2. The two processes can be controlled individual and, as long as the upper and lower level for the storage space is respected. These processes can potentially be controlled in a flexible way. The load of process 1 can be intermitted as long as it does not disturb process 2. If the amount of load and the flexibility over time are significant, the process has economic flexibility, which can be used in a smart grid.
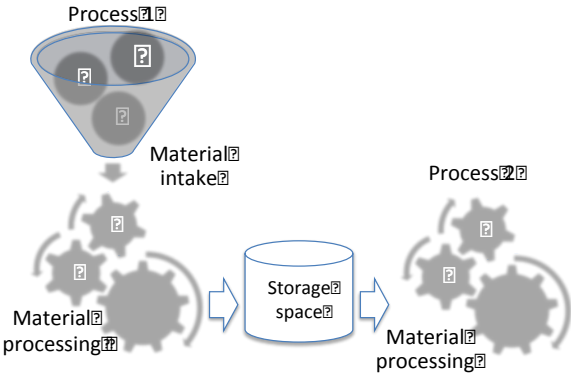

Figure 2 Two processes are linked by a storage space constrain and can be operated flexible.

When additional storage space is made available, the flexibility of the constrained processes is enlarged, since the flexibility over time increases. Adding storage space can split interlocked processes, such as the material intake and processing in figure 1 up. This is an

important measure to increase the flexibility of parts of a production process. When interlocked processes are split by a storage space, as in figure 2, it is important that process 1 has some overcapacity: It should be able to catch up the production after it has been stopped for a while and the material storage is at its lower limit. In this way, an optimization can be made between the desired flexibility and available space. Examples of storage space constrained processes, which are subjected to load management can be found in cement industry, production of paper, flour mills, etc. Application of pumps, for instance in sewer systems, sludge processing or pumping stations can have significant flexibility. Although industrial activities vary widely, flexibility can be found in many industrial processes.

To use energy in a flexible way, an optimization should be made that takes in account constrains of the process. The potential of flexible energy usage in industry is large, yet application is still low. Barriers as lack of knowledge, limited incentives or organisational barriers are often mentioned.

BUSINESS MODELS

Identified flexibility in energy use can be exploited financially in a number of ways. The general principle is that supply and demand of energy can be matched by a market mechanism. Four business models are proposed, which are based on the findings of the e-harbours report "Strategies and Business Cases for Smart Energy Networks" (2012).

Contract optimization is the most universal applicable model to exploit flexibility. Prices of energy can vary over time, for instance by using time of use tariffs, such as a cheaper energy fairs during the night. In some cases, hourly varying prices can be offered, or energy can be purchased directly on the spot market, where energy is traded for the day ahead. By using energy when it is cheaper, significant savings can be made.

Another business model is to **trade energy on the balance market**. This is a market mechanism to maintain balance on the high voltage electricity network, which is regulated by the transmission side operator (TSO). On short timeframes of 15 minutes, the system is kept at balance by adjusting the demand of consumers or the supply of producers. Consumers, or a pool of them who satisfy the requirements to act on the balancing market platforms, can earn money by offering their flexibility as balancing services, as illustrated in figure 3.
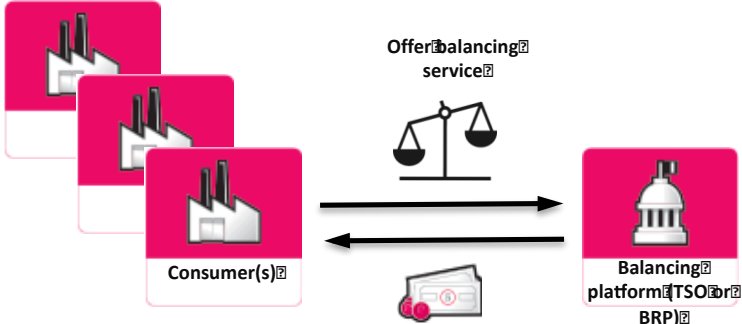
Figure 3 The flexibility in energy use of large consumers can be offered as a balancing service to the transmission side operator or the balance responsible parties.

Smart micro grids are privately developed energy networks where energy can produced and consumed without being transported over the public grid. The connected users are free to make arrangements on energy prices and, since transport costs and in some cases taxes can be avoided, a price benefit can be achieved. Local generated energy from solar panels, windmills or CHP plants can be used local or sold to the grid if it is in excess of

the demand. A company within this micro grid can use its flexibility to meet the supply of the local produced energy. If the connected users in the micro grid can consume energy in a flexible way, by means of demand management, the grid becomes 'smart'. These micro grids, as illustrated in figure 4 can be interesting breeding grounds for smart grid technologies and can have significant financial benefits for participants.
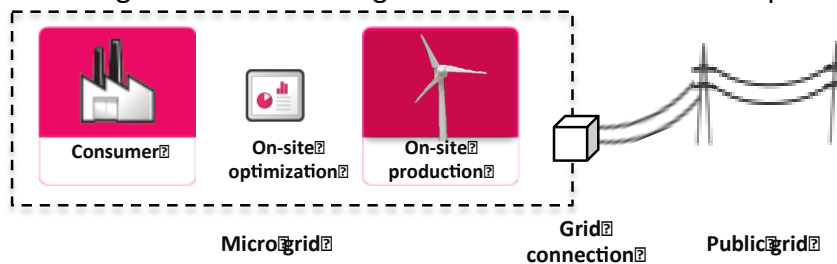

Figure 4 Production and consumption of energy is optimised within a smart micro grid.

The business model of a **Virtual power plant** (VPP) is an advanced optimization between a portfolio of small-scale produces, such as windmills and solar panels and several flexible loads. All these agents can be distributed over a large area, but the VPP is operated as if it where a single power plant. Since the energy production is more controlled, by having flexibility of consumption within the VPP, the energy can be managed better in the power grid and markets. To clarify this concept, an example is given in figure 5.
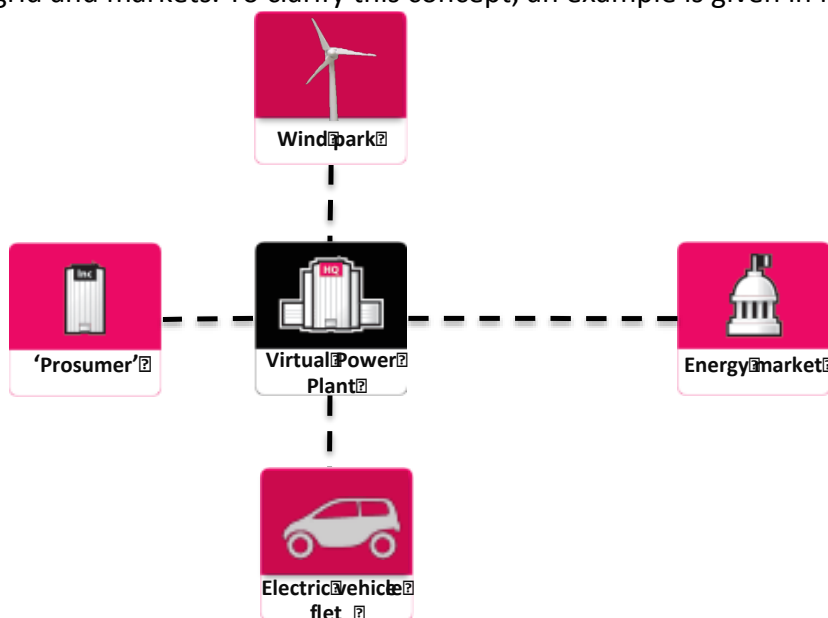
Figure 5 In a virtual power plant, the production of renewable energy is made controllable by using flexible loads

The VPP in figure 5 consists of a windmill park, a building equipped with solar panels (prosumer) and a fleet of electric cars. The production of the renewable energy is intermitting and uncontrollable, but by using the batteries of the electric cars that are connected to the grid as a buffer, the production becomes controllable. Hence unbalances in the grid can be avoided and better revenues can be made from the produced energy.

CASE HOOGTIJ

In this research a case study for a smart grid application has been preformed. The municipality of Zaanstad, who is a partner in this study, requested to investigate the added

value of a smart grid for the industrial development area HoogTij. The aim for HoogTij is to create a sustainable energy infrastructure: Development for wind turbines is taking place and a collective heat/cold network is planned. One of the alternatives is to produce heat and cold for the heat grid by a collective heat pump. Heat pumps are efficient devices, which use heat from the surrounding air or (ground) water to produce heat. These heat pumps can have flexibility in their operation, together with the projected wind turbines, the ingredients for a smart grid application are identified. To be able to operate the heat pump in a flexible way, heat storage should be available to buffer the heat temporarily. A heat buffer tank or the mass of buildings can be used to store the heat, so that the production of heat can be optimized on the availability of electric energy.

Currently, only a few companies have settled on HoogTij, however, the Rijksgebouwendienst has issued a tender for the construction of a new detention centre at HoogTij. In a study on a collective heat grid, the detention centre is observed as the client with the highest demand for heat. Since it is also an actual development at the moment, the detention centre can become a 'launching customer' to develop the heat grid.

To assess the economic benefits of the potential smart grid for HoogTij, a few business models where selected. The model for contract optimization can be used; benefits of using day/night tariffs are tested. Creating a smart micro grid seems as a promising scenario as well. The wind turbine and the heat pump can be placed in a micro grid, and thus share the same connection to the public grid (figure 6). In this way, the heat pump can directly uses the energy that is generated by the windmill. The heat pump exploits its flexibility to optimise the share of wind energy: the production of heat is matched to the availability of wind energy.

Besides the benefits of the better integration of wind energy in the electricity grid, there is a financial benefit. The rate for power supplied by the windmill is lower than the rates that are offered by energy suppliers. Since no taxes and transport costs apply on the energy that is supplied by the windmill, an interesting price difference applies. In this case, the use of a heat buffer tank and passive heat storage are tested.
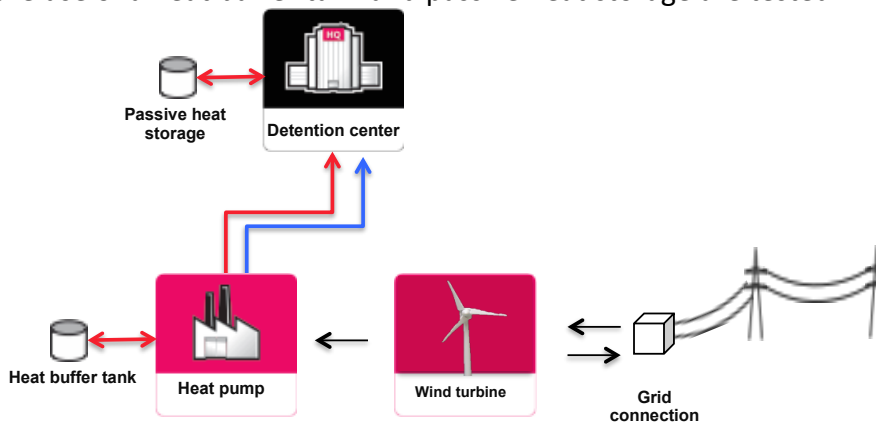
Figure 6 Proposed smart micro grid scenario. Production of heat is optimised to the availability of wind energy, by using heat storage in building mass or heat buffer tanks.

To assess the financial benefits and the improvement of integration of wind energy in this smart grid, an agent based simulation model has been developed to test the various scenarios. The agents in this model represent the wind turbine, the buildings, heat pump, and the heat buffer. To simulate the production of the wind turbine, a KNMI dataset of hourly wind speed measurements is used and converted to wind speeds that occur at the

hub-height (90 meter) of the wind turbine, and randomized to 15-minute time slots. By using a typical power curve of a wind turbine, the energy production is simulated.

Using a model for losses by transmission and ventilation simulates heat demand of the building. The heat demand is corrected by the internal heat gain by sunshine and the presence of occupants. To calculate heat demand, a dataset of outdoor temperature and solar intensity is used. A number of assumptions had to be made on the building characteristics, such as the shape and the performance of building materials.

Heat pumps transfer heat from a low temperature source to a higher temperature, which is suitable to heat buildings. As a heat source, the water from the nearby canal is used. The production of the heat pump is calculated based on the coefficient of performance (COP), which gives the relation of required electrical energy to the produced heat. To operate the heat pump flexible, an optimization is made by using heat storage capacity. This heat buffer can simulate the optimization in the various scenarios. The capacity of the heat pump and the heat buffer turned out to be the determinants of the flexibility of the system. In figure 7, a screenshot of the developed Netlogo simulation model is given.
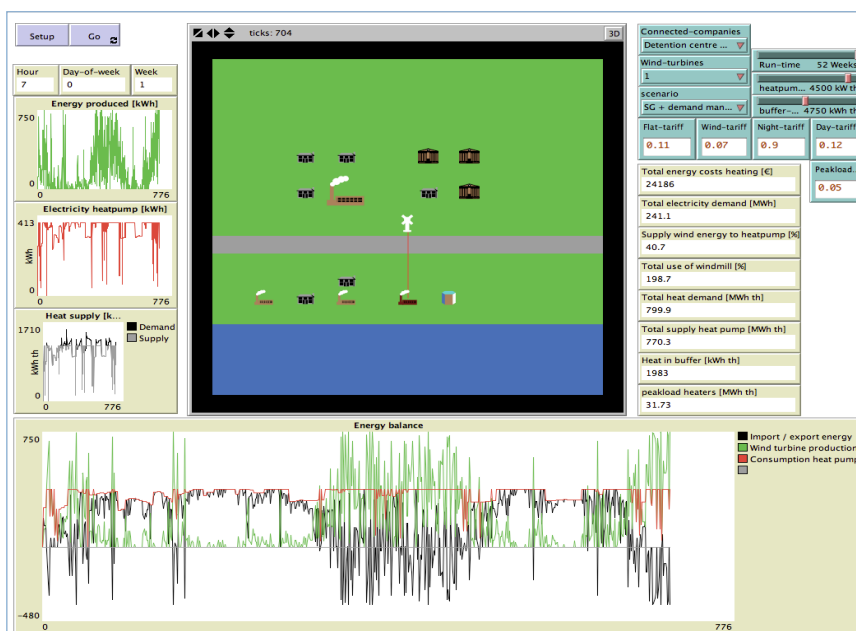
Figure 7 The model simulates the production of the wind turbine and the flexibility of the heat pump is used to match this.

RESULTS

The simulation study indicates a significant saving in energy costs for the heat network. In the scenarios for contract optimization (day/night tariffs) cost savings of 7% can be made. The scenario of the micro grid is more interesting; just connecting the wind turbine to the heat pump can result in a 18% cost saving but has no benefit for the integration of wind power. The smart grid scenario with passive heat storage and has the greatest benefit for both costs as well as the integration of wind energy. A cost saving of 23% can be achieved, and the heat pump is supplied by 82% of wind energy (figure 8). The heat pump can consume about 9% of the total supply of the wind turbine to heat the buildings of the detention centre.

Figure 8 Results of energy costs and the fraction of wind energy that is used in different scenarios of the simulation

The smart grid significantly reduces the energy costs for the heat network, and hence improves the business case for this heat grid. To find out how much the business case is improved, the exploitation is calculated as well. In the business as usual scenario, the project is acceptable, but not very attractive for investors to develop. Yet, the smart grid 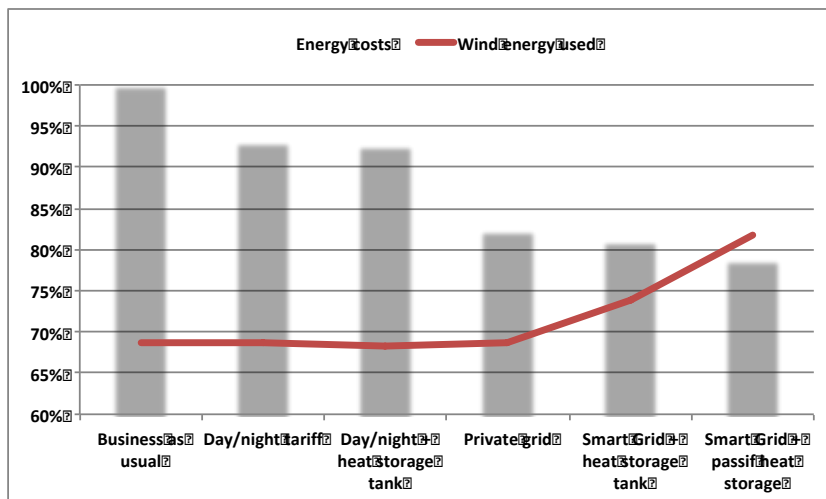alternative makes the exploitation very profitable! Some key facts of the business case of the heat/cold network are given in table 1.

1.		2. Business as usual	3. Smart Grid
4. Investment		5. € 414.000, -	6. € 472.000, -
7. Pay back time [year]		8. 11,1	9. 7,6
10. Internal Rate of Return		11. 7%	12. 14%
13. Net present value [7%, 15 years]		14. € 1450, -	15. € 139.000
16. CO_2 reduction		17. 19%	18. 73%

Table 1 Most important findings of the business case calculation of the heat/cold network.

CONCLUSION

To make a transition towards an economy that is based on renewable energy, solutions have to be found to deal with the uncontrollable and intermitting supply of renewable energy sources. Industrial processes can have flexibility in demand that can be used to match this intermitting supply. Although the industrial sector makes a range of different products and services, flexibility can be exploited based on similar concepts. Thermal applications, pumps and production lines can be used flexible by optimizing the production and using the available storage spaces in a smart way. The identified flexibility has economic value; to exploit this, four business models are proposed, which can be applied widely.

The case of the industrial development HoogTij is a good example of an application of smart grid technology. Flexibility that is present in the system of the heat network can be exploited in a smart grid. The economic benefits are so significant, that it makes the heat

network profitable. Hence, this case can really improve the sustainability of the development of HoogTij. A feasible way to accomplish this is to establish a local sustainable energy company where the different stakeholders collaborate, and the benefits can be shared.

The developed simulation model can be used in further research on thermal applications in smart grids. Extensions can be made by adding agents for different processes; an interesting study would be to operate the municipal pumping stations in a smart grid. These pumps generally operate a few hours per day, hence flexibility could be found here.

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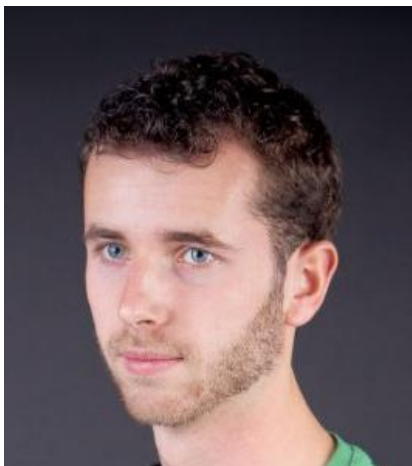
F.S. (Simon) Lubach

'Every clarification breeds new questions'

The development of smart grids is a complex problem, and a great challenge to investigate!

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EXPLOITING THE ENERGY SAVING POTENTIAL OF NON-RESIDENTIAL CORPORATE PROPERTY
By adopting a new strategy to building maintenance and repair

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ABSTRACT

Within the maintenance activities of non-residential real estate, there is a substantial potential to implement energy efficiency improving interventions that will lead to energy reduction. Besides preserving the technical performance, a focus on the optimization of energy efficiency can contribute to realizing energy saving objectives and lower overall maintenance and energy costs. Besides reflecting on identification and assessment approaches to examine energy efficiency interventions, a dynamic assessment tool was developed with which maintenance scenarios can be assessed in which improvement interventions are included. By the use of a case study into the City Hall of Nijmegen the assessment tool has been verified and assessment has shown that for this specific case cost effectively energy can be reduced.

Keywords: energy efficiency, building maintenance and repair, corporate real estate management, System Dynamics, Monte Carlo Analysis

INTRODUCTION

In the Dutch non-residential building stock there is a large energy saving potential (Daniels & Farla 2006; Schneider & Steenbergen 2010; Menkveld & Van Den Wijngaart 2007). Besides the reduction of energy consumption and consequently carbon emission being vital to mitigate climate change, the potential also implicates a large potential financial gain. Nonetheless, the potential is not exploited due to a lack of commitment to energy reduction, the financial gain for corporate organisations being relatively low (Högberg 2011; Kulakowski 1999) and the presence of practical barriers. Building maintenance is an existing activity within corporate property management that offers possibilities to improve property energy efficiency and so reduce the use of energy (Agentschap NL 2010). With the aim to contribute to solving the problem of unexploited opportunities to reduce energy consumption, the following research questions were posed:

How can the opportunities to improve energy efficiency within maintenance activities of existing non-residential property be exploited?

RQ1: How can building maintenance & repair activities improve property energy efficiency?
RQ2: How can energy efficiency improvement opportunities be identified?
RQ3: How can identified improvement opportunities be assessed?

METHODS
Data collection
Extensive literature review has been carried out to provide knowledge on and data within the areas of property management and energy management. Journals and magazines in the fields of facilities management, real estate management, environmental management, energy policy, energy economics and the built environment where reviewed. Interviews with experts in the consultancy sector have been instrumental in supporting the scientific knowledge gained from literature with empirical knowledge. Besides literature review and expert interviews, a case study was performed into the City Hall of Nijmegen. The purpose of the case study was to 1) verify the dynamic assessment tool that was developed by the use of System Dynamics and 2) to analyse what for the specific case the effects of energy efficient maintenance are. In the end, interviews were conducted with civil servants within the maintenance department of the municipalities of Nijmegen, 'S Hertogenbosch and Eindhoven to verify the assessment tool and case study results.

System Dynamics
System Dynamics (SD) is a methodology and mathematical modelling technique for framing, understanding, and discussing complex issues and problems and is used in this research to develop a tool that aids decision-making. SD is applied as the main methodology in developing a dynamics assessment tool because its ability to simulate behaviour of multiple interdependent and dependent components and its ability to handle much quantitative information, resulting in outcomes that are easy to read and interpret and so consequently can support decision making. A basic principle of System Dynamics is its ability to simulate a system over time using stocks and flows, which are influenced by variables.

Monte Carlo Sensitivity Analysis
Modelling future behaviour by the use of System Dynamics is inevitably linked to making assumptions; these assumptions can be wrong. Therefore, testing the effects of deviant behaviour regarding the results and conclusions is very important. Sensitivity analysis asks whether conclusions change in ways important to the initial purpose when assumptions are varied over the plausible range of uncertainty (Sterman 2000). In this research, this process is lead by Monte Carlo analysis (MCA). MCA is a variance-based sensitivity testing method that builds models by substituting a range of values for the parameters that are uncertain and simulating the model subject to the analysis using these different range of values.

FINDINGS
Literature study and expert interviews
Energy efficient building maintenance
Property energy efficiency can be defined as functioning in the best possible manner without waste of energy. Improvement of energy efficiency can be realised by implementing measures regarding the building service systems and building envelope with the aim to eliminate waste of energy (Hertzsch et al. 2012). For corporate bodies that own non-residential property, building maintenance and repair (BMR) is a non-core business activity in

which minimum effort is expected to realize the required functionality by conserving the technical performance of the property. Traditionally, replacement of elements occurs when components' lifetime has ended, preventative maintenance is performed to ensure components achieve their expected lifetime (Stanford 2010). Building maintenance can improve property energy efficiency within existing maintenance activities (i.e. preventative maintenance of service systems and replacement of service systems and building elements) and by adopting new type of activities (i.e. commissioning, insulation and additional placement of elements). In figure 1 a comparison between the traditional BMR strategy and the energy efficiency focused strategy is shown. The maintenance schedule, in which maintenance activities are planned in advance, offers a large opportunity to involve energy efficiency improving measures within BMR (Agentschap NL 2010). The identification of opportunities and assessment of improvement measures are required before deciding what interventions to implement.

Traditional BMR	Energy efficient BMR
Aim: Conservation of technical functionality	Aim: Conservation of technical functionality and optimization of energy efficiency
• Preventative maintenance to ensure technical and economic lifetime of service systems and building components • One-to-one replacement of systems and components when technical lifetime has ended	• Preventative maintenance to ensure technical and economic lifetime of service systems and building components, and to optimize energy efficiency • Replacement of systems and components when or before technical lifetime has ended with energy efficient solution • Placement of new systems and components including insulation if this can improve energy efficiency

Figure 1– Comparison of traditional and energy efficient building maintenance and repair

Identification approaches
The process of identifying improvement measures comprises the identification of inefficiency, components subject to improvement and technical solutions. The lack of information on the energy consumption of a property and thus the lack of information on the energy performance prevent owners from identifying a saving opportunity. Identifying improvement opportunities goes accompanied by specific technical knowledge of the building systems and elements. Although building operators have sufficient knowledge on the building characteristics, it can be questioned whether they are aware of the newest technologies and solutions concerning energy efficiency. Note that a large part of organisations rely on external contractors when it comes to maintenance of property, so specific technological knowledge is often not available in-house and organisations rely on the technical knowledge of their contractors or consultants concerning improvement of their property performance. The identification of the right opportunities of interest for assessment is crucial to maximize efficiency improvement, what means that in the identification phase having access to sufficient information about the property of subject is essential.

Opportunity assessment methods

Assessment of opportunities should provide insight in the impact of the interventions concerning both finance and benefits such as reduced carbon footprint, increased environmental quality, improved sustainability ratings, a better corporate image, and possibly increased asset value. The assessment of technical solutions that can improve energy efficiency in current practice often consists solely of financial valuation by determining the simple payback period of energy savings regarding the investment cost. This method ignores the time-value of money and energy cost savings that occur after the payback period. A more sophisticated valuation method is Life Cycle Costing (LCC) together with the discounted cash flow (DCF) method that supports calculating the Net Present Value (NPV) of an improvement measure. Considering that energy efficiency improvements are an increment to maintenance activities that are already scheduled, replacement of a component by an energy efficient solution can be assessed by calculating the Net Present Value of all incremental costs or income regarding the current building component. A positive Net Present Value indicates a higher value for the energy efficient solution what means that implementation of this solution will, over its total lifetime, lead to cost savings.

Multiple problems arise regarding the assessment of improvement measures. First of all, multiple solutions are possible to eliminate energy inefficiencies, what means that for an entire building, multiple combinations of solutions are possible. Furthermore, the measures can be assessed using multiple criteria and valuation methods, of which more sophisticated financial valuation methods require more complex calculations. Valuation of measures is also influenced by environmental factors such as price increases. Another problem within current assessment approaches is the isolation of improvement measures, while the measures are part of a range of expenditures. Especially when improvement measures are considered as a part of maintenance activities, insight in all maintenance expenditures is required to make decision on the complete overview of costs. The above problems hamper sophisticated assessment of measures and therefore, a support tool is needed that provides help in performing the assessment of a combination of interventions.

Dynamic assessment tool

Functionality

A dynamic assessment tool was developed to aid organisations in assessing energy efficient maintenance scenarios. By the use of Vensim PLE Plus, an assessment tool was created that separates specific input (from a case) from the analysis method and output, what aids structuring and managing data and information. The basic elements of the tool consist of a calculation model and a user interface. Via the user interface, input can be given and output is visualized. This core principle can be seen in figure 2.
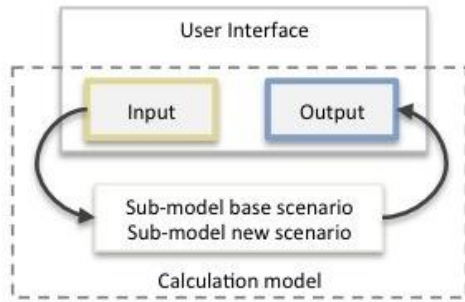
Figure 2 – Core principle of the assessment tool

The aim of the model is to assess maintenance activities regarding its financial effects and energy performance effects; therefore, assessment criteria regarding this aim were determined. The three main criteria considered the most important to aid decision-making are 1) total energy and maintenance expenditures, 2) energy savings and 3) carbon footprint. Besides these three assessment variables, multiple other parameters are used in the model either to support the calculations. SD aids in structurally describing these interrelated variables. To compare the standard or base strategy to BMR with a new strategy in which energy efficient measures are integrated, scenario thinking is applied. Scenario analysis is used in the assessment tool by 1) developing two sub-systems in by the scenarios can be run simultaneously and consequently compared. Both sub-systems need to import external data relating to the case that is been assessed. Besides the two sub-systems, 2) the ability is created to simulate the model under different circumstances by varying parameter values. Not only can the tool be adjusted to align with specific case characteristics e.g. by adjusting initial use of energy and initial energy prices, but also can the model be simulated by varying economic factors that indicate price increase in inflation, maintenance cost, electricity and gas price. The input and output variables can be found in figure 3.
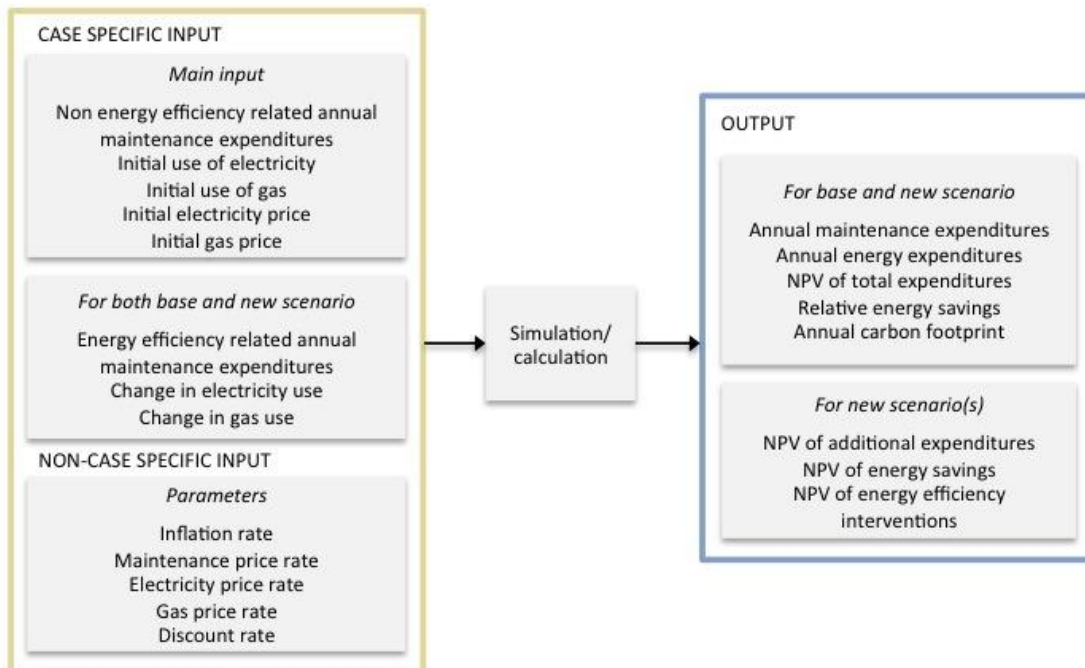

Figure 3 – Assessment tool in and output

The financial valuation method that is used in the model is the discounted cash flow method, translated into Net Present Value (NPV). The NPV discounts cash flows back to the present value what enables comparing cash flows that occur on different moments in time. The System Dynamics software Vensim offers predefined formulas to aid in using NPV calculations. The NPV of the energy and maintenance expenditures for both strategies are calculated to enable comparison of the total value of the two approaches. Additionally for the new scenario, the NPV of the additional maintenance expenditures regarding the base scenario and the NPV of the energy expenditure savings are calculated. The sum of the two latter represents the NPV solely of the energy efficiency interventions. The dynamic nature of the assessment tool accrues from the possibility to adjust multiple variables, depending on the tool user environment. Figure 4 shows the core part of the calculation model used for both sub-systems.
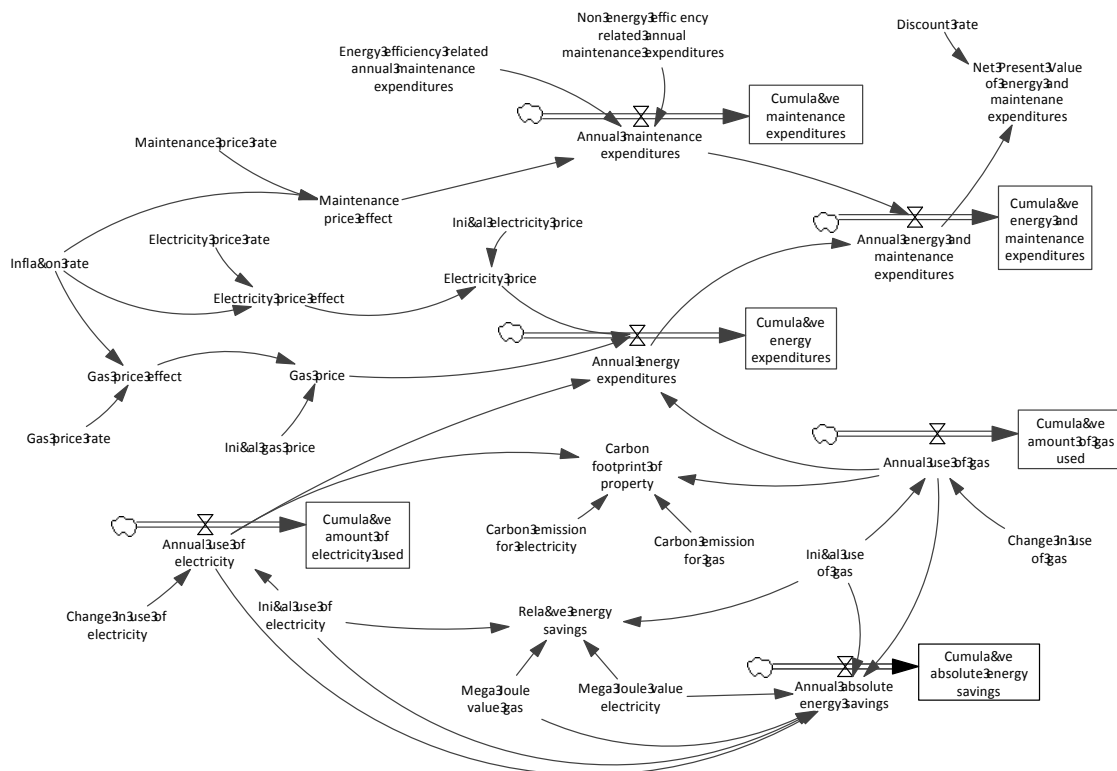
Figure 4 – System Dynamics calculation model

Case study

The assessment tool is tested using a case study into the City Hall of Nijmegen, the Netherlands, for which nine efficiency improvement interventions were determined. The interventions were identified using former EPA-U documents, by the use of information obtained from the current maintenance schedule and based on expert input. Consequently, annual cash flows and projected energy savings were listed for a base scenario and for the new scenario in which the interventions were implemented. This means that all maintenance cost during the lifecycle of a component were involved.

The listed cash flows and energy savings were linked to the assessment tool, and the required parameter values were determined. Besides entering the case specific variables including, initial use of energy and initial energy prices, the inflation rate (2%), maintenance price rate (0.5%), electricity price rate (1%), gas price rate (4%) and discount rate (5%) were

entered. Consequently, the model was simulated over a period of 20 years. This time period represents a part of the buildings lifecycle in which many maintenance activities take place, including cost and savings made associated with the interventions. The assessment tool shows that over a period of 20 years, the net present value of the energy efficient scenario is 5% higher in value than the old maintenance plan, as can be seen in figure 5 (€10.5M and €10M).
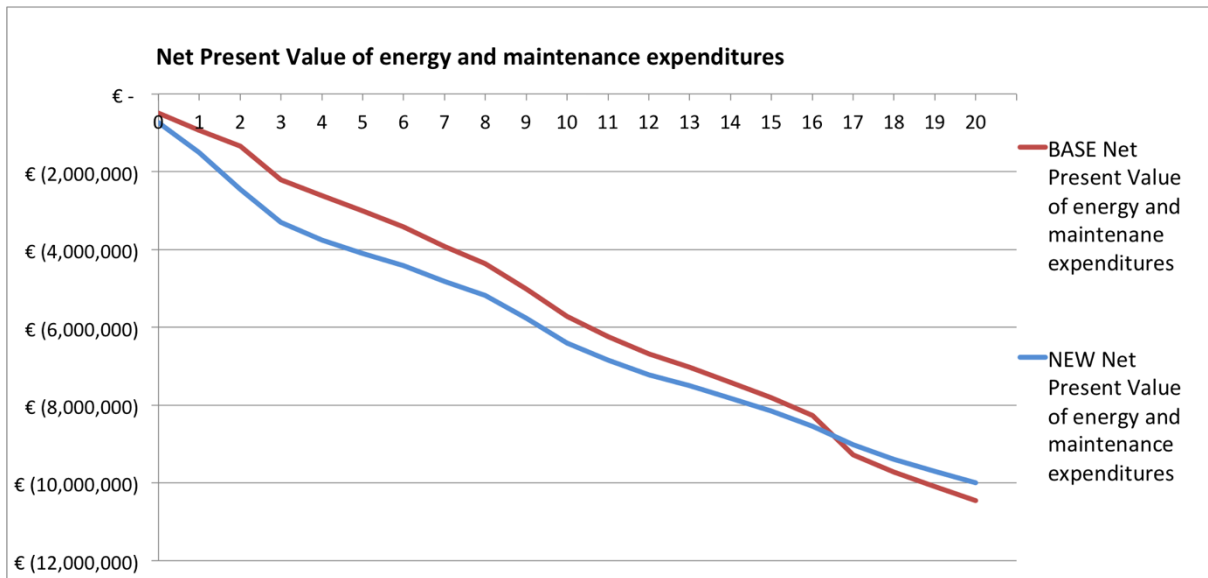
Figure 5 – Case study assessment outcome

The energy consumption and carbon emission of the new scenario, decreases compared to the base scenario consecutively 25% and 20%. If the NPV over 20 years are calculated back to the price per square meter per year, one can find that by spending €2,- (i.e. €16,- instead of €14,-) more on maintenance activities, €4,- is saved on the energy bill (i.e. €17,- instead of €21,-). This together results in €2,- savings on total energy and maintenance expenditures per square meter per year (i.e. €35,- instead of €33,-).

Monte Carly Sensitivity Analysis (MCA) was performed to test whether substantial differences in the NPV of the base scenario and the new scenario occur what might lead to other decision-making. Figure 6 shows the parameters involved in the MCA, including the uncertainty distribution, mean value and uncertainty range. Thousand iterations were run, what means that thousand random sets of parameter values within the depicted range were used to run the model.

Parameter	Distribution	Mean	Range
Inflation rate	Triangular	2	1-3%
Maintenance price rate	Triangular	0.5%	-0.5%-1.5%
Electricity price rate	Triangular	1%	2-3%
Gas price rate	Triangular	4%	3-5%
Uncertainty on change in use of electricity	Uniform		0.8-1.2
Uncertainty on change in use of gas	Uniform		0.8-1.2

Figure 6 – Monte Carlo analysis parameter values

The boxplot as shown in figure 7 including analysis shows that for none of iterations run in the MCA, the NPV of the base scenario is higher than in the new scenario. This indicates that for this specific case assessment, no other decisions would be made if the NPV is the leading

indicator. Besides this, the spread of the new scenario NPV MCA outcome is lower, what means that the uncertainty on the size of cost is lower.
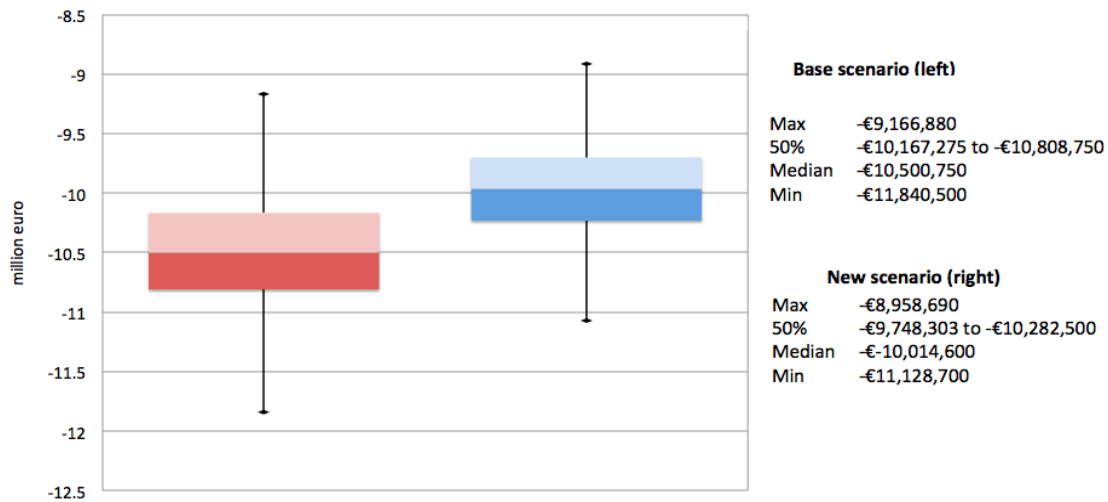

Figure 7 – Boxplot of sensitivity analysis outcome: NPV of annual energy and maintenance expenditures

Conclusion

The development of a dynamic assessment tool aims helping organisations in assessing energy efficient maintenance scenarios that include multiple energy efficiency interventions as a part of other maintenance activities. The tool provides organisations a method with which multiple maintenance scenarios can be analysed. The tool was verified by expert interviews in the municipal sector and consultancy sector, which notice that the use of NPV provides useful insights in energy efficiency improvement measures.

Main research question: How can the opportunities to improve energy efficiency within maintenance activities of existing non-residential property be exploited?

This research has resulted in determining that maintenance activities can contribute to energy efficiency by embedding energy improving interventions within the existing maintenance planning. The steps to examine specific energy efficient solutions comprise of finding energy inefficiencies, determining inefficient systems or components and consequently technical interventions. Possible assessment criteria are identified of which financial assessment criteria are discussed in more detail, leading to the advise to use Life Cycle Cost Analysis and the discounted cash flow method to evaluate improvement measures. To support the assessment phase, a dynamic assessment tool was provided that supports the assessment of multiple improvement interventions as a part of a complete maintenance schedule. These research results provide useful guidance in exploiting opportunities within maintenance activities to reduce energy consumption.

DISCUSSION

Practical implications

The findings of this study have a number of important implications for future practice. Three courses of action are suggested to all parties concerned with corporate real estate management, and specific courses of action are suggested to corporate organisations, advisory companies and national government (i.e. stakeholders of the research problem). Firstly, organisations concerned with property management are recommended to gain

insight on the actual energy consumption. Any barriers or split incentives regarding property cost and energy cost should be eliminated. Secondly, the use of the simple payback period calculation as a means to assess the profitability of single improvements is recommended to reconsider. Instead, the use of life cycle costing analysis can be used. Thirdly, organisations are, besides individual assessment of improvements, recommended to assess a combination of improvements as a part of a complete maintenance scenario while taking future uncertainties into account. This method of assessment is a more holistic approach and aids decision-making by providing a complete overview of the possible range of costs. Tools, such as the assessment tool developed in this research, can help organisations in performing this more complex assessment.

Following implications arising from the research results that are applicable to property management within organisations. The case study has shown that within maintenance activities cost effectively energy reductions can be realized. This implicates that organisations should consider whether for their own property, likewise results are possible. Many organisations have the strategic aim to reduce energy, although these aims are not yet translated into effective practical solutions. Embedding energy interventions within existing processes such as property maintenance, poses to be a sustainable solution to fulfill saving objectives. For consultancy companies there is an important role when it comes to aspects concerning sustainability such as energy reduction; many organisations heavily rely on consulting expertise. This research pledges advisory companies to adopt a proactive role in providing insight to clients on benefits and drawbacks of improving energy efficiency and finding tailor-made solutions. Lastly, one implication is given that concerns government. Because many practical barriers are faced in the improvement process, organisations are not compliant to end-result based legislation. Rather, government should focus on compelling conditions that ease or are an essential part of the improvement process.

Limitations and further research
The following limitations were identified that influence the result and generalizability of the research. First of all, the assessment tool is supported by System Dynamics and made using Vensim software; no other methods have been tested. This indicates that other methods possibly provide a more accurate or easier to use assessment tool. Besides this, the assessment tool is verified by the performance of a single case study. Although the case study proves the functionality of the assessment tool for this specific case, multiple case studies should be performed to identify if the tool is actually robust. A suggestion for further research is to perform more case studies within various sectors to test the tool. The case study was not aimed at gaining generalizable data regarding maintenance cost or energy savings. However, the tool can possibly be used to gather this type of data. Future research can focus, besides the verification of the tool, on performing case studies with a large sample size (i.e. >10). In this way, for example for one specific market sector can be determined whether energy can be reduced cost-effectively by embedding energy efficiency interventions within maintenance activities. Secondly, expert interviews were performed as a means to gather data in the exploration phase and to verify the assessment tool and case study data. The technique of interview is not free from bias, especially if the interviewer is one single researcher. Ideally, the research is supported by the use of a statistical data collection method. Future research can therefore for example use survey research to verify the assessment tool to eliminate the drawbacks of interview research.

The following other topics have been suggested for further research based on the findings of this research. This research pointed out that energy reduction of non-residential property possibly goes accompanied by multiple benefits of which not all are included in the assessment tool. Further research is suggested to examine how other impacts can be translated into measurable variables. This can lead to an extension of the assessment tool. The current research was not designed to evaluate for which real estate sector the new approach to building maintenance is the most suitable or will lead to the highest benefits. A suggestion for further research is to investigate building operators views on the energy efficient maintenance approach by the means of survey research within specific sectors.

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From a societal perspective, energy reduction is vital in mitigating climate change. In the corporate real estate market, energy saving and profitable business can go hand in hand. However, fundamental and also many practical barriers need to be overcome to make business out of the energy saving potential. A weighted balance between academic and empirical research can lead to solutions that will bring seizing opportunities closer to reality.

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TENANT PARTICIPATION IN SUSTAINABLE RENOVATION PROJECTS
The influence of project content on the tenant participation of sustainable renovation project within housing associations, using AHP and case study.

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ABSTRACT

This paper is about tenant participation in sustainable renovation projects performed by Dutch housing associations. By law is stated that in most cases, 70% of the tenants have to participate before the renovation plans can be executed. For housing associations this participation level can be a problem with the consequence that sustainable renovation projects are postponed or stopped. This research investigated the content of the project plans and their influence on the tenant participation. This is done by literature study, a survey distributed around project managers and case study.

The most important conclusions were that a project plan has to be understandable, beneficial and within the ability of the tenant. The most important factor herein the level of rent increase, even though the aim of the sustainable renovation project is to lower the energy costs and thus lower the integral housing costs for the tenant. This research ends with a checklist with tips for project managers to give substance to the sustainable renovation plans.

Keywords: tenant participation, integrated housing costs, sustainable renovation, willingness to participate, housing association, social rent

INTRODUCTION

As a response to worldwide environmental issues, a new subject has become increasingly important for the built environment: energy. Within the European Union the energy use by the built environment is over 40% of the total energy consumption and 30% of the total CO_2 emission (EnergyCounsil, 2002). In 2008, the Dutch government responded to the energy topic and the EPBD by making it obligatory for Dutch dwelling owners to have an energy label for their dwelling. An energy label shows the energy performance of the dwelling and can only be determined by an authorized certified advisor. The label of a dwelling can vary from A: 44 points and thus highly energy efficient to G: 0 points and thus not energy efficient. The points are based on several characteristics of the dwelling that influence the

energy efficiency. For example the size, window surface, materials and installations. An energy label is made obligatory to stimulate energy reducing measures and as being house owners who also include the Dutch housing associations. For these housing associations, an additional covenant was created the Ministry of Spatial Planning and Environment in collaboration with the housing association sector. This covenant includes agreements on goals on energy saving improvements (Ministry of Internal Affairs, 2012). Within this covenant is mentioned that an average energy label B for the stock of a housing associations is the target in 2020. These ambitions are high and ask for solutions for the whole building stock of housing associations.

To increase the energy performance of their dwellings, housing associations perform sustainable renovation projects. In this research sustainable renovation is defined as:
"A renovation to transform an existing building to fulfil the requirements on the field of the energetic performance and the health and comfort of its users while achieving economic viability"

With sustainable renovation, housing associations are able to increase the energy performance of their dwellings. When a housing association wants to perform a renovation, it is stated by law that 70% of the tenants which have to deal with the renovation on which the project has an effect on the service costs and/or the rent have to give their permission (Hoppe et.al, 2008). According to a research performed by Atriensis (2012) the implementation of sustainable policies faces problems, with the result that the covenant goals are not reached. Even when the association has implemented an energy policy, they are not always convinced about meeting the goals. Several barriers were investigated and one of the main problems is that non-commitment of tenants and the intensive process to convince the tenants leads to delay or a stop of the sustainable renovation project. This research focuses on factors that influence this participation with the aim to improve the project plans of sustainable renovation projects in such a way that tenants are more willing to participate.

RESEARCH DESIGN
Assuming that the responsibility of convincing the tenants to participate in the sustainable renovation project lies with the housing association, this study had the aim to make statements about improving the project plan of these sustainable renovation projects. This is because this plan is the mean the housing association has to approach the project and on which the tenants react by participating or not participating. This leads to the following main question:
How can a sustainable renovation project be composed in order to encourage the tenants to participate?

To answer this question the research is designed as follows: the content of a sustainable renovation project will derived from literature study. Also the influential factors on tenant participation are based on literature study. This will lead to a preliminary statement on the influence of the project part on the tenant participation. Thereafter, the effect of the project plan parts on the tenant participation according to the project leaders will be researched using applications of the Analytic Hierarchy Process.

The analytic hierarchy process (AHP), developed by Saaty (Saaty, 1980) is a popular decision support tools because of its powerfulness, simplicity, and potential of being utilized for a group decision-making process that involves multiple actors, scenarios, and decision elements (criteria, sub criteria and alternatives). The AHP requires a well-structured problem represented as a hierarchy with the goal at the top. The subsequent levels contains of criteria and sub criteria, while alternatives lie at the bottom of the hierarchy. The AHP determines the relative importance of set of (sub) criteria by employing pair-wise comparisons of the hierarchy elements at all levels following the rule that a given hierarchy level, elements are compared with respect to the element in the higher level by using a fundamental importance scale (Saaty, 1980). The AHP method is applied in construction projects in several ways, for example to find the best value-bid for a tender, to assess risks and uncertainties of construction projects or to determine the best project contracting approach. In this research, the hierarchy is structured with respect to the overarching goal: tenant participation.

After this an attempt will be made to forecast the effect of a project plan on the tenant participation by applying case studies as alternatives within the AHP. These results will be compared with the real participation of the tenants in these cases. The conclusions and statements derived from the research components lead eventually to recommendations on the content of sustainable renovation project plans with the aim to increase the tenant participation.

SUSTAINABLE RENOVATION PROJECT PLANS
A project plan for sustainable renovations mainly consists of the technical improvements, financial calculations, tenant approach, and execution decisions. For each part, the housing association can make different decisions. The technical decisions consist of individual or communal energy saving improvements, possible supplemented by other maintenance or renovation work like kitchen renovation or a paint job. The financial decisions hold the pass of the investment costs to the rent for the current tenants and after mutation. This can be calculated as a percentage of the expected savings on the energy bill or as a percentage of the investment costs. It is also possible not to pass the costs to the rent for the current tenants. This can encourage the participation, but does not solve the problem of the split-incentive for the period until the current tenant moves. The split-incentive problem occurs when the investing party (the housing association) does not benefit from the financial revenue of the improvement (the tenants benefit from the savings on energy costs). Rent increase after mutation is often calculated on the basis of the increase of property value points. As an extra incentive, housing associations can provide an inconvenience fee as a compensation for the nuisance of the renovation.

In the project should be mentioned how the tenants are approached with the project plan. It is desirable that the communication is adapted to the type of tenants, for example when they are elderly or from foreign origin. The level of participation of the tenants within the renovation process can differ. It is possible that the tenants are only informed about the plans, that they are consulted, or that they have a say in the plans. Often, an interest group is composed at the beginning of the renovation process. The decisions concerning the execution are globally described in a project plan, but often to a great extent left to the

contracting party. The planning of the project and nuisance limitation are important aspects of the execution.

TENANT PARTICIPATION

The tenant participation in sustainable renovation projects depends on several factors. These factors belong to the tenant him or herself, the tenants' needs or the project content. This research states that the participation of a tenant is to a great extent dependent on the connection between the project content and the needs of the tenant. From literature the most important needs are described: understanding, benefit and nuisance limitation. When a tenant understands the project, how much benefit they want to have from the project or how much nuisance the tenant finds acceptable is dependent on the characteristics of the tenant and the level of resistance a tenant has. Also the project content has influence on the tenant participation. Thereof, the financial factors are considered to be the most important, especially the level of energy costs saving and the level of rent increase. The level of tenants say is also considered to be very important, in contrast to the other to aspects of the tenant approach: the frequency and type of communication. The most important aspects of the dwelling renovation (the lay-out improvement, improvement of the facility spaces and the improvement of the energy performance) are considered to be average important. The nuisance (duration, decrease of living convenience and preparatory activities) is considered to be less important. The most important criteria were thereafter schemed in a hierarchy model, shown in Figure 4.
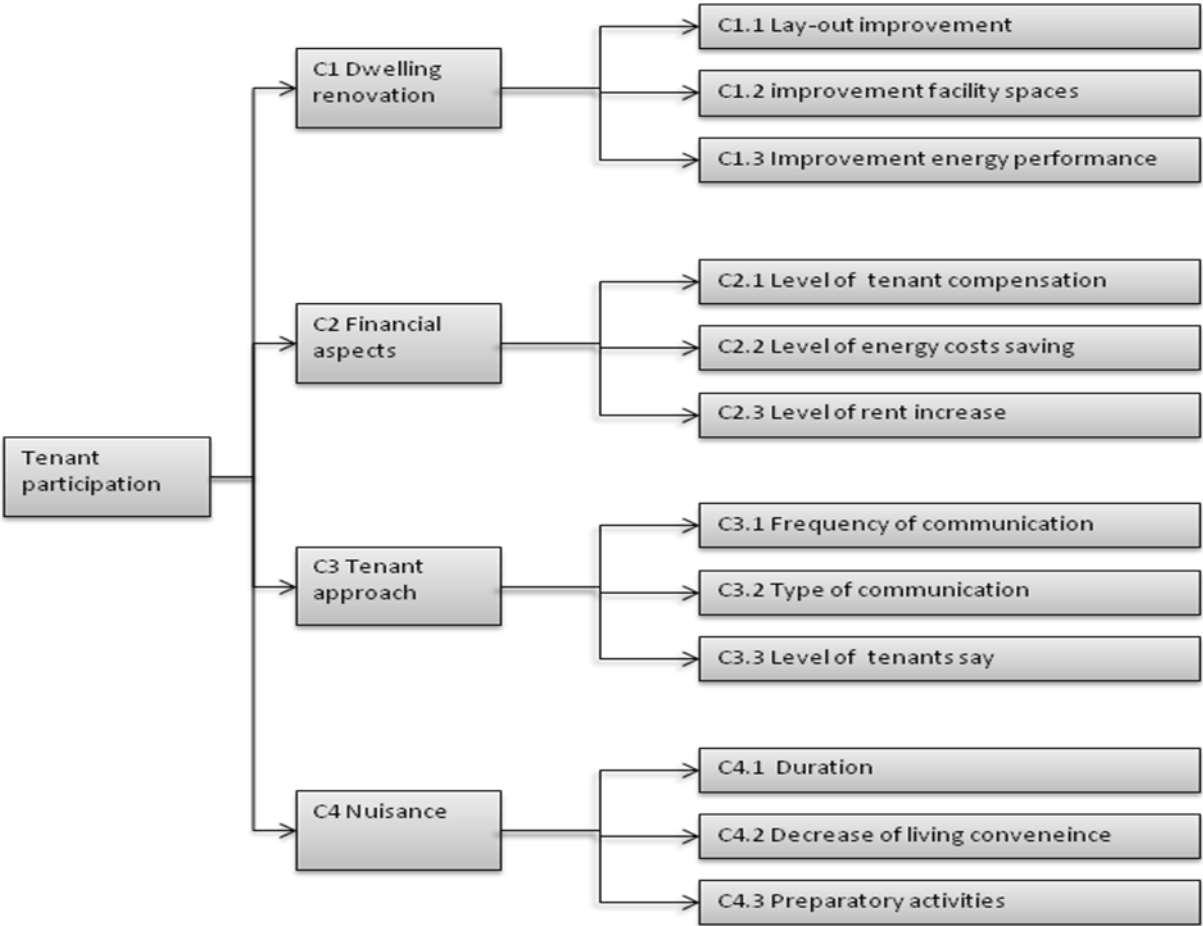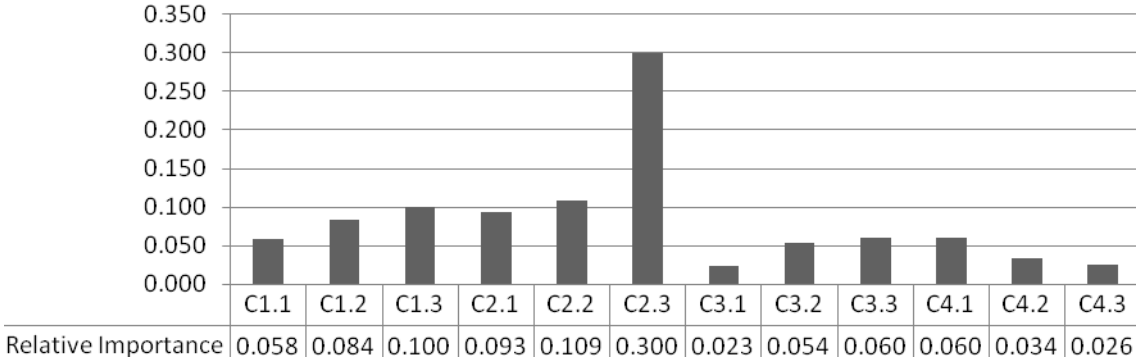

Figure 4 The hierarchy model of the influential criteria

To get the view of project managers on the influence of the project content on the tenant participation a survey was distributed among 125 project managers with experience in sustainable renovation projects. Within a period of two weeks, 36 project managers responded and their data was used for further analysis. A respondent consistency ratio of 15% was maintained which led to an exclusion of 14 of these 36 respondents. The design of the survey and the processing of the data are done on the basis of the AHP method.

According to the project managers, the financial factors are the most important aspects that influence the tenant participation. Thereof, the level of rent increase is the most important criteria. Next, the aspects of the dwelling renovation are considered to be important, with the improvement of the energy performance as most influential sub criteria. The tenant approach and the nuisance are considered to be less important. The most important sub criteria of those two criteria were the level of tenants say, the type of communication and the duration. The total result is shown in Graph 1.

Relative Importance

	C1.1	C1.2	C1.3	C2.1	C2.2	C2.3	C3.1	C3.2	C3.3	C4.1	C4.2	C4.3
Relative Importance	0.058	0.084	0.100	0.093	0.109	0.300	0.023	0.054	0.060	0.060	0.034	0.026

Graph 1 Relative importance of the criteria

Striking was that there was a large diversity between the answers of the respondents. Therefore was tried to divide the respondents group into different groups and analyze the differences in outcome. The respondents group was divided on the basis of experience, housing association size and restructuring activities of the housing associations. The relative importance differed in all different divisions.

This difference in the three divisions led to two possible conclusions. The first is that there is a difference in the approach of 'older' and 'younger' project managers and the younger project managers focus more on the tenant approach. 'Older' and 'younger' is determined on the basis of experience years. The second is that project managers are influences by the characteristics of the housing association they work for. When a certain criterion is important for a housing association, the project managers think that this is also an issue for the tenant, because this is an important focus within the process of the establishment of the sustainable renovation project. This can be a low budget and little possibilities to limit nuisance for small housing associations. The research shows that housing associations with less than 10.000 housing units or with relatively less money for restructuring activities think the financial aspects are more important to the tenant than larger or actively restructuring housing association. Also restructuring housing associations think that tenant attach more importance to the dwelling improvements than housing associations with less restructuring

activities. This is probably due to the fact that restructuring housing associations try more innovative and less conventional improvements causing the type of improvements to be more important.

CASE APPLICATION

In the research five cases were analyzed to investigate the possibility to calculate the score of the project plan content of the cases and link this score to the real tenant participation. Although the cases were quite diverse, the scores of the cases were very close to each other with normalized values between the 0.18 and 0.21. These scores found to be not correlated to the real tenant participation of the project cases. However, there were conclusions which could be drawn from the case studies.

The case with the lowest calculated score had a real tenant participation of 100%, and the case with the lowest participation (23%) turned out not having the lowest score. In both cases the real tenant participation could be explained by external influences. In the case with 100% participation the tenants were in favor of the sustainable renovation in advance. In the case with 23% participation a group of refusing tenants influenced the other tenants not to participate. This leads to the conclusion that a certain feeling within the group of tenants, for example resistance or a need for an improved dwelling has a major influence. The tenant participation rate in such case can be unrelated to the score of the project plan.

Another conclusion which can be drawn from the cases is that although the rent increase is states as being the most important criterion, people are willing to pay for a sustainable renovation. This is shown in all the cases and they had a varying rent increase from €7.60 up till € 92.50. Apparently, the benefits of the renovation project outweighed the possible negative aspects like nuisance. In the case with 100% participation the rent increase was even higher than the forecasted saving on energy costs. This was because of the improvements of the kitchen and balcony which matched the needs of the tenants.

STRIKING RESULTS

During the research, there were a few striking results. The interpretation of these results were discussed with experts a possible explanations for them were given.

First, the level of tenants say was substantiated from literature as a criterion with a high level of influence. But with a relative importance of 0.060 the high importance is not confirmed by the project managers. This difference can be explained in a few ways. The first explanation could be that the criterion is underestimated by the project managers or overestimated by the literature. Although in 4 of the 5 cases tenants had influence in the decision-making process, this influence was minimal. When a focus group had a vote in the contracting, this vote was too small to really make a difference. Also the possibility to choose the color of the paint for the window frames is not something which significant matters to the housing association. By an expert from Atriensis was confirmed that the voice tenants have in a sustainable renovation project is most of the time to give the tenant the feeling of influencing, but that this has a minimal effect on the content of the project plan. This could explain the difference in data: when the tenant has a vote in the decision-making process, the feeling of having a say is bigger than the real level of influence they have.

Second, although the influence of the level of rent increase was considered to be high according to both the literature as the project managers, the degree of importance is disproportionately. It is striking that this aspect is of such a big importance because in every case the renovation has the goal to decrease the integrated housing costs for the tenant. A possible explanation for this is that in every project, the level of rent increase contributes to the decision and the other criteria do not play a role in every project. This does not mean that in one project, the level of rent increase is substantial more important, but that when all the experiences of the project managers are summed the level of rent increase plays overall the biggest role. Although the degree of importance is probably out of proportion, it is still the most important criterion. However, this does not mean that the higher the rent increase, the more difficult it is to convince the tenants to participate, but that the level of rent increase should fit the needs and ability of the tenants. At the end of a renovation the integrated housing costs are calculated to be lower than before the renovation, due to decreasing energy costs. So, why is the level of rent increase so much more important than level of energy costs saving?

The explanation is that the level of rent increase is fixed, and the calculated saving on energy costs is an estimation. Therefore it is a risk for the tenant to participate because the saving can be lower that estimated. It should be taken into account that for the tenants' feeling, the higher the level of rent increase, the higher the risk feeling. Moreover, most of the time the rent increase is applied soon after the renovation, while the advanced payment of the energy bill is decreased after a new calculation of the energy use, most of the time after a half year. For tenants of social housing with a low income, the rent increase can cause financial difficulties when the tenants do not benefit from the sustainable renovation immediately.

RECOMMENDATIONS

The research on the influential factors on tenant participation within the project content of sustainable renovations from literature and from project managers, in combination with case study, has lead to recommendations. These recommendations have the aim to improve the project plans to persuade tenants to participate in a more effective way.
Understand, want, be able

The first recommendation is based on the conclusion that a project plan should focus on the tenants' needs. This means that tenants have to *understand, want,* and *be able to deal with* the sustainable renovation, in order to participate. This is shown in Figure 5 and is called the decision road. These three factors are goals which should be achieved by the project plan.

Figure 5 tenants' decision road

Every aspect of the project plan should follow the path of the arrows. Hereby, especially the financial factors should be taken into account. For a tenant, the total picture of the plan should fit also. The benefits should be in balance with the nuisance. Tenants are willing to pay for rent increase when on the other hand the benefits like a decrease of energy costs and increase of living comfort are present. When the housing association had plans for a building complex of which the tenants do not think they are immediately necessary, it is important to try to convince the tenant that it is important. In Table 1, tips are given to run through the decision road more successfully.

Table 1 Tips to run through the decision road

Understand	-	Keep a clear structure of the information leaflets and letters
	-	Do not use pretentious language
	-	Create a low threshold for questions or comments from the tenant about the project
Want	-	Argue from the problem of the tenant and show them the need for the improvement
	-	Give the tenants the feeling they have a say
	-	Be honest about the financial consequences and keep the financial risk for the tenant low
	-	Invest in a good relationship between the tenant and the housing association
	-	Show the improvements in a model dwelling
Be able to	-	Match the financial risk with the financial circumstances of the tenant
	-	Adapt the help to the tenants' characteristics and limit the nuisance
	-	Work in one dwelling as short as possible
	-	Guarantee the safety of the tenant and their property

Checklist

Although the project plans keep personalized reports, a procedure aiming at the implementation of the needs of the tenant helps improving the project plan. This is helpful because the project plan definitely has influence on the decision of the tenant to participate or not.

When a housing association wants to perform a sustainable renovation project and they need the participation of tenants, they have to keep in mind that it is their responsibility to convince the tenants. By presenting a checklist based on the findings of this research, project managers are helped to improve their project plan with the aim to get enough tenant participation in an efficient way.

Table 2 Project plan checklist

PROJECT PLAN CHECKLIST FOR THE PROJECT MANAGER	
Before intern	• What do you know about the tenants and their needs?
	• Make an inventory within the organization, what is the history of and experience with the building complex and their tenants?
	• Are limitations due to the tenant type, age, financial situation, young children, etcetera
	• To what extent do you want to involve the tenants? Is there already a residents committee?
Before extern	• Make an inventory via a survey to the tenant about the needs and complaints of the tenants
	• Is there a collective opinion among the tenants?
	• To what extent do the tenants want to be involved?
During the design	• Does the project plan match with the needs of the tenant?
	• What are the main subjects to communicate?
	- What are you going to do in the building complex, how long does this take?
	- What is the reason to do this renovation?
	- Why should tenants participate?
	- What is the result if they participate in terms of finance, living comfort and nuisance
	• Does the description fit on one paper?
	• Look again at the financial part
	- Is it clear that the tenant benefits from the renovation?
	- Is it understandable?
	- Is the rent increase adapted to the energy use of the household? Should it be?
	• Include a telephone number for questions
During the execution	• Use a focus group for (at least) consultation
	• Check if the tenants understand what is going on and what is expected of them
	• Be accessible for questions and comments
	• Be service oriented and help tenants when necessary
	• Ask afterwards if the tenants are satisfied

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This summary is the result of my graduation thesis about tenant participation within sustainable renovation projects performed by housing associations. This research was done as completion of the master track Construction Management and Engineering at the Technical University in Eindhoven and in collaboration with Atriensis, a specialized consultancy firm. The research led to recommendations for housing associations to give substance to their project plans with the aim to efficiently convince tenants to participate in the renovation plans.

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SUSTAINABLE STADIUM DEVELOPMENT

Increasing the benefits of stadiums for a municipality through sustainable (re)development - A case study of Stadion Feijenoord

Author(s): R.G.A. Schrama (Robert)

ABSTRACT

Due to emotions and the apparent benefits of stadiums, almost all Dutch municipalities hosting a professional football club are owner of the stadium. This brings along too high financial risks in relation to the gained benefits. With sustainable (re)development these stadiums can become more beneficial. A questionnaire among 31 City Councillors of the cities Amsterdam, Rotterdam, Eindhoven and Enschede showed that the low financial risks and attracting companies are the most important criteria for a municipality to invest in stadium projects. Specific sustainability aspects are considered as less important, but the sustainability of the whole project, including long-term planning could increase the benefits for municipalities. A case study of Stadion Feijenoord was analysed for this research.
Keywords: stadiums, municipalities, sustainable development, financial risk, AHP

INTRODUCTION

A majority of the Dutch municipalities with a professional football club (BVO) in their city is owner of the stadium. The apparent benefits for society and the high emotions related to football are the main reasons for the decision of municipalities to get financially involved in stadium projects. The main problem of municipalities being shareholder of a stadium is the related financial risks, which might in hindsight be too high in regard to its benefits. To increase the benefits for a municipality, their objectives should be met. These are mainly the social and economic impact of the stadium project on the city and its surrounding area. Next to this, sustainability is an increasingly important objective of most municipalities and is also an upcoming tendency in stadium development projects. Sustainable adjustments do not only improve the environmental aspects, but also affects the long-term planning and future legacy of the stadium, which are again related to the financial risks. Therefore, sustainability can play and important role in increasing the benefits of stadiums for municipalities.

The problem in this research can be state as follows:
The financial risks for a municipality due to investments in stadium projects turn out to be higher than expected, resulting in an undesirable financial situation for the municipality.

The main question for this graduation research is:
How can sustainable redevelopment increase the benefits of stadiums for municipalities?

The scope of this research considers municipalities in the Netherlands who are shareholder or important stakeholder of a stadium used by a professional football club. Development approaches for a stadium include all kinds of changes to the stadium itself or the use of the stadium, including demolishing or construction of a new one. 'Sustainable' includes both environmental behaviour as well as a long-term vision for a continuous operation and exploitation of the stadium. 'Beneficial' is used in terms of positive impact on the objectives of a municipality, including profitability and indirect impact on the economy and society. The sub-questions of this research are:

1. What determines the benefits of a stadium for a municipality?
2. What are the characteristics of sustainable stadium redevelopment?
3. Which aspects of stadium redevelopment are the most important for municipalities?
4. How to determine which stadium development alternative is the most beneficial for a municipality?

Municipal objectives regarding stadiums

In this first chapter the objectives of a municipality regarding stadium projects are determined, in order to find out how municipalities can benefit from a stadium in their city of which they are shareholder or investor. This is done by looking at the general objectives of a municipality and how the benefits of a certain project are determined. Subsequently, the investment criteria of public investments in real estate and especially in stadiums is researched including the possible ways of investments.

General objectives of a municipality

The overall objective of local governments is social welfare, which is broken down in political, economic, social, cultural and environmental objectives. The benefits of public real estate for a municipality depends on the overall objectives of municipalities and which of these objectives are tried to achieve with public real estate asset. However, municipalities do not have certain objectives that are specifically attempted to achieve with their real estate asset. This means that also sustainability, as a part of the environmental objectives of a municipality, could be a criteria that is attempt to be achieved with public real estate.

Most part of the public real estate asset (69%) is social real estate and is publicly owned to get more influence on the exploitation of that object and the development of the surrounding area. Most municipalities do not have a supporting real estate department and the municipal administration hardly shows any attention for real estate unless in case of excess situations.

Making profit by real estate transactions or exploitation is not the main objective in MREM, but can be a positive side-effect. The other way around, potential high losses are avoided if possible by selling the real estate object in question. The benefits of the public owned real estate are more about the positive social and economic impact it has on the area than the profit or revenue it gains for a municipality. As a result, it is hard to measure if the right targets are achieved due to the exploitation of public real estate. The Decision Making Process for these intangible objectives is mainly based on debates and political viewpoints.

With the newly introduced SMART-principle only specific and measurable (qualitative and quantitative) targets and results are considered, which makes it possible to measure and

judge the performances of projects or policymakers in the field of MREM. However, if projects change over time or excess situations occur, the SMART-principle might become inadequate, because measurable targets could not be achieved anymore and it can be decided to cancel the project, while the intangible benefits might still be higher than the total investments for the municipality.

Objectives of a municipality regarding stadium projects
Regarding the limited liquid assets of most European BVOs, the high investment costs of a stadium, and the lack of interest of private parties to do such high and risky investments, it can be concluded that financial involvement of a municipality is inevitable for realizing a stadium. It is therefore necessary for a municipality to invest in the stadium development project in order to keep the direct and indirect benefits from their local BVO and stadium in their city.

Since a good financial situation of the concerning BVO is very important for constraining the financial risk of a public investment in a stadium, it is also beneficial for a municipality to focus on requirements for a stadium that are both beneficial for the BVO as for themselves. This is like killing two birds with one stone, since the municipality also benefits from a well performing and financially healthy BVO.

The main objectives of a municipality in every situation are the economic and social impact, and next to that the profitability of a project, since a good financial situation is required to achieve these social and economic goals. Sustainability is a relatively new topic for national and local governments. Since sustainable development is not always profitable for (private) parties, governments also consider this as a main objective for themselves.

From the Ecorys report about Roda JC Kerkrade (*2012*) and the verification with stadium experts, the most important sub-criteria for the four main criteria regarding stadium development for municipalities are determined. After combining somehow similar sub-criteria, in order to constrain the size of the resulting questionnaire, by chance the same number of sub-criteria for each main criteria were the result, namely four. These sixteen sub-criteria, which are important when considering the benefits of a sustainable stadium development project for a municipality. The selected sub-criteria of sustainability are explained in the next chapter, about environmental assessment methods.

Direct financial flows	Economic value	Social impact	Sustainability
Total direct investment	Creating jobs	Enjoyment	Energy costs
Rental revenue	Attracting companies	Local pride	CO_2 emission
Taxes	Branding and increasing value of surrounding area	Promoting sports among youth	Use of natural resources
Financial risks	Expenses supporters	City branding	Long-term planning

Figure 1 | Criteria to determine the benefits of professional football and the stadium for municipalities (Ecorys, 2012; Hellinga, 2013; Van den Broek, 2013; Veenbrink, 2013)

SUSTAINABLE STADIUM DEVELOPMENT
In this chapter the different alternatives of sustainable stadium redevelopment are determined by considering what makes real estate asset sustainable, and analysing case studies about the different alternatives and aspects of sustainable (re)developed stadiums.
The sustainability of real estate objects can be determined with different environmental assessment methodologies are recognized. GPR, LEED and BREEAM are the three mostly recognized certification methods. BREEAM is the best method for sustainable stadium

development in the Netherlands, since it is internationally recognized and it considers the Dutch laws and regulations.

Analysing the most sustainable stadiums in Europe and some well performed sustainable developed stadiums in the rest of the World, four main alternatives of sustainable stadium development are distinguished, all with their own characteristics. Next to these four alternatives it is also an option for a municipality for demolish or sell the stadium, or choosing the passive approach and leaving the stadium as it is. Demolishing and selling the stadium comes down to the same outcome for municipalities, since there are usually no private parties that want to purchase a non-profitable stadium. This results in a status quo for the municipality which only can be avoided by demolishing the stadium. Therefore, the following six alternatives for sustainable stadium (re)development are selected.

1) Changing the management of the stadium
A very cheap option for making a stadium more beneficial is changing the management of the stadium. The attitude of the users and possible regulations can make that the stadium is used much more effective. This could be sustainable changes but also a better way of sharing the stadium, possible with other sports clubs or other kind of users.

2) Make technical adjustments to the stadium
When the existing facilities meet the requirements of the users of the stadium, a total renovation is not always necessary to change the use of the stadium. Technical adjustments can make the stadium more energy efficient and more sustainable. There are multiple examples of stadiums in the Netherlands and Germany where an energy company or an electrical company pays for the technical adjustments to achieve these requirements.

3) Renovate and expand the stadium
The renovation of a stadium is a less expensive alternative if an existing stadium does not longer meet the modern requirements. It can include expansion or just a modernisation.

4) Building a new stadium
If it is practical impossible to achieve the changed requirement of the user of owner with redevelopment of the stadium, the construction of a new stadium can make the difference. There are no preconditions of the old stadium and the sky is the limit.

5) Disposing the stadium
When it becomes clear that the stadium is really causing very high losses for the municipality and the acceptance of the waste of the investment costs is more beneficial than keep paying for annual ownership costs and financial risks for the long-term future, it may be more beneficial for the municipality to sell the stadium or give it away to the using sporting club or an interested third private party. And if there are no interests purchasers, then it is also an option to demolish the stadium, but of course only if the using club is bankrupt or does not need the stadium anymore since they already has an alternative.

6) Passive approach
If the municipality decides not to invest in the stadium at all, because the investment will not be recouped, than there is the last alternative to choose a passive approach and leaving the stadium as it is.

CASE STUDY   STADION FEIJENOORD
Although, Stadion Feijenoord is not owned by a public party, the current situation of the stadium is a suitable case study for this research. The municipality of Rotterdam admits recognizes the public benefits of Feyenoord and the exploitation of the stadium. However,

they are still considering if they want to invest in the renovation of the stadium or construction of a new state-of-the-art stadium. First, the municipality wants to know the (financial) risks of such an investment, and of course they are looking at the benefits for their city. The sports club itself and the owning company of the stadium both claim that a new stadium is the best option for the club and the city, but the fans and inhabitants of Rotterdam want to renovate the current stadium. In this case it is useful for the municipality to know which option is the most beneficial for them, before they are investing in the stadium. Currently, two development alternatives of Stadion Feijenoord are seriously considered by the municipality of Rotterdam and the 'Feyenoord family' itself: A new stadium and a renovation of the stadium. When the decision is will be postponed automatically the third alternative, passive approach, will be applied.

- **Alternatives vs. sub-criteria matrix**

Concluding from the case study of Stadion Feijenoord, the following scores are given to the different sub-criteria in the conducted survey for all six stadium development alternatives.

Sub-criteria	Management changes	Technical adjustments	Total renovation	New stadium	Disposing stadium	Passive approach
Financial flow						
Investment	€ 1 mln	€4 mln	€117 mln	€ 362 mln	€ 47.5 mln	None
Rental revenue	€ 1.5 mln	€ 1.5 mln	€ 5 mln	€ 10 mln	None	€ 1.5 mln
Taxes	€0.5 mln	€ 0.5 mln	€ 1 mln	€ 2 mln	None	€ 0.5 mln
Financial risks	€ 12.5 mln (loan)	€12.5 mln (loan)	€ 32 mln (loan)	€ 172.5 mln(loan)	None	€12.5 mln(loan)
Economic value						
Creating jobs	4.778	5.556	7.278	7.889	2.389	3.556
Attracting companies	5.167	5.278	7.000	7.778	2.000	3.389
Area branding	5.556	5.444	7.111	8.111	1.722	3.667
Supporters' expenses	5.389	5.167	6.222	7.000	1.333	4.000
Social impact						
Enjoyment	5.611	5.278	6.278	6.833	1.778	4.000
Local pride	5.556	5.778	7.167	7.056	1.722	3.889
Promoting sports	5.222	5.500	6.389	7.167	1.833	3.889
City branding	5.556	5.556	7.000	8.167	1.889	3.667
Sustainability						
Energy costs	€400,000	€250,000	€600,000	€700,000	None	€477,812
CO2 emission	3000 tons	2000 tons	4000 tons	None	None	3000 tons
Natural resource use	None	100 tons	24000 tons	990000 tons	None	None
Long-term planning	10 years	15 years	25 years	35 years	0 years	5 years

Figure 2 | All values are annual scores. The values for the 'Economic value' and 'Social impact' are unit-less ratings between 1 and 10.

- **AHP model for sustainable stadium development**

The decision making process of a specific stadium development alternative is based on a lot of different criteria. The using sports club, the most important stakeholder of the stadium

project, is mainly concerned about its own interests, which results in decision criteria like; costs, capacity, business facilities, and revenue possibilities. For a municipality there are much more criteria that determine what is the most beneficial development alternative for a stadium. The different development alternatives do not only influences the use of the stadium, but also the surrounding area, the local economy, and other projects in the area or city. This are all important objectives that municipalities should consider in their decision making process. That is why the decisions about the most beneficial stadium development alternative for a municipality should be based on the analysis of multiple criteria.
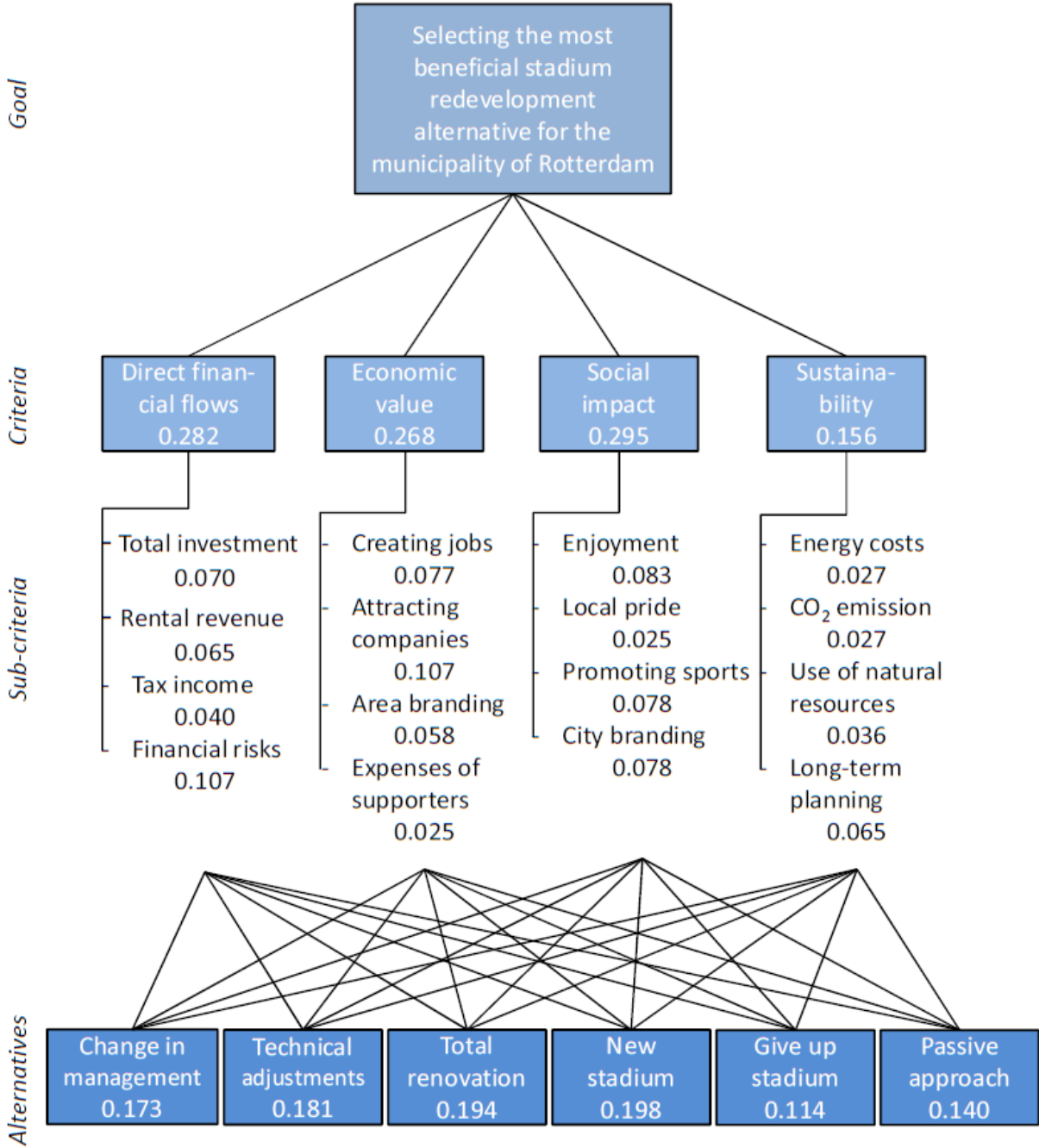
RESULTS

Figure 3 | Analytic Hierarchy Process model of the results of this research

First the consistency of the responds is analysed, in order to determine if the results are reliable. Then the relative importance of the criteria and sub-criteria according to the municipality regarding stadium development is presented in table and figures, followed by the variation in relative importance between the different subgroups. The results of the second part of the survey are shown by two figures about the direct prioritization of the different development alternatives for the case study Stadion Feijenoord and the prioritization based on the AHP analysis. Finally, the sensitivity analysis of the results is determined. The final prioritization of the (sub-)criteria and alternatives according to all participating city councillors is presented below.

CONCLUSIONS AND RECOMMENDATIONS

Considering the amount of responds, an inconsistency limit of CR ≤ 15% still provides sufficient data to get reliable results and conclusions. Also the distribution of the different subgroups is well spread and therefore the research is based on a realistic reflection of the reality. There is not enough data to draw reliable conclusions about all the different subgroups, although some indication can be suggested due to large differences between some subgroups.

Relative importance

From the results about the relative importance of the different (sub-)criteria about making SDPs more beneficial for municipalities it becomes apparent that they can be divided in three groups. Attracting companies and financial risks are by far the most important sub-criteria (*the black bars*). That financial risks have a higher relative importance than the direct investments and revenues seems logical, since an investment is only considered as too high when the expected results are not sufficient in regard to the height of the investment and if the financial risks attached to it are acceptable.
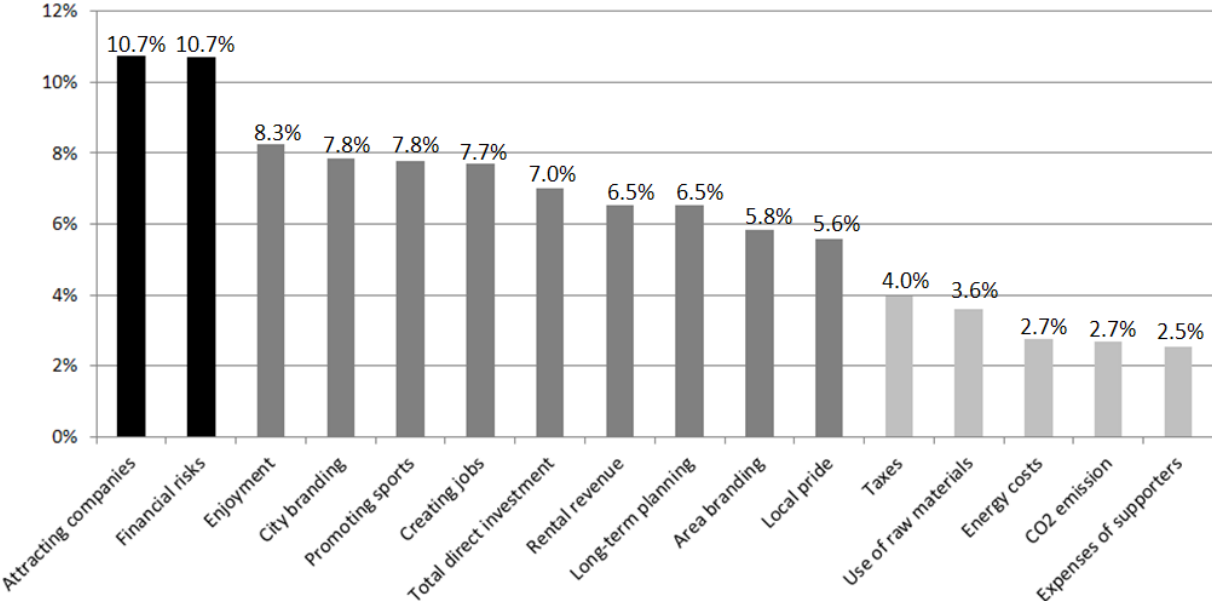

Figure 4 | Relative importance of the sub-criteria divided in three groups

The sub-criteria that also have a high relative importance (*dark grey bars*) also play in important role for the municipal. In particular the social aspects have a high relative importance. This can be explained by the fact that a stadium is usually not a profitable real

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estate object for municipalities. Apparently, municipalities seen the purpose of a stadium more in comply with their social objectives, like amusement and vivacity during events, city branding, promoting of sports (e.g. among youth) and in lesser extent local pride by the performance of the using BVO or the impressive effect of the design of the stadium.

The most beneficial stadium development alternative for a municipality is the one were the financial risks are low and the attraction to companies is high. These two criteria can be met with a combination of a total renovation, by modernize the stadium which makes is attractive for companies to hire a sky box or VIP seats, and by making technical adjustments and possible even change the management of the stadium regarding environmental behaviour in order to making it more sustainable. Companies want to be associated with a modern and sustainable stadium. So, be combining the positive parts of the three renovation alternatives (i.e. change in management, technical adjustments, and total renovation) a stadium can achieve the main objectives of a municipality without extraordinary high financial risks. On the other hand, a new stadium can have a very positive impact on both the financial and sportive performance of a BVO, and therefore on the financial risks for the municipality, although a new stadium brings along high investment costs and with that new financial risks for the municipality. It can therefore be a good alternative for both the municipality and the using BVO to lower the price of the new stadium, especially to the detriment of expensive aspects of the stadium design that do not have relatively strong impact on the other objectives of the municipality.

Stadion Feijenoord
While the average opinion of the City Councillors assumes that a new stadium for Feyenoord is definitely not the best alternative, the results of this research show that the new stadium can still be very beneficial for the municipality, even if it is by far the most expensive and most risky alternative for them. However, the other three redevelopment alternatives were almost as beneficial as the new stadium alternative (19.8%). The total renovation of the stadium (19.4%), performing technical adjustments (18.1%), and a change in the current management of the stadium (17.3%) also are beneficial alternative for the municipality of Rotterdam. Abandon the stadium or leaving the stadium in its current state are both significantly less beneficial and therefore no realistic option for both the municipality and the using BVO, namely Feyenoord.

Influence of sustainability
Sustainability (15.6%) as main criteria has a low importance in the decision making process of municipalities regarding stadium development in relation to the three other main municipal objectives, which are direct costs and revenue (28.2%), economic value (26.8%), and social impact (29.5%). Related to this result also the sub-criteria of sustainability have a low relative importance for municipalities. Surprisingly, the three most environmental sub-criteria (i.e. use of natural resources, energy costs and CO_2 emission) have a much lower score than the forth sub-criteria of sustainability; long-term planning. Possibly because the long-term planning also has a significant relation to the highly ranked criterion financial risks. If during the design phase of the stadium sufficient attention is paid to the long-term planning regarding strategic design (for a possible change of function or change in requirements) the stadium will keep its value for the city and the using BVO for a much longer period of time. This can ensure the municipality of a higher benefit during its lifetime without new public investments.

With the results of this research it seems like single sustainability aspects (i.e. energy use, use of natural resources, and CO_2 emission) are not plying an important role in the decision making process of municipalities regarding stadium development projects. During the conduction of the questionnaire City Councillors also suggested that a stadium is not the most efficient way to express the sustainable objectives of a municipality. Sustainability aspects (e.g. long-term planning) that ensure the municipalities of increased benefits from the other main objects are relatively more important in their decision making process.

Recommendations

With the results of this research several recommendations can be given to Dutch and other European municipalities, stadium developers, and especially to the 'Feyenoord family' (i.e. the BVO Feyenoord, the amateur club SC Feyenoord, and the management and shareholders of Stadion Feijenoord together).

The recommendations to municipalities from this research are:
- Also consider future financial risks that are the result of an investment in a stadium.
- Do not automatically choose for the less expensive stadium development alternative. It will cost less money but will possibly gain much less benefit in comparison to the more expensive alternatives.
- Do not demand for additional functions or adjustments to a stadium that are not relevant for the using BVO, since this only makes the stadium more expensive, which increases the financial risks for both the municipality itself as the using BVO.
- Do not demand for specific high performance sustainability adjustments, because the direct and indirect benefits would probably be disappointing.
- Do not underestimate the economic added value of stadium development in general.

The recommendations to stadium developers from this research are:
- Do not only focus on constraining the initial investment costs, but also look at the indirect costs like financial risks in the future for the municipality or the using BVO.
- Focus on the social and economic impact of the stadium during the design phase.
- Do not only concentrate on specific sustainability aspects, but on the environmental behaviour of the whole stadium development project, especially long-term planning.

The recommendations to Feyenoord family from this research are therefore:
- Although the new stadium seems the relatively best stadium development alternative for the municipality of Rotterdam, other alternatives (i.e. total renovation, technical adjustments, or change of management) are almost as beneficial as the new stadium for the municipality. This may be a less beneficial option for the Feyenoord family according to themselves, but these other alternatives can possible convince the municipality to provide the necessary investment, unlike the (apparently) too expensive current new stadium design.
- For the revision of the proposed plans for the new stadium especially the financial risks and the attraction of companies should be considered.
- For the revision of the new stadium plans, do not focus on the individual sustainability aspects, but look at the environmental behaviour of the whole stadium project, especially the long-term planning for the exploitation of the stadium.

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R.G.A. Schrama (Robert)

After I finished high school in Enschede in 2006 I went to the Eindhoven University of Technology. After finishing the bachelor Architecture and Engineering, with the minor Construction and Engineering and the final bachelor project Construction management, I started with the master Construction management and Engineering. This was the result of my acquired experience apart from my study as the project manager of the relocation project of the Eindhovens Studenten Corps. Both projects will be finished in September 2013.

2006 – 2011	Bachelor Building science and architecture
2009 – 2010	Member of the board of the Eindhovens Studenten Corps
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2011 – Now	Master Construction Management and Engineering

CONVINCING TENANTS TO PARTICIPATE IN SUSTAINABLE RENOVATION
Research into the willingness-to-pay for renovation packages of choice

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ABSTRACT

This research investigates how tenants can be convinced to participate in sustainable renovation against rent increase. Housing associations are forced to improve their existing housing stock in order to cope with governmental goals and to keep the stock competitive and valuable. Moreover, rent increase is necessary to recoup costly investments due to new regulations by the Rutte-II administration. Therefore, a survey, including a conjoint choice experiment, is distributed among tenants of BrabantWonen. The results of the survey and choice experiment were used to gather information about what measures are regarded as most important by tenants, in order to compose renovation packages focused on the respondents' energy using profile. Together with other factors mentioned in the theoretical research, an advice is given to how to convince tenants with the living-costs approach and with choice in renovation packages.

INTRODUCTION
In recent years there have been several developments which necessitate the sustainability of the existing housing stock. Because the global real estate market is the number one energy consumer (40% of the total consumption) and producer of CO_2 (30% of the total production), sustainability plays a very large role in housing development and management. In the Netherlands, approximately 2.4 million of the 7.2 million dwellings in total belong to social housing associations. Only 20% of these dwellings has an energy label B or higher. Therefore, housing associations can contribute a lot to the sustainability of the Dutch housing stock.

When renovating the existing housing stock, housing associations still have to cope with some bottlenecks. Financially it is a heavier burden for housing associations than ordinary planned maintenance. Moreover, since the new 'housing agreement', which was introduced on February 13, 2013, housing associations have to deal with new regulations that will significantly affect the financial situation of most associations. When rent increase will be applied after renovation, a direct return on investment can be guaranteed, which makes it

able to recoup the renovation investments within the alleged lifetime of the renovation measures. When a rent increase is proposed, tenants play an important role. 70% of the tenants must agree to the renovation. However, they do not always act positive towards (sustainable) renovation, especially if the rent will be increased afterwards. In this case however, the tenant gets all the benefits in the form of a lower energy bill and more living comfort and the housing associations can finance these benefits. Some housing associations however are already practicing a rent increase after renovation, but most do not. One of the reasons for this is that housing associations want to avoid conflicts with their tenants. Therefore, the attitude of tenants towards sustainable renovation could and should be changed in order to make great strides in the sustainability task of housing associations. Tenants should be convinced that against a lower energy bill and better living comfort, a certain rent increase is ordinary, and necessary for housing associations to stay operative. In order to convince tenants to let the housing association renovate against rent increase they should be more aware of the full package of benefits. Therefore, literature describes that the 'living cost approach' and the offer of renovation packages aimed at tenants' preferences, can play an important role in changing the tenants' attitude. This problem definition leads to the research question: *"Can renovation packages specified for certain target groups, ensure that tenants are more willing to participate in large-scale renovations against rent increase?"*

The goal of this research is to find out if the living cost approach towards tenants and the choice in renovation packages can contribute to the willingness and satisfaction of tenants to participate in large-scale sustainable renovations. The objective is to combine the interests of the housing association (policy-wise and financial) and the interests and benefits of tenants, to generate input for a survey among tenants in order to investigate and validate the gathered input.

Theoretical research
The municipality of 's-Hertogenbosch in which housing association BrabantWonen is active and where this research will be conducted, has their future sustainability plans listed in the Energy and Climate Program 2008-2015. This Energy and Climate Program 2008-2015 has one important goal: that the municipality will be energy neutral in 2050.

HOUSING ASSOCIATIONS AND SUSTAINABILITY

The sustainability task of housing associations is determined in 'Convenant Energiebesparing Corporatiesector' introduced in 2008 by Aedes, the Woonbond and the (former) Ministry of VROM and WWI. It states that the gas consumption of the existing housing stock should be reduced by 20% in 2018. Moreover, all dwellings should be upgraded to energy label B or with at least two energy label steps. Renovating the current dwelling stock is also of interest for housing associations policy-wise. The traditional business model which is based on the increasing value of dwellings is not realistic anymore. Due to the absence of a new (sustainable) business model, housing associations are forced to constantly sell their dwellings in order to generate sufficient profit. When dwellings are being sustainable renovated, rents can be increased significantly, which seems as an impulse for an association's direct cash flow which covers all direct investments.

The research is conducted at BrabantWonen, at this moment still a financially solid housing association in the municipalities Oss and 's-Hertogenbosch. Two years ago BrabantWonen

composed the Policy Plan 2025, which also described the Energy Policy. BrabantWonen follows the three principles of the Trias Energetica. First reduce the demand for energy by taking care of the isolation of dwellings and after that use sustainable measures to generate energy from natural sources. The goal is that all dwellings should at least have energy label C and 60% energy label B or higher in 2025. Currently BrabantWonen does not charge a rent increase after sustainable renovation. However, together with the current political situation, this way of working is not future-proof so it is considered to implement rent increase.

SUSTAINABLE RENOVATION

The research will focus on single-family dwellings from the period 1946-1975. These dwellings cover almost 30% of the total housing stock of BrabantWonen, and around 20% of the housing stock in the Netherlands and the energy label of these dwellings differ between E, F and G meaning they are of low energetic quality.

First, to give insight in what is necessary to obtain an energy label B or higher, different renovation measures will be discussed and calculated. The model calculates the linear redemption sum per month to make each measure feasible in its respective depreciation period. Due to an annual inflation correction, no extra inflation and interest ratios are added to the equation. In addition, the energy savings for a family consisting of four persons will be listed to get an overview what the savings for tenants will be per measure.

Table 1 shows a renovation where the calculated rent increases are compared with the savings per month. It shows that tenants can save up to € 30 p/m.

	Current situation	Situation after renovation	Rent increase (per month)	Savings (per month)
Insulation	Poor/moderate	Good	€ 14	€ 45
Glazing	Single glazing	HR++ glazing	€ 7	€ 20
Installations	VR boiler	HR-combi + solar boiler	€ 25	€ 36
Ventilation	Natural	Mechanical	€ 23	€ 16
PV panels	None	15 m² panels	€ 20	€ 30
Living spaces	Outdated	Renovated	€ 28	€ 0
Energy label	E	A	€ 117	€ 147

Table 1: Overview of energy label gain, rent increase and monthly savings

Tenants' perspective

One of the most important aspects in regards to sustainable renovation is the tenants' perspective. Therefore an overview from the tenants' perspective is elaborated next. In general, tenants profit the most from (sustainable) renovation. Lower energy costs are guaranteed and the living comfort improves due to certain renovation measures. Besides these benefits, tenants have interests as well. The most important interest is that their current situation does not change in a negative way. For instance, nuisance during renovation has to be as low as possible and a rent increase is not desired. Even when no rent increase is asked so far by certain housing associations such as BrabantWonen, tenants act suspicious when it comes to convincing them to participate in renovation. Therefore, involving tenants in the preparation phase of the renovation can be of great importance to give them a feeling of *right of say*. Too many times housing associations only have motives

that are focused on their own profit, not the profit of tenants. Therefore, focusing on tenants' motives and giving them a say in the early phases of the renovation could result in more satisfied tenants. However, it is of great importance that the degree of participation is measured precisely because too much involvement leads to loss of overview and interest from tenants. Moreover, too much involvement, especially when it comes to choice in renovation, leads to short-term mindedness, which collides with the long-term vision housing associations have. Besides the benefits and interests of tenants and the level of involvement by tenants, there are still restraints among tenants to participate in (sustainable) renovation. They are reluctant for change, especially the elder tenants (> 55 years), they are against any form of nuisance, do not think the renovation improves their living situation or they do not think the associations policy is justifiable.

It is clear that great strides can be made in convincing tenants to participate in renovation. Most important aspect is that tenants want to have a feeling of involvement in the renovation process and choice can be a trigger to give them this involvement. Moreover, by advising tenants (through third parties) and by approaching the right tenants that are more willing to participate a successful planning phase can be reached, even against rent increase. However, there will always be restraints and often these are hard to tackle. Still, with the mentioned solutions, there are possibilities in changing the tenants' attitude.

FIELD RESEARCH

Now the theoretical background is elaborated, the focus of the field research can be defined. The problem focus can be determined as follows: *"At this moment, rent increase after (sustainable) renovations is uncommon at many housing associations such as BrabantWonen, but necessary for future financial stability."*

It is inevitable that housing associations have to ask for a rent increase in order to stay financially healthy, but at this moment this is not always the case. Therefore, it is of interest what tenants' needs and wishes are in regards to large scale sustainable renovations and what their willingness to pay extra rent for certain measures is. This can be investigated by executing a field research under tenants of BrabantWonen. The main research question is: *"What measures, and against what acceptable rent increase, can be taken to improve the tenants' willingness to participate in renovation?"*

METHODOLOGY

A survey will be conducted which will first ask for some basic housing and household characteristics from the tenants to distinguish or segment them later on. After that, their opinion about renovations in general and sustainability/environmental awareness is asked. This is distinguished in eight theorems that ask for the respondents' opinion. Next, on the basis of these theorems, respondents are asked in which energy using profile they fit: *Ease*, *Conscious*, *Costs* or *Environment*. Finally, a conjoint choice experiment will be conducted.

Sustainable theorems

To analyze if the chosen energy using profile is valid, the means per energy using profile group are compared with each other. With a splitting variable significant differences can be discovered. In this case the energy using profile will function as the splitting variable. The differences can be discovered with an ANOVA analysis and F-test.

Conjoint choice experiment

Conjoint stated choice experiments involve the design of product profiles on the basis of the formulated product attributes and their respective levels. Respondents will then be asked to repeatedly choose a certain profile from different sets of profiles. The variables that will be randomly mixed throughout all choice sets are chosen and composed in consultation with BrabantWonen and the findings from the field research. They are shown in table 2.

Attribute	Level 1	Level 2	Level 3
Dwelling expansion	No expansion	2,5 m^2 expansion	Dormer on front or back
Renovation of living spaces	Kitchen	Sanitation	Both
Sustainable solutions	PV panels	Heat pump	Solar boiler
Nuisance	3 weeks, out-of-house	3 weeks, nuisance	4 weeks, decide-yourself
Living-costs savings	€ 10 p/m	€ 25 p/m	€ 40 p/m

Table 2: Conjoint choice experiment attributes and levels

The total number of packages which can be chosen from can be calculated with a formula and is called a full factorial design. In this case this would consist of 3^5 = 243 profiles, too large to include in a survey. Therefore, a fractional factorial design, which presents a small fraction of the full design is sufficient to discover the main effects for each factor level in the experiment. In this case a fraction design of 18 profiles is calculated (nine choice sets of two profiles). Moreover, all respondents will be asked after each choice if they would accept both profiles. This is called the dual response format.

The methods used to calculate the required results are:
- **Random utility theory:**
  When a respondent chooses between two alternatives, it can be assumed that he or she picks the alternative that has the highest 'total worth' for this person. First, all 'part worth values' can be calculated, and together with the base component, the total worth of a package can be calculated:

$$V_i = \beta_0 + \sum \beta_k X_{ik}$$

  With this information, the relative importance can be calculated. This simply shows which attribute is regarded as the most important, compared to the others. This can be done by taking the absolute difference between the lowest and highest part worth value. To distinguish differences in the respondents' energy using profile, the random utility theory will be calculated per energy using profile by using interaction effects.
- **Latent Class Analyses:**
  With a Latent Class Analyses (LCA) a possible segmentation of respondents can be derived from all results. The model makes it able to categorize people into two or more classes using the observed items and can identify the items that have the biggest distinction between the found classes. The LCA model formula is:

$$U_{jit} = \beta_c' X_{jit} + \varepsilon_{jit}$$

- **Scenario analysis:**
  When all parameters are predicted per attribute level, the total worth per energy profile can be calculated with the sum of all part worth values. Now, every renovation package, and even renovation packages that were not included in the choice experiment can be compared to each other, and the chance that a certain package will be chosen instead of

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a compared package or a "no choice" option, can be calculated with the following formula:

$$P_{Package\ A} = \frac{e^{VpackageA}}{\sum e^{VpackageA} + e^{VpackageB} + e^{nochoice}}$$

A scenario analysis can result in an overview which packages are the most convenient for all respondents, or for each energy using profile.

RESULTS

The respondents are approached via the tenant database of BrabantWonen (department 's-Hertogenbosch). To save time, the survey is only sent to tenants with an e-mail address. Eventually, 1511 tenants were approached, from which 271 responded correctly.

The sample group was compared with information from the Housing Lease department at BrabantWonen and it was mentioned that the sample group shows representative results for the population, but not for the whole tenant database. Moreover, tenants were also asked to fill in their energy using profile. The "*Conscious*" profile (in red) is by far the largest energy using profile. Moreover, the profile "*Costs*" (in green) is also well represented. Still, almost 10% thinks he or she is "*Environmental"* minded.
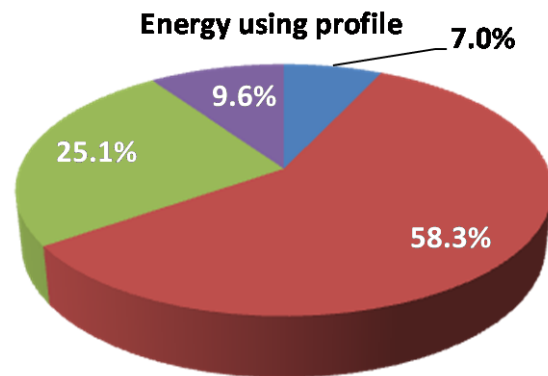
Tenants were then submitted some theorems about sustainability and renovation. With an ANOVA test, these results were compared with the chosen energy using profile. Most notable is that the majority of the tenants is concerned about rising energy prices and is open to sustainable renovation. When their dwelling is being renovated, most tenants are open for rent increase when the energy bill decreases with at least the same amount. Moreover, guarantees by the housing association are more than welcome. Most important about these results is that respondents have categorized themselves correctly in their respective energy using profile.

Conjoint choice experiment

To validate the model, the Rho-square value is analyzed for the model for all respondents and the segmented model per energy using profile. Both Rho-square values are below 0,2, indicating that the predictors are not suitable, which could be expected due to the small sample group. Still, the analyses show expected results.

Multinomial logit model for all respondents

First, all part worth values are calculated to indicate which attribute level is regarded as most important. For **dwelling expansion**, results show that an expansion on ground level is the most important attribute level. The **renovation of living spaces** also showed a very logical result, however a mistake has been made in the formulation of the attribute levels. Therefore, both showed up to be the most chosen level, which was expected. The **sustainable solutions** attribute shows that respondents think equal as positive about PV-

panels and a solar boiler. At the same time, the heat pump has a negative influence. The attribute **nuisance** shows interesting results. The '4 weeks decide-yourself' is the most positive attribute level. At BrabantWonen they are questioning if people want to move out instead of staying at home during the renovation, which is not the case among respondents. The **living-costs savings** results speak for themselves. The highest savings are regarded as the most positive. From all the data gathered above, the relative importance per variable can be calculated by using the absolute difference between the highest and lowest part worth value. Figure 2 show the results. Living-costs savings can be regarded as the key-variable, compared to the rest. The outcome can be interpreted as logical because people tend to choose more for their own well-being and living comfort, e.g. living-costs savings and nuisance.
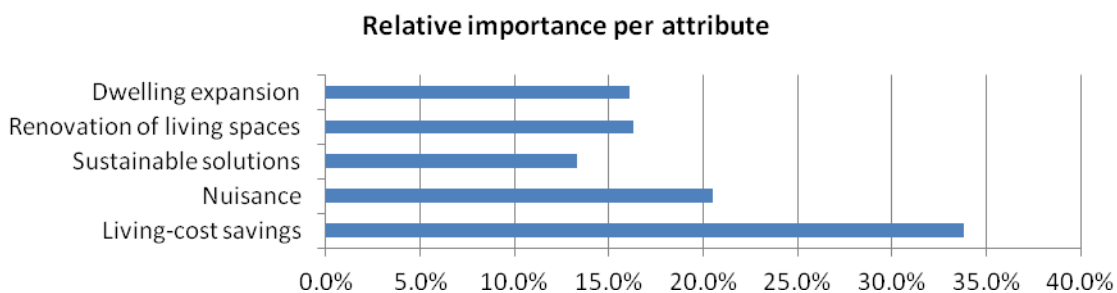

Figure 2: Relative importance per attribute

Multinomial logit model per energy using profile

The model is also applied on the separated energy using profile groups. None of the values are significant; however, some values still show some results that could be beneficial for this research. Most notable are the values of the profile *Environment*. The attributes expansion, nuisance and savings are of low importance for this profile. In comparison, the importance of the sustainable solutions is very high. Also, the profile *Costs* has the highest part worth value of the € 40 p/m savings level. The profile *Conscious*, the biggest group, shows the most general results as was expected. The profile *Ease* thinks staying at home during the renovation is very important. Results are shown in figure 3. Finally, when the base variables are compared with each other, it shows that the profile *Ease* chooses the most for the '*no choice'* option, compared to profile *Environment* and *Costs* that accept most packages.
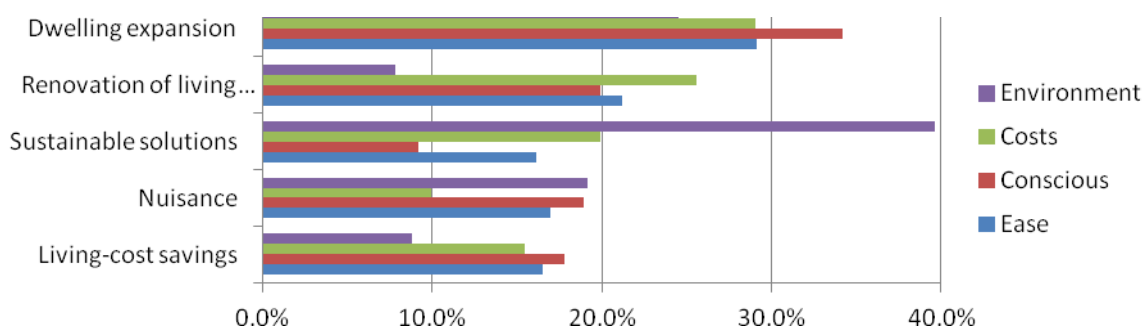

Figure 3: Relative importance per attribute for segmentation in energy using profile

Latent Class Analyses

Besides the calculations per energy using profile, a Latent Class Analysis is conducted to analyze if tenants can be segmented and if these segments have different characteristics. A model with four classes proved to be the most convenient, because of the best validation

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values and most significant part worth values. The four classes respectively cover 39,5%, 30,0%, 15,6% and 14,9% of all respondents. Most part worth values are significant, except all values in *class 4*. However, this is the smallest group and therefore the results could still lead to recognizable conclusions. When these results are compared with the social-demographic characteristics per class, the four classes can be interpreted as shown in table 3. Significant differences between groups were found for the characteristics energy *using profile*, *household composition* and *work situation*.

	Conjoint choice results	Energy using profile	Household composition	Work situation
Class 1 – "Costs minded"	Living spaces & Sustainable solutions minded	More *Costs* less *Conscious* & *Environment*	More households with children	More part-time working people
Class 2 – "Average tenant"	Nuisance minded	Average profile deviation	More singles & households without children	More part-time working people & students
Class 3 – "Higher living standards"	Not attached to living costs savings	More *Environment* & less *Costs*	Less singles & more elderly and other	More full-time working people & less students
Class 4 – "Not interested"	Nuisance and living costs savings minded	More *Ease*	More singles & less elderly and families	Less working people & more unemployed and retired

Table 3: Social-demographic characteristics of the Latent Classes

Scenario analyses

For the scenario analyses, two scenarios will be investigated: the most ideal renovation package for all tenants and the four energy using profiles. The other scenario will be the most ideal renovation for BrabantWonen (i.e. the least investment costs and a respective gain in energy label), with the highest choose probability by tenants. When these packages are compared to each other it shows that the package optimal for tenants is, indeed, the most popular, but BrabantWonen its package is also of interest for most respondents or respondent groups.

CONCLUSIONS

The results of the tenant survey showed that tenants, are actually concerned about the high energy prices and do think positive towards sustainable renovation. It has to be noted that the sample group is not a good representation of the total tenant database; for instance, the elderly are under-represented but are regarded as important by BrabantWonen to reach, because they are known for their inadequate knowledge in regards to sustainability. The conjoint choice experiment shows that tenants do think savings in living costs is the most important aspect of a renovation. Moreover, sustainable solutions are regarded as the most unimportant aspect. When respondents were segmented in Latent Classes or energy using profile groups, distinctions could be made.

With these conclusions from the field research, the research question *"Can renovation packages specified for certain target groups, ensure that tenants are more willing to participate in large-scale renovations against rent increase?"* can be answered. It can be concluded that with the survey results, certain distinctions can be made between tenants and their energy using profile. Moreover, with the LCA model, significant distinctions

between tenant groups were discovered. When the energy using profiles were compared to each other, *Environmental* tenants showed more interest in sustainable measures than the rest. In general this was the least important attribute, but the energy using profile segmentation proved there are distinctions. Also, the profile *Costs* has the highest part worth value of the € 40 p/m savings level at the living costs savings attribute. The profile *Conscious*, the biggest group, shows the most general results as was expected. Finally, the profile *Ease* thinks staying at home during the renovation is very important, instead of the profiles *Conscious* and *Costs* that rank the decide-yourself attribute level as the most important. Besides these clear distinctions between tenant groups, it has to be noted that convincing tenants to participate in sustainable renovation is dependent on many other factors as mentioned in the literature study. First of all, as discovered in this research, segmenting tenants can help convincing them more easily. Moreover, the use of advisors and/or other tenants that are easier to convince can help to tackle the harder to convince tenants. In this case, the environmental-minded tenants in a neighborhood can help fulfill this task.

DISCUSSION

As mentioned before, the output of the tenant survey is not sufficient enough to generate significant conclusions. Also, the sample group represents the population but not the total tenant database of BrabantWonen. For instance, the tenants that are hard to reach and convince (older tenants and immigrants) were under present in the sample group. This probably has to do with the distribution of the survey through e-mail. Most of these hard to reach tenants do not have an e-mail address. Moreover, the initial research goal of the conjoint experiment was to investigate the willingness-to-pay for certain renovation measures. However, the first order interaction effects could not be investigated afterwards. In addition, due to the convenience of the survey, the attributes were reduced to five, resulting in only the most important aspects for BrabantWonen and its tenants. In this research, the scenario analyses were conducted only for all tenants and the different energy using profiles. However, this can also be conducted per attribute level, such as the Latent Classes. The classes did show distinctions between them so a scenario analysis could be useful.

Another important discussion is the every changing sector housing associations operate in. During the research, the Rutte-II administration was formed and revised the governmental policies in regards to the (social) housing sector resulting in cutbacks for housing associations. Most of these policy measures are taken into account, even the newly formulated coalition agreement as of February 13, 2012. Still, the financial calculations of renovation measures were done with 21% VAT; however renovation of existing dwellings will be stimulated by introducing the low VAT rate (6%), saving 15% on renovations. This also shows the importance of the sustainability topic. Every month, new ideas, models and ways to green the housing stock or other sectors arise, and governmental plans differ as much.

RECOMMENDATIONS

For future research, a similar research among a larger group of tenants that focuses purely on the conjoint choice experiment should be investigated, in which more attributes can be implemented and first order interactions can be conducted. Then the willingness-to-pay can be investigated for all chosen measures. Moreover, a segmentation on other aspects could

be interesting to analyze, such as lifestyle, personal interests, etc. In future research it is important that the groups that were not reached in this research such as retired residents and non-western immigrants should be reached because they are the most difficult target groups in regards to the willingness to participate.

The technical focus of this research was on single-family dwellings, period 1946-1975. It is recommended to investigate other dwelling typologies in order to achieve different results. For instance, apartments from the 1960s show the same technical issues as the single-family dwellings treated in this research. In regards to the tenants' perspective there has been done extensive research to these topics; however these were very theoretical. It could be investigated what forms of tenant participation are possible for housing associations and how this relates with the satisfaction level of tenants.

For housing associations such as BrabantWonen a large majority of the respondents answered that they are willing to participate in sustainable renovation but they want to see some guarantees that the energy costs will reduce with the same amount as the rent increases. Housing associations could investigate this way to convince tenants to participate. Moreover, in spite some results are insignificant; BrabantWonen can contribute from some of the survey results. For instance, it was believed that tenants want to move out during a renovation but results showed otherwise. Moreover, the results from the energy use profile Environment showed interesting results. Even more, there could be made a distinction in tenant groups. Through surveys in an early phase of the project, tenants can be asked about their opinion on sustainability and different social-demographic characteristics, which could lead to specified renovation packages.

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This graduation research is the end of my (bachelor and) master program at Eindhoven University of Technology. The graduation period was very interesting and informative and I am ready to use all gathered knowledge in the field.

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INFLUENCE OF TAX BENEFITS ON ENERGY NEUTRAL RENOVATION OF PRIVATE HOMEOWNERS

Using conjoint choice experiment to determine the willingness of homeowners to renovate

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ABSTRACT

In the recent past, the Dutch government has tried to motivate homeowners to take measures in order to reduce energy consumption through the provision of subsidies. This has often resulted in small changes and measures such as double glazing, solar panels and etc., without any comprehensive and structural approaches such as reducing energy loss through the shell of the building. However, to achieve the international (Kyoto and later Bonn) agreed objectives some comprehensive approaches are need to be taken to reduce CO_2 emissions of build environment. Hence, the objective of this research is to investigate if tax benefit can influence the willingness of privet homeowner to renovate their homes towards energy neutral level. In this paper, a desk research has been conducted to find out what the benefits of energy neutral renovation are to its stakeholders. The desk research has been also helpful to find out what the impact of tax benefits regarding sustainability have been in the neighbouring countries. Thereafter, two fiscal scenarios have been constructed and taken into survey with the existing fiscal scenario. Subsequently, a stated conjoint choice experiment is used to determine the preferences of homeowners regarding renovation packages. Finally, the results are given and conclusions are drawn.

Keywords: Tax benefits, energy neutral renovation, private homeowners, conjoint choice experiments

INTRODUCTION

The Dutch government is committed to achieve the international (Kyoto and later Bonn) agreed objectives to reduce CO_2 emissions. According to the European Climate and Energy Package (ECEU, 2012) the aim is to have a 20-20-20 reduction in 2020 compared to 1990; 20% less greenhouse gas, 20% more sustainable energy and 20% energy saving. This means that the new dwellings from 2015 should have at least an EPC value of 0.4 and from the 2020 only energy neutral /zero energy houses should be built. With expected sharply increase of energy prices in the future, the share of energy cost as part of the total living cost will continue to increase. In a choice between energy efficient dwellings and energy inefficient dwellings, the marketability of energy-insufficient dwellings will come under great pressure.

The built environment in the Netherlands is responsible for around 30% of energy consumption. In the Netherlands there are around 7.3 million housing stocks (see figure 1).
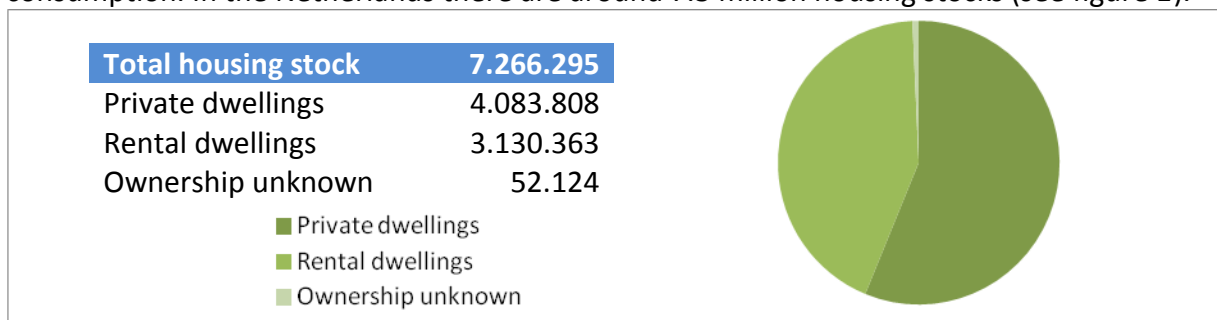

Total housing stock	7.266.295
Private dwellings	4.083.808
Rental dwellings	3.130.363
Ownership unknown	52.124

■ Private dwellings
■ Rental dwellings
■ Ownership unknown

Figure 1: Characteristics of existing housing stocks (CBS, 2013)

Around 3.1 million of the housing stock is rental, the ownership of small number of houses is unknown, but the majority of the dwellings, around 4.1 million are private owned dwellings

In the recent past, the private homeowners have tried to take measures in order to reduce energy consumption through the provision of subsidies. This has often resulted in small changes and measures such as double glazing, solar panels and etc., without any comprehensive and structural approaches such as reducing energy loss through the shell of the building. In order to compete with highly energy efficient (energy neutral) dwellings, it is important and desirable for the private homeowners to renovate their houses towards high energy efficiency / energy neutral level. But a renovation on such a level needs around €40.000 euro is needed (Weevers, B. 2013) and the willingness to invest. In return, the homeowners can receive benefits such as increase in lifespan of their houses, decrease in their energy-bill, better and healthier living environment and added value to their property.

In the Netherlands, inhabitants pay different kinds of taxes to the government: income tax, milieu tax, wealth tax, sewer tax, land value tax, inheritance tax, car taxes and etc. The government also supports its citizens though tax benefits. *The question is, can tax benefit influence the willingness of private homeowners to renovate their homes to energy neutral?*

In order to find answer to this question, first a desk research is conducted to find out what the benefits of energy neutral renovation are, what the impact of fiscal instruments have been concerning sustainability, what the most suitable tax form for this research is and what kind of financial barriers do the homeowners face when they decide to renovate their homes. Then, two fiscal scenarios are constructed and taken into survey with existing fiscal scenario to find out what the preferences of homeowners are. Finally, the results are given and the conclusions are drawn in the last part of this paper.

DESK RESEARCH
- **Energy neutral renovation and its benefits:** A clear definition of energy neutral dwelling is important to prevent confusion about the used terms in this article.
- ***Energy neutral:*** Energy neutral or zero energy dwellings are the dwellings that generate as much energy as they need to be comfortable. An energy neutral dwelling has an EPC of 0.0 and that means energy label A++ on the ladder of energy labels. The energy neutral dwellings are well insulated to keep the heat demand in the winter to its minimum and the needed artificial cooling in summer is almost unnecessary. Living comfort, good ventilation and a healthy indoor climate are all crucial aspects of energy neutral dwellings which can be achieved through renovation by using modern construction methods, the right materials, energy efficient systems, efficient installations (for walls, floors, windows and doors, façade, glazing) and making use of the sun, wind, water and soil in a correct way.

- ***Benefits for homeowners:*** Investing in energy neutral renovation will decrease the energy bill which is the direct return of investment. Reducing the energy usage and using energy from renewable sources for the remaining amount of energy will result in great energy bill reduction. A project in Sleephellingstraat of Rotterdam has led to energy bill saving of €1.200-, per year after renovation to energy label A++ (AgentschapNL, 2013a). The investment in energy neutral renovation does not have the only benefit in from of substantial savings in energy bills, but it also improve the value of property which is the indirect return on investment. Research shows that the value of property rises as the energy label gets greener (BNN, 2012). Groenestein has concluded in his study that the added value of energy sufficient dwelling can vary from €1000 to €25000 (Groenestein, 2011). Creating a healthy, comfortable, safe and affordable dwelling are other benefits of energy neutral renovation. In addition, the extension of the living space or the improvement of kitchen and sanitation are the other possible benefits of renovation which can make the live environment more comfortable and pleasant.

- ***Benefits of Government:*** Energy neutral renovation thru tax benefits can create jobs, not only in the construction sector but also in the production and installation sector of PV panels, HR boilers, glazing companies and etc. Tax benefits in the form of VAT reduction had already a positive impact on the construction sector as the sector made a total of 2.2 billion euros additional revenue in a year and the jobs in the construction sector has been preserved (BouwendNL, 2011a). Bigger tax benefit which can influence the private homeowners (4.2 million) to renovate their homes to energy neutral level can create much more revenue and jobs than what VAT reduction did. Furthermore, the Dutch government can achieve its international (Kyoto and later Bonn) agreed objectives with energy neutral renovation of existing buildings as the Dutch built environment is responsible for 30% of total energy consumption (BZK, 2011). Besides the job creation and achieving its goals, the government can have some financial benefits from the renovation of the existing dwellings. In February 2012 around 16600 people from the construction sector were receiving unemployment benefits (Dutch: werkloosheidswet uitkering) while in February 2013 it was escalated to 25500 people, a growth of 8900 people within a year (CBS, 2013). Job creation in the construction sector will reduce the number of receiving unemployment benefits. The government will also receive 21% of every investment back via VAT for materials. The government will also receive income tax of labour and corporation tax when renovation companies make profit. The energy neutral renovation can also improve the public health which means less health care costs.

- **Tax benefits in the Netherlands and neighbouring countries:** In total, there are eight VAT reduction and four governmental instruments in the form of tax credit for energy efficiency of buildings in the European member states (BPIE, 2012). France and Belgium use tax deductions and VAT reductions combined as a governmental instrument in order to improve the energy performance of existing dwellings, while the Netherlands uses only VAT reduction on the labour of energy saving measures as an instrument to improve the energy performance of buildings and to stimulate the construction sector.

Literature studies showed that in all three countries, tax benefit policies were efficient. In France the income tax deduction came out as the most efficient measure (Charlier *et al*., 2012). It was even possible to achieve the objectives of the government with the tax deduction policy but with higher rates, namely 54%. In Belgium, the tax benefit also had a positive influence. There has been sharp increase in double glazing, use of high efficient boilers and specially roof insulation, from around 8.000 in 2007 to 60.000 in 2010 (BBL

,2012). After the success of the VAT reductions in 2010, where the Dutch construction sector benefited from €2.2 billion additional revenue (BouwendNL, 2011a), the second term of VAT reduction has also been successful. In the first few months of second term, around 300000 households took part in sustainable renovations (Duurzaam gebouwd, 2013). These results shows that tax benefits as governmental instrument for sustainability has been successful for sustainability as well as for the construction sector.

- **Suitable tax form for the research:** In the Netherlands there are different forms of taxes available, from income tax to dog's tax. However the most relevant forms of tax for this study are; income tax, corporation tax, real estate transfer tax, environmental taxes and property tax. The most suitable tax form for this research is chosen via a selection tables with 5 selection parameters, namely; *applicable for all homeowners, similar benefits, shortest payback time, quick benefits and transparency.* Income tax scored the highest as it has a maximum range (it is applicable for every homeowner), it is transparent and it has a shorter payback time (the homeowners can cover a big part of renovation cost at once).

- **Financial barriers:** Technical solutions exist for residential energy neutral renovation. However, there are several barriers which prevent the implementation of such techniques. One of the most important barrier is the financial barrier. Reports showed that high investment costs is the biggest financial barrier when it comes to sustainable renovation (Tommerup *et al.,* 2012; IEA 2008). Researches (Nair et al., 2010; Tommerup *et al.,* 2012) also show that investment cost is one of the important factors of homeowners' choice of energy efficiency measures. In practice, the cost of many energy saving measures and techniques are high which makes the payback period also longer and that makes the renovation projects less attractive to homeowners. Homeowners with low income and homeowners who recently purchased a house using all their financial means typically do not have capacity to invest in energy saving renovation (Tommerup *et al.,* 2012). Lack of access to money or higher priority given to non-energy issues such as kitchen renovation, new bathroom, painting and etc. is limiting investments in energy efficiency measures. Energy efficiency renovations generally call for substantial additional up-front investments, as compared to repairing or overhauling options (Jakob, 2006). The homeowners do not have enough savings to do the renovation. Additionally, uncertainties about labour market and about cost and benefits are the other important financially barriers when it comes to renovation of existing dwellings.

- **Fiscal and financial constructions:** Two fiscal scenarios have been constructed by the author of this article as solution for mentioned financial barriers.

Scenario 1: 40% tax benefit for energy neutral renovation

The homeowners will be allowed to deduct 40% of expenses which has been made in order to renovate their homes to energy neutral from taxable income. The tax deduction will be eligible for payments which are paid for renovation cost including labour, professional services, materials, equipment and permits costs. This tax deduction will make the energy saving investments financially interesting for homeowners and will lower the payback time, as 40% of the high investment cost will be covered by this tax benefit scenario. The percentage of the tax benefit is chosen in such a way that it can be favourable for the government as well.

Scenario 2: 20 % tax benefit for at least two energy label improvement

The homeowners will be allowed to deduct 20% of expenses which have been made for renovation from taxable income. The tax deduction will also be eligible for payments which are related to eligible work and include cost of labour, professional services, materials,

equipment and permits. These costs will be eligible only if the renovation is done by a professional contractor with an establishment in the Netherlands. This scenario is chosen because it is not possible to achieve energy neutral level on every existing dwelling. Financially and technically it will not be possible for some dwellings to achieve energy neutral level. Therefore, the homeowner can choose to renovate his house and improve the energy label of his house at least with two labels. The investment cost of this measure is also lower than energy neutral renovation which can attract homeowners with low income.

Scenario 3: 15% VAT reduction for renovation and restoration

The third scenario is the existing scenario in the Netherlands. The government has reduced the VAT from 21% to 6% in order to motivate homeowners and tenants for renovation and/or restoration of their dwellings. The VAT reduction rate of 15% can be applied to all renovation and repair work that has been made in a dwelling. Renovation and repair in this context can include; the renewal, addition, repair or replace of parts of the house. The reduced rate of VAT applies only to labour and not to the materials used in the renovation and restoration activities. This scenario is taken into survey in the field research with two newly created scenarios for comparison. Green mortgage, green loans, own saving of homeowners can be the solution for problem access to money. In the Netherlands, there are different banks which are willing to offer green loans and green mortgage if the homeowners improve the energy efficiency of their homes.

FIELD RESEARCH

A field research has been conducted to investigate whether the solutions formulated in previous section are appropriate enough to influence the willingness of homeowner to renovate their home into energy neutral. The municipality of Barendrecht is used as case study area for field research. Barendrecht is a city in the Netherlands, located in the Rotterdam region in the province of South Holland. The municipality of Barendrecht has 47362 inhabitants on an area of 21.73 km^2. Barendrecht consists of more than 96,000 dwellings. Only around 5300 of them are rental houses. More than 70% of the dwellings are privately owned. The percentage of private dwellings is much higher than the average percentage of 56% in the Netherlands. Experimental variables of the field research were derived from desk research. Five attributes and their levels are taken into survey in conjoint experiment (moreover in methodology), to determine the preferences of the homeowners when doing renovation. It has been assumed that all attributes are independent. The attributes are as follow;

- *Renovation option:* The first attribute is the renovation option. The homeowners can choose from three renovation options. 1) Energy neutral renovation. 2) At least two energy label improvement. 3) Taking some energy saving measures.
- *Tax benefits:* The second attribute is the tax benefits they can obtain. Besides three renovation options, the homeowners can choose from three forms of tax benefits. 1) 40% of the renovation cost is deductible from income tax. 2) 20% of the renovation cost is deductible from income tax. 3) 15% VAT reduction only on labour of the renovations costs.
- *Tax deduction period:* The homeowner has also the option to choose from three periods of tax deductions. 1) Flexible, the homeowner can receive the cost in one time or divided into multiple number of years. 2) 5 years, the homeowner can receive the renovation cost in 5 years of time. 3) 10 years, the homeowner can get the renovation cost in 10 years of time.

- *Financial possibilities:* Energy efficiency renovations generally call for substantial additional up-front investments and not every homeowner has enough capital to do the renovation, therefore the homeowners are given three financial possibilities to choose from. 1) Green mortgage. 2) Green loans.   3) Own savings.
- *Service:* The last attribute of the conjoint experiment is the service option. The options to choose from are; 1) One-stop-shop. 2) Different companies. 3) Do it self.

Methodology

Stated conjoint choice experiment is used in this research. Conjoint choice experiment is a commonly used research method to determine how people value different features that make up an individual product or service. In conjoint choice modelling respondents require to choose between two or more profiles. Usually there is also a "none of the above" option available if none of the presented profiles are attractive enough for the respondent.

In this case the profile consist of five attributes, renovation options, tax benefits, periods of tax deduction, financing possibilities and service as it is mentioned in previous section. The 5 attributes and their 3 level will result in 3^5 = 243 choice profiles if the full fractional factorial design is used. Incorporating all the alternatives requires too many choice profiles to be taken into questionnaire which will take too much time of respondents. Therefore a fractional factorial design is created. The orthogonal generator function of SPSS 21 is used to design the fractional factorial design, holding 18 alternatives. These alternatives have randomly put in choice sets, each holding two profiles alternatives. In the experiment the respondents were first asked to give their preferred package from the set presented, totally nine choice sets were presented to them. Secondly, they were asked to reveal whether they find the packages acceptable to be implemented in practice. The different attributes were coded by using effect coding (Kemperman, 2000). Furthermore, three models have been used for calculation of the results. The three used models are theory of random utility, regression analyses and latent class analyses.

RESULTS

A total number of 1488 homeowners were approached for the survey. The number of responses were 324, and 17 out of them were filled wrongly. These questionnaires were removed from the database. The Socio- demographic of sample group showed some notable results when comparing them to Dutch population. Especially the education level of respondents, where 72% of the respondents have a PhD, WO or HBO diploma compared to 32% of Dutch population. This means that the majority of private homeowners who took part in the survey are highly educated people. This finding is in line with the literature indicating a positive relationship between educational attainment and environmental concern (Alibeli *et al.*, 2009). Literature shows that, well educated people are more likely to show higher levels of environmental concern than the less educated. Additionally, the results showed that "high investment cost", "long payback time" and "limited financial resources" are indeed the main barrier which prevents the homeowners to invest. With 37 percent, the choice "long payback time" resulted in the biggest reason of not investing. The second biggest reason was "the high investment cost" with 21 percent.

Relative importance of attributes for implementation

First the relative importance of the attributes are calculated and elaborated in figure 2. As shown in figure 2, tax benefits with 45% has the highest relative importance to homeowners who want to implement one of the renovation packages to renovate their home. It can be

regarded as the key attribute compared to other attributes. Service has the lowest importance and while the other three attributes has almost equal importance to homeowners.
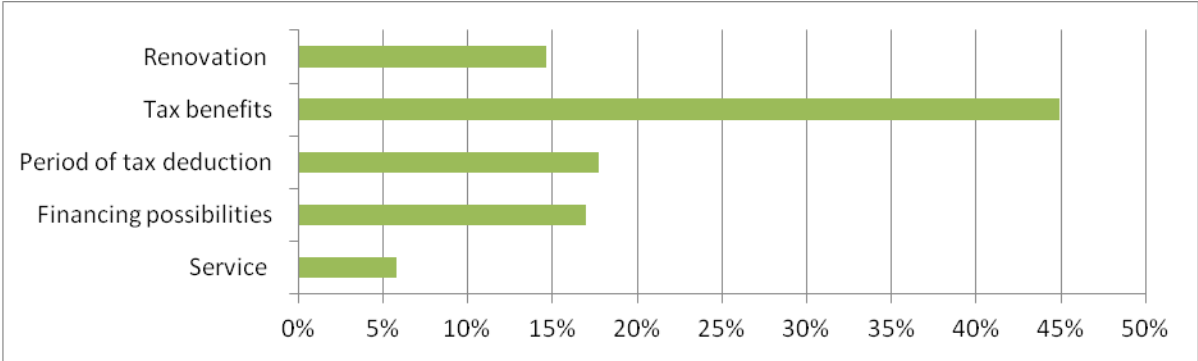

Figure 2: Relative importance of each attribute for implementation of choice sets

Part worth value of levels

The following figures will elaborate the value of each level for two important attributes. If a bar is positive, than the respondents find the level attractive which results in an increased positive attitude towards a particular choice package. When a bar is negative, it shows that the respondents find the level not attractive.
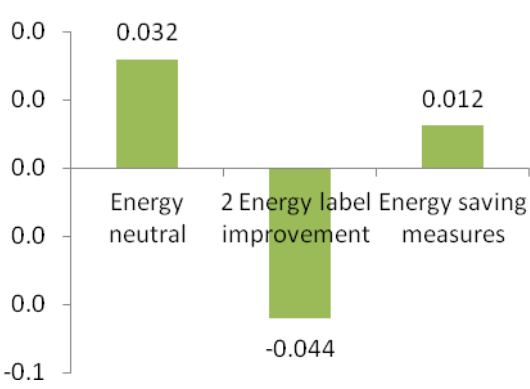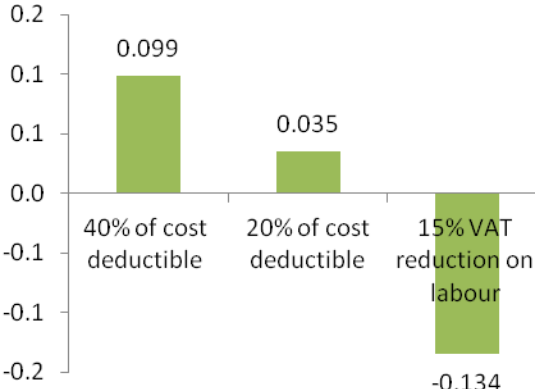

Figure 3: Part worth value of Renovation   *Figure 4: Part worth value of Tax benefits*

Renovation: Figure 3 shows that energy neutral renovation is the most important attribute level for homeowners. This is a logical result as energy neutral dwellings have the most of the benefits. Energy saving measures came as second and 2 energy label improvement came as last.

Tax benefit: Figure 4 shows that "40% of renovation cost deductible" has the highest value for the homeowners. "20% of cost deductible" has a negative value which means it has less value for the respondents, while 15% VAT reduction on labour which is current governmental policy to promote sustainability and create job in construction sector has least value for homeowners.

Comparison of three scenarios

By adding up the part worth values of *renovation* and *tax benefits* together, it can be concluded that scenario 1 is the most acceptable scenario for the homeowner with a part worth value of 0.131. The homeowners have negative preference for Scenario 2, while the existing scenario of the government is least preferred scenario (see figure 5). By taking the antilog of each of the total part worth values, the percentages to predict the proportion of homeowners who choose each of the scenarios to renovate their home is calculated. The

result showed in that 38% of the homeowners have chosen for scenario 1, 33% have chosen scenario 2 and only 29% have chosen the existing scenario.
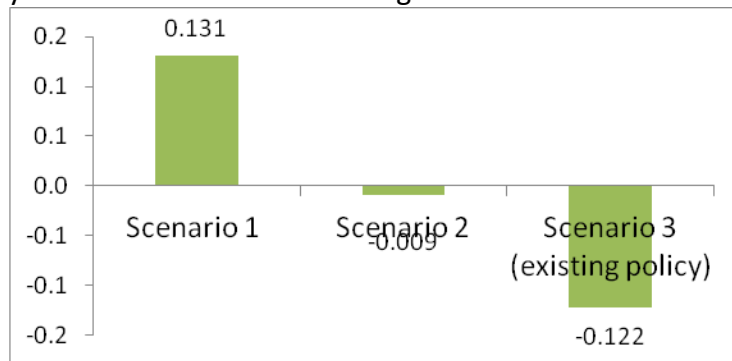

Figure 5: Comparison of different scenarios

Latent class analysis

As mentioned before, Latent Class Analyses (LCA) is a method which is able to find respondent segments in a sample group based on preference variables. For this research LCA is performed in NLOGIT. There are two class found in NLOGIT, class 1 which represents 63% of the respondents and Class 2 which is representative of 37% respondents. The classes are named after the analysing the differences in part worth values of levels. Class 1 is named as "Active homeowners" as this class is interested in energy neutral renovation with tax benefit of 40% tax deduction of renovation costs. Furthermore, this latent class has chosen for green mortgage and one-stop-shop as service option. All choices are logical and it seems that they are really interested in energy neutral renovation of their dwellings. In addition, the majority of the value in this class is significant and has p-value <0.05. The respondents in latent class 2 have minimal interest in *energy neutral renovation* and *2 energy label improvement*. Latent class 2 has high importance for *energy saving measures* and *40% tax benefits*. Therewith, it should be mentioned that 40% tax benefit has an insignificant value. It can be concluded that this latent class is not interested in energy neutral renovation, and therefore it will be named "*Passive Homeowners*". After analysing the output of part worth values and relative importance of attribute per class, two optimal packages with 95% confidence level are chosen for both classes. The packages are shown in the following table (see table 1).

Table 1: Characteristics of optimal packages

	Class 1 - Active Homeowners	Class 2 - Passive Homeowners
Attributes	Attribute level	Attribute level
Renovation	Energy neutral	Energy saving measures
Tax benefits	40% of costs deductible	15% VAT reduction on labour
Deduction Period	In 5 year time	Flexible
Financing	Green mortgages	Own savings
Service	One-stop-shop	Do it self

CONCLUSIONS

It should be mentioned that special attention should be given to financing of energy neutral renovation. Tax benefits and added property value after renovation can cover big part of the renovation cost and they can make the payback time of renovation cost shorter and therewith the renovation more attractive for homeowners. However energy neutral renovation needs a substantial additional up-front investments and not every homeowner has that money. Thus, it is important to make access to financing resources possible and

easy for homeowners besides tax benefits. Then, with the results of field research based on gathered data from the municipality of Barendrecht, it can be concluded that the homeowners showed high interest in energy neutral renovation with 40% tax benefits. The interest was large in choice of renovation packages as well as in implementation of them. The results showed that tax benefits and energy neutral renovation has high value for private homeowners. From scenario comparison it can be concluded that scenario 1 has the highest value for homeowners, followed by scenario 2. The existing scenario, scenario 3, has the least value and therewith it is the least chosen scenario among homeowners. Subsequently, the results of scenario comparison showed that 37 percent of homeowners, with 95% confidence level intend to renovate his dwelling towards energy neutral if 40% tax benefit is given. By use of Latent Class Analysis two possible segmentations of the respondents are derived from observed data for more accurate results. From the result of LCA, it can be concluded that class 1 with 63 percent of the respondents and 95% confidence level, were interested in energy neutral renovation with 40% tax benefits and green mortgage. Whereas, class 2 with 37 percent of the respondents, appeared to be not interested in energy neutral renovation. Finally, it can be concluded that tax benefits has a big influence on the willingness of homeowners to renovate their dwellings towards energy neutral level. The combination of 40% tax benefit and energy neutral renovation was preferred. The homeowners could have chosen for 40% tax benefit and 2 energy label improvement or 40% tax benefit and energy saving measures, but they favoured energy neutral renovation on other two mentioned renovation options.

DISCUSSION AND RECCOMENDATIONS
The field research has been conducted in municipality of Barendrecht. The majority of the respondents were highly educated and had on average high income than average Dutch citizens. A similar research among a larger group of homeowners from different municipalities can be done for better prediction. The percentage of tax benefit (40% for energy neutral renovation) is selected in a way that it is still profitable for the government. However a detailed calculation of cost and benefits is needed before coming to a conclusion that 40% tax benefit is profitable for the government. For example, homeowners pay energy taxes on every Kwh electricity and cubic meter gas that they use. When their dwelling is renovated, they will use less energy which means less energy tax. Thus, it is important to find out how much energy tax will government miss. On the other hand, the Dutch government achieves the agreed international goals, when the existing housing stock is renovated to energy neutral, it is important to calculate what the benefits of government will be by achieving environmental goals. Furthermore, the government and municipalities pay different subsides, when 40% tax profit is given to homeowners, than these subsidies will be not necessary for private homeowners. Thus, it is important to calculate how much the government and municipalities can profit from this measurement. Finally, a system dynamic modelling can be used to predict the effect of different scenarios described in this research on environmental goals and construction sector for longer period of time.

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SUSTAINABLE BUILDING REUSE
Understanding user preferences for the housing market

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ABSTRACT

Vacant buildings represent an insufficient exploited "gold mine" for future developments. By finding the future users preferences, vacant buildings can be reused and could generate a significant contribution towards a more sustainable development within the construction industry. Throughout this paper the environmental, social and urban benefits of building reuse are presented and a discrete choice experiment is used to indicate the most important attributes and the preferences of the potential future occupants.

Keywords: sustainability, building reuse, vacancy, discrete choice experiment, housing market, user preferences.

INTRODUCTION

Due to increased focus on sustainability and the current European Union targets to reduce the carbon footprint, the construction sector, as a major energy consumer, should also explore its options towards more sustainable solutions.

There are ongoing research works to investigate how to significantly reduce the consumption of energy and material flows in the building industry. In residential buildings, embodied energy in the building process represents between 30 and 100% (for passive houses) of total life cycle energy consumption. That is why, the adaptive reuse of existing building stock that has reached the end of its useful life, but not its physical life, is an important ingredient in the necessary change of the building industry in order to diminish its impact the environment and to conserve valuable resources for the future.

Vacant buildings represent an insufficient exploited "gold mine" for future developments. By finding the future users preferences, vacant buildings can be reused and can generate a significant contribution towards a more sustainable development within the construction industry.

When considering sustainability performances, the environmental benefits of building reuse are obvious from waste management and embodied energy perspective, but there are other two major factors that must be taken into account. These are the economic and social development in terms of its life cycle performance. Building vacancy is an emergent problem of our society with repercussions not only on environmental level but on economic and social levels too. This research hopes to elucidate the specific attributes that

would lead to success and increased feasibility of a building reuse project. Decreasing vacancy and encouraging developers to consider building reuse, as viable solution prior to demolition and new build, will lead to a more sustainable build environment.

Successful reuse and preventing vacancy in the building's new life must be ensured by uncovering users' preferences on specific attributes. Revealing attributes and quantifying their importance according to potential future occupants' preferences is the key to a sustainable reuse project that will prevent further future vacancy.

PROBLEM DEFINITION AND RESEARCH QUESTION
According to statistics by 2030 more than 80% of the global population will live in cities. Inevitably, this puts a substantial pressure on urban land use, especially as, over time, the built environment becomes obsolete and needs replacing. By regenerating previously developed buildings to maximize the use of existing resources, the increasing pressure on urban areas can be answered. Of course this is not sufficient to solve such a great emergent problem, as urban agglomeration, but it makes the best out of the available inner city means and can diminish urban sprawl. The focus of the adaptive reuse of vacant buildings is on the ones from urban areas, justified by the high land value and the increasing losses caused by their vacancy.

"*The existence of unused buildings represents an underutilization of city resources, a missed opportunity for forms of urban development that might, with simple yet often untried technical solutions, make effective use of physical resources. These buildings represent a negative feature for the idea of the sustainable community.*" (Ball, 2010) Reuse of an existing structure may be a project's major sustainable feature. But finding the right structure for reuse that also meets users' preferences in terms of location and attributes is the challenge. Coping with vacancy by transformation into housing is the main issue of this research as the transformation of structurally vacant buildings may offer a solution to the tight Dutch housing market.

This leads to our main research question:
What type of building is best suited to fulfill customer preferences in a building reuse project developed for the housing market?

During this research the focus is on building reuse for housing purposes. Both industrial and office buildings are tested against user preferences in order to asses which one proves to be best fitted for the new use.

In order to better understand vacancy coping possibilities, other sub questions are answered:
Sub question 1: What are the contributions of building reuse towards sustainability within the construction sector?
Sub question 2: What is the targeted market segment?
Sub question 3: What are the main attributes that future users look for in a reuse building project developed for the housing market?

RESEARCH DESIGN
The research comprises of 4 main blocks: a literature study, a case study, a discrete choice experiment and results analysis and conclusion.

By focusing on buildings reuse contribution to sustainability and current state of vacancy in the Netherlands and Eindhoven, the literature study tries to answer the question:

Why does building reuse matter? Considering current market trends, a solution for diminishing the increasing levels of vacancy is proposed.

The case study is researching Eindhoven's potential for building reuse. Using the results of this case study and the market situation, a discrete choice experiment aims at finding future users' preferences. This is a market research using an online questionnaire, specially developed to give insight on possible future users expectations.

The last part of the thesis analyses the results of the market research, a conclusion is drown and recommendations are made.

WHY DOES BUILDING REUSE MATTER?

Adaptive reuse of buildings

'Adaptive reuse is a process that changes a disused or ineffective item into a new item that can be used for a purpose other than which it was built or designed for.' (DEH, 2004) While old buildings become unsuitable for their programmatic requirements, as progress in technology, politics and economics moves faster than the built environment, adaptive reuse comes in as a sustainable option for the reclamation of sites. In many situations, the types of buildings most likely to become subjects of adaptive reuse include industrial buildings, as cities become gentrified and the process of manufacture moves away from city; political buildings, such as palaces and buildings which cannot support current and future visitors of the site; and community buildings such as churches or schools where the use has changed over time.

Adaptive reuse is seen as an effective way of reducing urban sprawl and environmental impact of the build environment. By reusing an existing structure within a site, the energy required to create these spaces is lessened, as is the material waste that comes from destroying old sites and rebuilding using new materials. Through adaptive reuse, old, unoccupied buildings can become suitable sites for many different types of use.

There are often several criteria for deciding whether a building should be conserved and reused or just demolished, these generally concern historical and social value of the site, natural ecological condition of the site and potential for reuse of the structure, as in potential damage, and building's character and fitness for the new use.

Buildings reuse contribution to sustainability

Contribution of building reuse to a sustainable environment must be regarded from environmental, economical and socio-cultural points of view.

While economical benefits are still being debated, due to unforeseen expenses or costly interventions in order to update old buildings to current standards; the environmental and social ones are obvious.

An important debate currently running in the building industry concerns the relative costs and related benefits and constraints of reuse versus new build. Adaptive reuse may not be an economically viable option when the structure of a building requires extensive strengthening to be undertaken. Also the presence of contaminations by substances or other materials, such as asbestos, and nonconformance with current governmental health and safety standards can become barriers for adaptive reuse.

Environmental benefits of building reuse

One of the environmental benefits of building reuse is diminishing urban sprawl by

maximizing the use of inner city resources, thus preserving greenfiels.

Another environmental benefit of building reuse, compared to demolish and new build, is the preservation of the embodied energy of the building. In residential buildings, embodied energy in the building process represents between 30 and 100% (for passive houses) of total life cycle energy consumption. The total life cycle energy consumption is made up of embodied energy and operational energy. Operational energy is the energy requirement of the building during its life from commissioning to demolition (not including maintenance or renovations). The embodied energy is the energy required to construct and maintain the premises. A brick wall for example, consists of the energy required to make the bricks, transport them to site, lay them, plaster them and (if necessary) paint and replaster over the life of the wall.

The reuse of building components is an alternative for the reduction of construction and demolition waste when renovating and demolishing buildings. By performing building deconstruction, the recovery of building parts as functional components such as bricks, windows, tiles is enabled. This is different from traditional demolitions in which parts are transformed into amorphous materials. The energy used in producing building materials corresponds to a considerable amount of the total energy consumed during the building life cycle, thus reusing and recycling buildings parts result in an energy saving that cannot be ignored.

But still, the most energy efficient solution considering the lifecycle of a building, with smallest environmental impact, is the reuse of the building, incorporating reuse of materials, components and forms of the building. The remaining parts of the building can be reused and form a new existence, together with the additions. This way, hardly energy is required to keep the materials in the built environment. With a rehabilitation design, there are always subtractions and additions. This process can be even forward improved by reducing the unnecessary subtractions and by minimizing additions. Further on, by not extracting natural resources for the additions, the designer will be preventing and preserving the natural resources.

Social benefits of building reuse

For society, vacancy presents problems of insecurity and social uncertainty and may bring about criminality ranging from vandalism and graffiti to break-ins, illegal occupancy and fires. Abandoned buildings are often unattractive, and it is not just the building itself, but their surrounding grounds too, and they affect other properties within a neighborhood by lowering property values, having a negative effect on community and neighborhood aesthetics. Other negative impact of vacancy on social level may concern purely economic aspects of well being as they trigger loss in tax revenues for the community as a whole. By adaptive reuse of these buildings, negative impacts are removed and replaced by the benefits of new developments. Also, adaptive reuse can restore and maintain the heritage significance of a building and help to ensure its survival

Current vacancy levels

Though it seems unrealistic for a densely populated country like Netherlands, to face vacancy, the numbers are increasing day by day, for example: a farm a day, two churches a week and so on. (Vacant NL, 2010)

In Netherlands, on industrial level there is 3.5% vacancy, leading to above 9 million sqm of vacant estate; for office 14.6% vacancy, which is considerably higher than 8%

assumed normal on a healthy property market and resulting in almost 8 million sqm of vacant property; and for retail there is a 5.9% vacancy rate resulting in almost 2 million sqm. The research is focusing on office and industrial buildings, as they generate the highest amount of vacant estate.

In Eindhoven, the office market has 13% vacancy rate, below the national level and still decreasing, and a 9% vacancy for industrial property, the second highest vacancy rate in Netherlands, with continuous increasing tendency.

Proposed solution

When faced with vacancy, property owners have 5 different options of coping with this problem. Preservation and waiting for better times to come, thus generating maintenance costs and susceptibility of the building to vandalism, squatting and degradation. Renovation or upgrading, resulting in disruption of building use and income of revenues, might be expensive and does not guarantee the influx of new users if vacancy is due to location characteristics. Selling, on a lower price that initially expected, because selling a vacant building results in smaller prices than for a fully occupied one. Demolishment and new build, which is an expensive solution and a waste of materials if the building is in a good state. Transformation/reuse of the building, resulting in disruption of use for a shorter period, but must also consider that location is suited for the new use.

Considering the tight Dutch housing market and the continuous migration toward urban areas, vacant buildings are proposed for reuse to support the increasing housing demand and as an adjoining solution to urban sprawl.

In Netherlands, the shortage of dwellings is approximately 2.5% of the total housing stock and with the increasing number of households (CBS, 2010) and a large part of the housing stock that needs to be replaced, will lead to an increase of demand if the production of housing is not speeded. According to CBS, Central Statistical Office , the number of persons per household is changed, from an average of 3.93 person/household in 1950 to 2.22 person/household nowadays and a predicted further decrease to 2.09 persons by the year 2040 (CBS, 2005). Following this trend, the demand for single occupancy dwellings (like e.g. apartments) will increase.

Transformation of structurally vacant buildings into housing can help balance the housing supply and at the same time create redevelopment possibilities for these buildings of which the current function no longer satisfies market demands.

In such a tight housing market, newcomers have a difficult time finding accommodation. So the target groups is composed of lower income groups like students and starters, singles or couples. Smaller housing units developed for starters, can also be suitable for elderly, so they are also included as possible market segments.

BUILDING REUSE POTENTIAL IN EINDHOVEN

In order to test Eindhoven's potential for building reuse, a list of vacant buildings was created using information from RealNext (2013) and Funda-in-Business (2013). Obviously not all vacant buildings are suitable for redevelopment into housing and through literature a wide variety of tools and instruments have been developed in order to analyze buildings' transformation potential and feasibility using a range of criteria.

Wilkinson, James and Reed (2009) made an extensive literature study about the attributes identified in previous researches considering risks which need to be acknowledged and managed in reuse projects. These building adaptation criteria are summarized as age,

condition, depth of the building, envelope and cladding, structure, building services, internal layout, flexibility for a range of differing uses and functional equipment, purpose of the built buildings, location, perceived heritage value, size, accessibility, proactive policy making/legislation (planning and building codes including fire), acoustic separation, user demand and site conditions. (Wilkinson, James, & Reed, 2009)

The adaptive reuse potential (ARP) is a conceptual framework, which requires an estimate of the expected physical life of the building and the current age of the building, both reported in years. It also requires an assessment of physical, economic, functional, technological, social and legal obsolescence. Here the economic variable is tightly related to the geographic location of the building relative to a major city, central business district or other primary market or business hub. (Langston, 2012)

There is also a 10 performance criteria tool developed and used to assess the level of satisfaction that a residential building can offer to its users, developed by Ilesanmi (2010). These criteria concern: external visual quality of buildings, maintenance quality of buildings, structural quality of buildings, detailing quality of buildings (doors, windows, ceilings, roofing members), quality of building services and, quality of estate roads, quality of landscaping, quality of semi-public open spaces, quality of environmental layout, quality of the location. The first five criteria relate to the buildings, while the next five deal with their location. They cover aesthetic, functional and technical quality. (Ilesanmi, 2010)

In its book on building adaptation, James Douglas (2006) published a series of checklists developed by Building Research Establishment (BRE), BRE Good Building Guides. These checklists focus mainly on the buildings characteristics and their potential of transformation, and do not approach the location or neighborhood characteristics. (Douglas, 2006)

For this study only a quick-scan is used to select the case studies, using an adaptation of the "transformation meter" developed by Geraedts and Van der Voordt (2003) (2007) (Remøy & Voordt, 2007). This tool, initially developed for office buildings, uses physical aspects of buildings and their location in order to estimate their value and suitability for housing, also considering organizational and market aspects. While most of the aspects related to the internal building characteristics can be modified, the location criteria can be the source to a negative transformation advice. For transformation to be a feasible way of coping with structural vacancy, location criteria should be met. It must also be taken into consideration that the financial feasibility of the transformation projects varies greatly depending on the targeted market segment.

The initial list was filtered using aspects related to location and building characteristics, like floor height and building depth, which were unanimously considered most important throughout literature.

Location is the most important, as it is the only aspect about the building that can't be modified no matter the amount of investment. If located in the city centre, in housing areas or on the edges of such areas, they have high possibility of suitability for transformation into housing, while transformation of buildings in mono-functional parks will need further consideration, as they need to be considered on a large scale urban area development. Other aspects related to location that must be considered are pollution, noise, air-quality, travel time, parking possibilities, level of facilities and services in or near the location, green area and the mix of functions are the most important.

From building characteristics point of view, structures must provide the minimum allowable floor height for housing units and their depth must allow day light inside the

dwelling.

Taking these aspects into consideration, a final list with a total of 11 buildings with reuse potential was created, showing that Eindhoven has high potential for such redevelopments.

DISCRETE CHOICE EXPERIMENT

The discrete choice approach requires that a representative sample of customers make choices in simulated situations derived from realistic variations of market offerings. Performing a discrete choice model experiment typically comprises of three steps. First, using market assessment, case studies, industry data, literature reviews and other information sources, a list of drivers that are believed to influence customers' decisions is compiled. Once the list of choice drivers, attributes, is finalized, experimental design techniques are used to develop many realistic versions of alternative offerings. Next, choice experiments are constructed that ask respondents to select one out of two or more alternatives available to them in a series of choice sets. In the final phase, econometric models based on responses from a representative sample of potential future customers are used to identify empirical key patterns in the survey responses, providing a relative weighting, for each attribute and its levels. Developers and managers can then select the optimal combination of attributes to develop a profitable and sustainable value proposition that, under normal competitive constraints, will maximally leverage their available resources. (Verma & al, 2009)

For the market research, an online questionnaire was developed both in English and Dutch, and it was distributed through social media. All respondents were presented with a scenario, developed according to the targeted market segment. Because the target market consists of lower income groups, the housing units are for rent and the energy label is B, in order to keep the redevelopment costs and also the rent prices lower. All housing units have parking and are easily accessible, as required for the selection of the case studies in Eindhoven.

The attributes used were: type of housing unit, surface of the dwelling, price that was defined in relation to the distance to city center, availability of private outdoor, furnishing and type of building.

Figure 1. Researched attributes and their levels

Building type attribute was introduce because it was of interest to see how the initial use of the building affects the decision of the respondents, as building type can influence not

only the exterior appearance of the building but also the internal layout and the character of the housing unit. If respondents reject a certain building type, this has a great influence on the number of buildings suitable for housing transformation that Eindhoven has to offer. Respondents were presented with 8 choice sets each consisting of two alternatives and a "no choice" alternative.

Features	Alternative I	Alternative II	None
Housing unit	One bedroom	Studio	
Surface	50-75 sqm	50-75 sqm	
Price	13-16 euro/sqm	13-16 euro/sqm	
Private outdoor	None	Garden	
Furnishing	Fully furnished	Semi-furnished	
Building type	Industrial	Office	
Your choice	⊙	◎	◎

Figure 2. Example of choice set

Next to the discrete choice questions, respondents were asked to answer some questions regarding their socio-demographic characteristics (SDC), stating their age and size of the household, in order to generate interest groups. Though our target group consisted of singles or couples, many respondents with households with children took part in the survey.

IDENTIFYING GROUP PREFERENCES

In total there were 230 respondents, above the minimum threshold of 200. The market group of adults with children (between the ages of 33 and 64) was highly represented among respondents, but also had the highest percentage of "no choice" responses. This was expected as they are the least probable to be interested in the small housing units.

The minimum number of respondents of 30 was reached for all age cathegories except the 65+ group, where only 2 respondents addressed the questionnaire, so this market segment, elderly, can't be further modeled.

4 blocks of multinomial logit model (MNL) were generated. The first model was designed with all respondents in one group, the second grouped respondents by age, the third grouped respondents by age and household and the last one where respondents were grouped by household size. Goodness of fit increases with the increase in heterogeneity of the group, so the focus is on the third block, where respondents are grouped also by age and household size, generating 5 groups: 18-24 singles, corresponding to students; 25-32 singles and couples, corresponding to starters; and 33-64 couples and families with children, corresponding to adults.
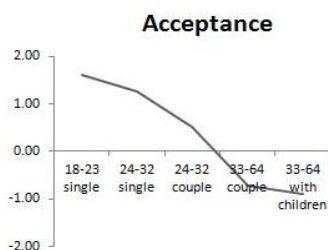
Figure 3. Acceptance variation

The general attitude towards the presented alternatives was modeled. This varies from + to -, showing that age group 33-64, couples or with children, are not interested in these type of developments, while younger age groups show a high level of acceptance. This was expected as adult families were not part of the targeted groups. A positive outcome is that the targeted groups, students, young singles and couples, have a positive attitude towards this type of redevelopment. Further on, only the targeted market segments is analyzed.

The table from Fig. 4, images the preferences for each attribute level by targeted market segment. Here the non-linearity of the estimated attributes levels is highly visible, and so are the differences in preferences between groups.

Attribute	Level	18-23 Single Coeff.	Sig.	Graph.	24-32 Single Coeff.	Sig.	Graph.	24-32 Couple Coeff.	Sig.	Graph.
Housing unit	Studio	0.216			-0.013			-0.288		
	One bedroom	-0.216	0.079		0.013	0.853		0.288	0.001	
Surface	30-49 sqm	0.147			0.024			-0.691		
	50-75 sqm	0.005	0.974		0.119	0.187		0.202	0.069	
	76-100 sqm	-0.151	0.375		-0.143	0.172		0.489	0.000	
Price	9-12 €/sqm	0.518			0.418			-0.018		
	13-16 €/sqm	0.055	0.696		-0.054	0.565		0.120	0.293	
	17-20 €/sqm	-0.574	0.002		-0.364	0.002		-0.102	0.457	
Private outdoor	None	-0.400			-0.658			-0.745		
	Balcony	0.110	0.431		0.314	0.000		0.066	0.544	
	Garden	0.290	0.073		0.344	0.001		0.679	0.000	
Furnishing	Unfurnished	-0465			-0.210			-0.181		
	Semi furnished	0.218	0.159		0.041	0.663		0.133	0.237	
	Fully furnished	0.247	0.159		0.169	0.109		0.048	0.713	
Building type	Office	0.004			-0.100			-0.058		
	Industrial	-0.004	0.975		0.100	0.136		0.058	0.482	

Figure 4. Market preferences

For students, or low income singles, the most significant attribute is price. This target group is looking for the cheapest housing possibility, with a preference for studios. The availability of a garden is also an important factor for this group, as it is for all groups within this model

For starters, 24 to 32 years-old singles, the acceptance is lower than for the previous group, but still high. Price and private outdoor are statistically significant, with similar preference for either balcony or garden.

Young couples with two incomes, have the lowest positive acceptance level, but still show a positive attitude towards these renting units. They are more interested in the division of the housing unit (with preference for separate bedroom), bigger surface and private outdoor, with an obvious preference for garden. For this group, price is not among the outmost significant attributes.

The results of the MNL model can be easily incorporated into a decision support system (DSS) so that the impact of changes in the levels of attributes on choice shares can be predicted. Also tradeoffs in different attributes levels can be tested in order to find the most attractive solution, or to test market competition. By introducing data of different alternatives, probabilities or utilities generated by them can be predicted

CONCLUSION AND DISCUSSIONS

From the discrete choice experiment it resulted that the targeted market segments (18-23 singles, 24-32 singles and couples) are open to the idea of living in reused buildings, rejecting neither industrial nor office ones. The fact that none of the industrial or office buildings are considered as a negative feature of the redevelopment represents a positive outcome as it results in an increase of the number of buildings that can be considered for transformation.

Due to the high contribution to sustainable urban development, building reuse should be encouraged by municipalities, by being cooperative and allowing exceptions from the zoning plan or facilitating legal procedures. Another way for municipalities to encourage such redevelopments is by limiting access for developers to greenfields, and forcing them to look for project opportunities within the city boundaries and by lowering land lease for vacant buildings.

Further research can be developed to establish if adult families reject the proposed housing units due to the size of the household or due to the building reuse. By increasing the size of the housing unit other market segments can be reached and their interest in such redevelopments can be tested.

Another implication of the findings of this research can be the development of a integrated support tool that assists developers in choosing the best structure for reuse, by acknowledging not only the best solution from the investor's point of view (building transformation potential), but the future users' preferences as well.

Taking into consideration that society is changing in a faster rhythm than the build environment, architects should develop buildings that are easily adaptable, thus buildings should be regarded not as a finished product, but as an ongoing process as part of a dynamic built environment.

ACKNOWLEDGEMENTS

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Born in 1985 in a family of civil engineers, Cristina began her engineering studies in Romania in 2004, graduating as a structural engineer in 2009. Willing to further her studies, she turned to the management field of the construction industry. Combining both her interest in buildings and management, she researched the potential of building reuse as a solution for a more sustainable build environment.

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SUSTAINABLE BUSINESS MODELS FOR PUBLIC CHARGING POINTS

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ABSTRACT
This paper is about the placement and operation of public charging points for electric vehicles. The points are placed in semi-large Dutch municipalities during 2013 to 2015 and operated until 2020. Different costs-, income- and organisation measures are combined in scenarios, showing the financial impact on the budget of the operator. Interviews are held with involved stakeholders on the measures and scenarios, revealing their opinions and preferences. Combining the analyses leads to a recommendation on optimal measure combinations.

Keywords: Electric mobility, public charging infrastructure, operating, scenario planning

INTRODUCTION

The transportation sector is gradually changing from a fossil fuel based sector to a green, durable fuel transportation sector, including electric vehicles. There are obstacles that hinder a successful growth of electric vehicles in the Netherlands. One of these obstacles is the limited amount of public charging points. The municipalities of the G4 organised public tenders to place points and a cooperation of distribution system operators (DSO) called e-laad placed 2500 free points all over the Netherlands. E-laad announced in September 2012 to end the placement of public points (e-laad, 2012). The last points will be placed in 2013. Without the support of e-laad, municipalities outside of the G4 do not have procedures for the placement and operation of public charging points. As a result there are currently no public charging points being placed, inhibiting electric vehicles to charge in the public space. The problem discussed in this research is therefore stated as: *There is currently no long-term viable business case for the placement of public charging points in Dutch municipalities outside of the G4, inhibiting the stimulation of electric mobility.*

Due to the recent state of this problem, there is not much research available on this subject. The research that is available is often outdated, due to the very dynamic market development. Some research has been very valuable. For instance, research performed by the national government on possible cost changes and the required law changes (Taskforce Formule E-team, 2012) and research performed by Movares on the extended private grid connection (Movares Nederland B.V., 2013). This report elaborated on these researches, by investigating the financial impact of the changes and collecting and analysing the opinions of

stakeholders on the changes. Furthermore this research contributes to solving the stated problem by also analysing income and organisational measures. Similar to the cost measures a financial and stakeholders analysis is held. The research question answered in this research is therefore stated as:

'What is the optimal combination of costs-, income- and organisation measures to stimulate the placement of public charging points, for the benefit of electric vehicle users?'

This research is restricted to semi large Dutch municipalities. The public charging points will be placed in 2013, 2014 and 2015 and operated until at least 2020. Measurements applied start in 2013. The costs are only examined for the operator.

METHOD
To answer the research question the following research model is used.
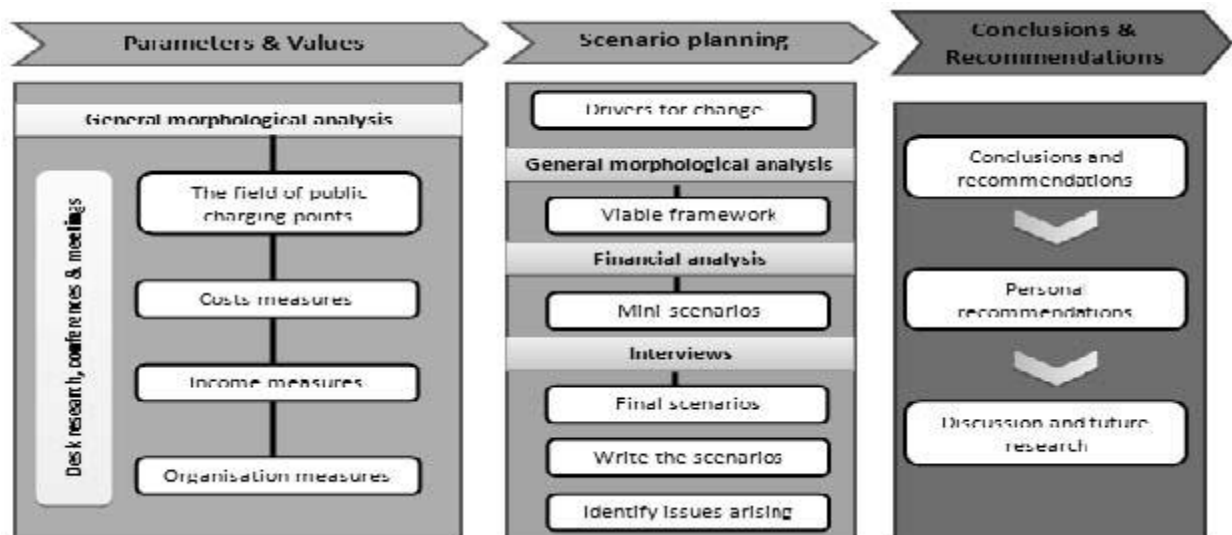

Figure 1. Research model

The research model is divided into three parts. Each part consists of several chapters, visualized as the white boxes. The light shaded bars visualize the used methodology.

The first part describes the parameters and values involved in the research. Distinction is made between fixed and variable parameters. The fixed parameters are set in the chapter *The field of public charging points*. The variable parameters are described in the chapters *Costs measures, Income measures* and *Organisation measures*. The background information on parameters and values is gathered trough desk research, conferences and meetings. General morphological analysis is used to identify the most important parameters and values (Ritchey, 2009). The second part uses the scenarios planning steps developed by Mercer (Mercer, 1995). This research will focus on normative scenarios that investigate how to reach a certain target. First an overview is given in *Drivers for change* of the parameters and values as found in part 1. In chapter *Viable framework* the combinations of parameters and values that are inconsistent with the research question and goal of the research are removed using general morphological analysis. Rules are established to perform a financial analysis using an Excel model revealing the operators' budget over the period 2013 to 2020. The results lead to mini-scenarios, in the chapter *Mini-scenarios*. In the chapter *Final scenarios,* qualitative

interviews are held with 14 of the involved stakeholders to assess the parameters and mini-scenarios and to use this information to develop three final scenarios. The main reason for conducting a qualitative interview is to obtain other, not foreseen, opinions and options to create a sustainable business case. The next chapter describes these final scenarios. The final chapter of this part analyses the scenarios by identifying the issues arising trough information gathered in the interviews, a financial analysis and a sensitivity analysis. The third part gives conclusions and recommendations on the results found. Personal recommendations are given and discussions and future research described.

FINDINGS

The research will focus on AC mode 2 type 3 stations with either one or two points attached. The points will be placed in semi-large Dutch municipalities, with 50 points placed in both 2013 and 2014 and 100 points placed in 2015. The points will be in use until at least 2020. It is assumed that 75% of the electric vehicles will be hybrid and 25% will be fully electric vehicle. The points are placed for two types of usage, as shown in figure X. It is assumed that 90% of the points fall under the first category of 3,7 kW points and 10% under the second category of 11 kW points.
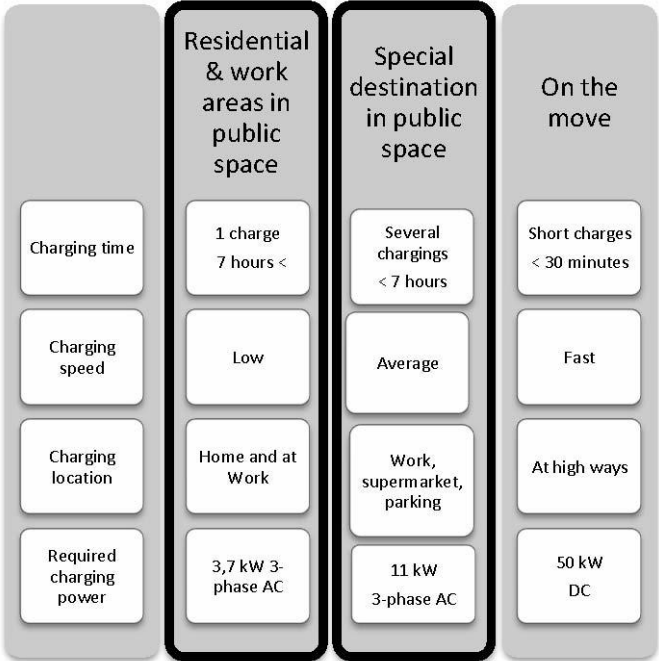

Figure 2. Focus groups based on usage

Measures

The cost, income and organisational measures taken into account in the final scenarios are:

Cost measures	Description
Practical measures	
Placement cooperation	Operator takes over municipal construction works and if possible the construction works of the distribution system operator. This results in a reduction of €200,- per public charging station
Extended private grid connection	Connect station with existing grid connection. The owner of the connection owns the station. Only 3,7 kW points are placed. The hardware is reduced with €1000,- per station. The construction costs are €700,- per station. Grid connection costs are zero.
Meter - Change requirements	The measuring device is changed and simplified. Yearly costs paid to the distribution system operator remain the same. Hardware costs are reduced with €50,- per station.
Law related measures	
Meter - Remove meter device	The meter from the distribution system operator is removed. Other meters in the stations must be improved, resulting in non changing hardware costs. No operational rent has to be paid.
Large-scale consumer	A network of public charging stations in one geographical area and belonging to one operator is qualified by the law as one large-scale consumer. As a result the energy tax can be consolidated, paying a lower tax rate for large quantities of energy. The tax rebate is only granted for one object and not for each object, due to all points qualified together as one object.
New connection category	A new connection category allowing smart grid options, like controlling the charging time, capacity and costs can prevent high peaks in energy usage. Cost for this new connection category can therefore be lowered. A 25% discount on grid costs is established.

Income measures	Description
Discounted interest rate	Discount of 5% or 3% on interest rate bank loan. Government stands guarantee for the investment
Public subsidy	Public parties' subsidies the capital expenditures of the operator. Subsidy is either 25 %, 50%, 75% or 100%
Revolving fund	Public and private parties start a fund for the capital investments. Operator repays between 2016 and 2020. Interest rate not included. Fund is either 25%, 50%, 75% or 100%
Higher energy price	The energy price to the service provider ranges between € 0,27 and €0,59 /kWh in order to be comparable to private charging while be lower than driving on fossil fuels
Implementing starting rate	A starting rate per transaction between € 0,- and € 1,-. It is expected that on average users charge 10 kW per transaction.

Organisational measures	Description
Set the specifications	Either public parties or the operator
Set the price	Either public parties or the operator

Some values used in the final scenarios differ from values used in the mini-scenarios due to new gained information based on either market developments or the interviews analysis.

ANALYSIS

The financial- and interview analysis of the mini-scenarios revealed the following: Placing 100 stations with two 3,7 kW points is most beneficial compared to station with two 11 kW points or 90 stations with one 3,7 KW & 10 stations with 11 kW points. Above 3000 kWh per year the influence of subsidies and revolving funds is limited. On average vehicles charge 2000 kWh per year. Starting rates are very influential on the cumulative budget in 2020. Most stakeholders prefer stations with two 3,7 kW points, a usage of 2000 kWh per year and the introduction of a starting rate.

X-axe value	1	2	3	4	5
Description	Least preferred	Not preferred	Neutral	preferred	Very preferred

Figure 3. X-axe description

Each stakeholder has its own preferences on costs- and income measures to implement. Matrixes are constructed combining an average of these opinions with the financial impact of the measures on the total costs or cumulative budget in 2020 for 180 stations with two 3,7 kW points & 20 stations with two 11 kW points. Both with a usage of 2000 kWh/year.
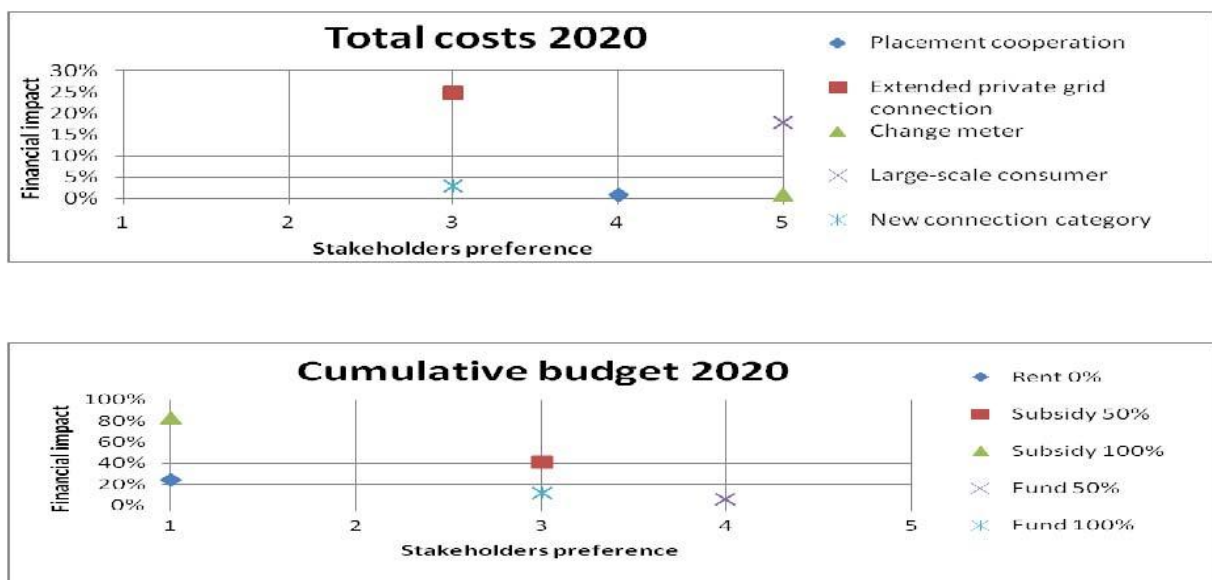
Figure 4. Costs and income combination financial impact | stakeholders preferences

Bases on the analyses final scenarios are constructed. They each have their own theme, see figure 5. The highlighted boxes show the measures implemented in the specific scenario. Each scenario has a positive budget for the operator in 2020. The highest cumulative budget is reached in the scenario 'Operator in control' which also has the most stable budget

throughout the period 2013 to 2020. After 2020 most profit is gained in this scenario, due to the paid off fund. The scenario 'Government in control' is most profitable for the users due to the lowest price per kWh. This scenario also requires the highest subsidies. The scenario 'User in control' requires a second user for income. It is assumed that the house owner does not pay extra for the charged energy.

Government in control: public tender

AC2 kW / point	Costs measures	Income measures				Organisation measures	
		Rate	Subsidy	fund	Energy price	Ownership	Price setter
3,7	Placement	0%	0%	0%	0,27	Government	Government
	Meter		25%	25%			
	New connection	2%	50%	50%	0,30		
11	Large user		75%	75%	Starting rate	Operator	Operator
	Extended connection	5%	100%	100			

User in control: Concession

AC2 kW / point	Costs measures	Income measures				Organisation measures	
		Rate	Subsidy	fund	Energy price	Ownership	Price setter
3,7	Placement	0%	0%	0%	0,27	Government	Government
	Meter		25%	25%			
	New connection	2%	50%	50%	Free | 0,40		
11	Large user		75%	75%	Starting rate	Operator	Operator
	Extended connection	5%	100%	100	None| 1.00		

Operator in control: Licence

AC2 kW / point	Costs measures	Extended connection				Ownership	Price setter
		Rate	Subsidy	fund	Energy price		
3,7	Placement	0%	0%	0%	0,27	Government	Government
	Meter		25%	25%			
	New connection	2%	50%	50%	0,40		
11	Large user		75%	75%	Starting rate	Operator	Operator
	Extended connections	5%	100%	100%	1,00		

Figure 5: Final scenarios and their measures

A sensitivity analysis on the final scenarios reveals that the kW per point, the kWh per year and the management and maintenance costs have significant influence on the cumulative budget in 2020. Comparing the scenarios on qualitative and financial aspects reveals that each scenario has their own benefits and downsides. Choosing one optimal scenario for all municipalities is therefore not possible. The choice depends:
- Implemented law changes
- The level of control the municipality wishes to have on specifications and price
- The municipalities' willingness and capability to invest in public charging points

CONCLUSIONS
Knowledge gained by literature, discussions and interviews led to an overall image of the possibilities to establish a feasible business case for public charging points. The research and analysis revealed that at this moment, not all public points are profitable to operate, but by combining certain measures, a positive business case can be established. Opinions of

stakeholders on which kind of costs-, income- and organisational measures will lead to the optimal business case, differ. The scenario planning, financial analysis and sensitivity analysis showed that the measures are profoundly interlinked and must be seen as part of a whole.

Overall, the research reveals that small differences in parameters significantly influence the budget of the business case. Changes in for instance the usage per point from 2000 to 3000 kWh per year, makes essentially unprofitable scenarios very profitable. Predictions on these parameters are uncertain, due to the dynamic developments in the field of electric mobility. As a result, business cases implemented during this period of development and innovation are linked with high risks, but also with interesting opportunities worth investing in.

Due to the many different correlations between aspects involved in establishing a positive and sustainable business case for operators in 2020, several combinations of measures to stimulate the placement of public charging points are possible. Depending on the cost measures implemented, the three final scenarios revealed which income and organisational measures are required to establish a positive budget for the operator. By analysing these scenarios, it was concluded that a combination of the scenarios complies with the preferences of most stakeholders, see paragraph 11.4. By combining the different scenarios, it is possible to place and operate points with limited public financial help. This is especially interesting for semi-large municipalities without financial budget. The market is made commercial and users are expected to contribute by higher prices per kWh and a starting rate. To operate commercially the municipality must set rules operators must oblige to. The optimal combination of costs-, income- and organisational measures is dependent of the public investments, usage and progress in implementing costs measures. For these reason it is advised to allow several business cased in one municipality. The municipality can subsidize points with low usage, while allowing the market to set the price. This price will decline ones more costs measures are implemented. Figures from paragraph 9.3 are used to show the financial impact and stakeholders' preference on the costs and income measures.

Main conclusions
- Only place stations with two points of 3,7 kW
    - Only on request by users & locate at the nearest street corner
- Allow several business cases in one municipality
    - **Operator in control**
        - High usage locations without public investments
        - Minimal usage each point: 2000 kWh/year
    - **Government in control**
        - Low usage locations with 25% public subsidy
        - Minimum usage each point: 1500 kWh/year
    - **User in control**
        - Extended private grid connection
        - House owner pays 50% point | € 150,- a year | no energy costs
        - semi-exclusive parking place
        - Minimal usage second point: 1000 kWh/year

- Operators set the price and implement a starting rate
- Without cost measures the price required is: **€0,40/kWh & € 1,- starting rate**

- With cost measures the price drops to €0,30/kWh & €1,- starting rate
  - Focus on treating stations as one large-scale consumer
  - Change connection category allowing flexible capacity rates
    - Reduce grid costs for public connections under 3x35 Ampere
    - Simultaneously change the meter device, no sooner.

- Shorten municipal procedure for licences & parking policy to maximum 4 weeks
- Shorten installation period for distribution system operator to maximum 4 weeks
- Municipality sets basis specifications: exterior, safety, interoperability & location

- If the municipality has the financial means: subsidise points with low usage
  - Otherwise: optimize procedures and allow market initiatives

Personal recommendations

Besides the conclusions and recommendations from the research itself, I personally have some recommendations.

Open the market to all operators complying to set specifications

Due to the dynamic market developments, I recommend not giving an exclusive contract to a set number of operators for a specified period. Opening the market enables new initiatives. This positively influences market competition and innovation. Furthermore, I advice a minimal distance between two points, reducing the risks attached to competition. The municipality should set specification as mentions in chapter 12. These can be extended with minimal limits to interoperability, management and maintenance.

Municipality sets maximum price per kWh and starting rate. Operator can lower the price.

To make the market self-sustaining I advise to let the operator set the price. This model enables fair competition with semi-public points outside the municipal scope. To prevent price increases for users who are dependent on public points, the municipality can decide to set a maximum price of €0,40/kWh and € 1,- starting rate.

Focus more on private and semi-public charging points

I agree with some operators, to put more emphasis on private and semi-public points. They cost less and do not need municipality interference. Furthermore, most users drive a hybrid electric vehicle, reducing the need for acutely charging and vehicles can charge during the day at work locations. This optimizes smart grid usage with decentralized energy production. In my opinion, electric vehicles must be considered part of a bigger electricity transition network, fulfilling a vital role in future smart grid applications.

DISCUSSION

By combining costs, income and organisational measures an overall view of the current market is given. This can be very helpful for all parties involved in establishing procedures for public charging points outside of the G4. Discussions and negotiations are vital during this stage and this research can give direction to the required solutions. A downside of the research is the uncertainty of all parameters, values and opinions used. The market is currently too dynamic, making it impossible to give correct measures. The research also revealed how opinions changed during just a few months, for instance on the kW of points. As a result this research gives an indication of the market at this moment in time.

With yet no procedures for points placed outside het G4, discussions still involve all major stakeholders. It is of importance to reach consensus soon, because otherwise it will negatively affect the image users have of electric mobility. In the current economic situation, I do not expect smaller municipalities to take over the procedure of a public tender used in the G4. Municipalities simply lack the required finance. Operators, however, are willing to take the financial risk, provided municipalities fasten their procedures for placing objects in the public space. If municipalities set the specifications and maximize prices, I believe a sustainable market can be develop and expanded without public investments. Municipalities should provide the framework and let the market fill in the rest.

Future research should focus on the specific specifications set by municipalities, the interaction between operators and service providers, the behaviour of users in case of more differentiation between market models and the optimal division between AC- and DC charging points, which in my opinion are complementary to each other. It is also interesting to investigate some other measures mentioned by the interviewees. These measure were outside of this research' scope, including subsidising the usage instead of the points; reduce the subsidies through the years; or implement an energy tax per charged kWh.

I am looking forward to the dynamic period ahead. I am convinced that by taking the initiative now, electric mobility and charging at public points will in 2020 be part of the standard street scene in Dutch municipalities and beyond.

Figuur 1. Laadpunt in Amsterdam **(Bontenbal, 2011)**

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Working on this research has been very interesting due to the dynamic and constant market developments. I hope this report will contribute to a more durable future.

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TOWARDS SUSTAINABLE PARKING:

Decision making of governmental and commercial stakeholders

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ABSTRACT

Sustainability of the urban environment highly depends on the pollution and emissions caused by mobility. Recently, attention is growing on sustainability in relation with parking. As a result, the parking industry and government are embracing a large number of developments. In order to successfully cooperate in projects, municipalities and parking operators should focus on the most promising developments. MDCA and AHP provide decision criteria which are used to evaluate six important sustainable developments in parking. The final ranking of developments results in a first priority for 'introduction of electronical navigation, way finding and payment systems' by both stakeholder groups.

Keywords: Parking, Decision making, Sustainability, MCDA, Analytic Hierarchy Process.

INTRODUCTION

Mobility in general, and car usage in particular have a negative impact on the environment due to the use of (fossil) fuels, and the emissions of particulate matter [fijnstof] and exhaust gasses including CO_2 (Q-Park NV, 2012a). The energy consumption in urban districts, related to traffic and mobility, accounts for almost 20% of the total of energy use in the urban environment (Energiebureau.nl).

Sustainability of the urban environment highly depends on the pollution and emissions caused by mobility: in 27 European countries the transport sector is responsible for 19% of the greenhouse gas emission. The situation in the Netherlands is even more extreme: the transport sector is responsible for 35% of the total emission. Overall, the transportation sector is responsible for 30% of all fossil fuel emissions in the European Union (European Union, 2007).

Parking is an important aspect of mobility in the context of the urban environment. Parking facilities, as elements of the built environment, provide users with spaces for their cars nearby their destinations. As a result, it affects urban planning, spatial use, the convenience of transportation and sustainability of the city is growing. Recently, attention on sustainability in relation with parking. For example way finding to a parking space: "On a daily basis, it is estimated that 30% of vehicles on the road in the downtown area of major cities are cruising for a parking spot and it takes an average of 7.8 minutes to find one" (Arnott, et al., 2005). As a result, the parking industry and government is embracing a large number of developments ranging from sustainable innovations to environmental policy in the context of parking.

In general, four types of sustainable developments exist (van der Waerden, 2012; Farla, et al., 2010; Q-Park NV, 2012a):

1.   Sustainability by technological improvement of personal vehicles;
2.   Sustainability by construction of sustainable buildings;
3.   Sustainability by improving the efficiency of traffic and way finding;
4.   Sustainability by mobility and parking policy.

Decision making

The increase of traffic congestion combined with a societal focus on environment and sustainability, lead to challenges in how mobility and parking have to be managed. For example, municipalities are eager to reduce traffic congestion for the improvement of the quality of life by solving problems related to pollution and noise (Giuffrè, et al., 2012). Governmental bodies like municipalities, national governments and the European Union have "an important role to play in building a system of sustainable mobility, through regulatory policies, and strategic incentives and disincentives" (Vergragt & Brown, 2007).

A market party's willingness to embrace developments and innovation towards a more sustainable society is a function of the following aspects: its attitude towards cleaner technology (based on the party perception of environmental and economic risks); the pressure that the party perceives itself to be under; and the control the firm believes it actually has over the innovation of cleaner technologies (Montalvo, 2002).

Problem statement

Given the indicated developments; differences of interests; and governmental policies in the field of mobility and parking, it is difficult for cooperating stakeholders to choose, invest in, or predict the effects of (long term) sustainable developments. In order to successfully cooperate in a project, individual actors should be able to predict preferences and decision making of partners and competitors. Therefore, an analysis of attributes, characteristics, and decision criteria is required in order to enable stakeholders to anticipate in future developments. The problem statement is divided in two parts which are presented below.

1.   The aspects, characteristics, and attributes of developments in the context of sustainable mobility are not clear. Most effects on mobility and sustainability are assumed but not quantified in detail.

2.   Actors in mobility and parking embrace specific developments in the context of sustainable parking, but also need the cooperation of other stakeholders. Therefore, the most promising developments according to decision makers are required. A ranking of sustainable developments in parking is currently not available.

Relevance

As far as the author knows, limited scientific research is available regarding the decision making in and evaluation of multiple sustainable developments in the field of parking. Limited literature is available on decision making in parking (e.g. Litman, 2013; May, 2003) and decision making regarding sustainable innovations (e.g. Montalvo, 2002). On the other hand, sustainable developments are individually assessed by researchers (e.g. Bakker, 2011; Dijk & Montalvo, 2011; Giuffrè, et al., 2012). A certain combination of both approaches could not be found during the preparation of this research.

This research aims to find criteria to compare and evaluate sustainable developments in parking with respect to the decision making process. Besides insight in criteria, developments could be evaluated using these criteria and help to select the most promising developments.

The parking industry continuously adopts new innovations and developments in parking (KpVV, 2013). Generally, these developments are initiated by financial benefits (efficiency), technological innovation, societal change or policy by legislators (e.g. Farla, et al., 2010; VROM, 2010; Montalvo, 2002).

In order to decide which developments should be implemented in business planning, developments have to be prioritized according to the stakeholders' interest. As stated in this introduction, governmental and market parties influence decision making in parking. Therefore, it is necessary to find the influential criteria, current developments in parking and priorities of both stakeholder groups. Comparing these priorities, should provide the parking industry insight in the most interesting developments that are supported by both stakeholders. Consensus on priority could ease the decision making process and improve the financial benefits en outcome of adopted developments.

METHODS

The main question in this research is: "What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?"

In order to answering the central question four sub-questions have been defined: Which stakeholders are involved in the decision making process regarding to sustainable parking?; Which criteria can be used to evaluate developments regarding sustainable parking?; What are important developments in the context of sustainable parking?; What is the importance of selected criteria regarding developments in sustainable parking?

Research Framework

An extensive review of literature is considered the start of this research (Phase 1). It provides background information on the subjects parking, sustainability in parking, and decision making. Besides a description of the subjects and relevant mechanisms, the literature review is conducted to identify a number of current sustainable developments in parking; important stakeholders and their incentives, and decision criteria. These three elements will be used as key ingredients for the used research method in the next phase and answer the first three sub-questions.

Decision making in parking by governmental and commercial stakeholders is a complicated process. Together, parking operators and municipalities, led by specific incentives, decide over new developments in sustainable parking. An Analytic Hierarchy Process decision framework is built to capture decision criteria with respect to both stakeholders (Phase 2). The framework is used as a base for the next steps in the research. The second phase consists of Multi Criteria Decision Analysis (MCDA) based on the methods included in Analytic Hierarchy Process (AHP). Qualitative Dominance scores (QD) are used to synthesize the results.

By using MCDA, multiple criteria of alternatives can be considered comprehensively. The method combines criteria weights and evaluation scores of alternatives, resulting in a general value for each alternative. In order to find the criteria weights AHP is adapted to a specific quantitative form of multi criteria analysis. QD is used to evaluate the developments, on a qualitative base.

An on-line questionnaire is used to gather data from governmental and commercial stakeholders in parking. Experts, working for both stakeholder groups, are asked to complete the questionnaire in which criteria weights are determined and developments are evaluated. After the synthesis and analysis of data results are available and developments are prioritized.

In the finalization phase (Phase 3) results from the literature review and Multi Criteria Decision Analysis are used to answer the research questions. Recommendations for practice and science will show the relevance of the research findings for both fields.
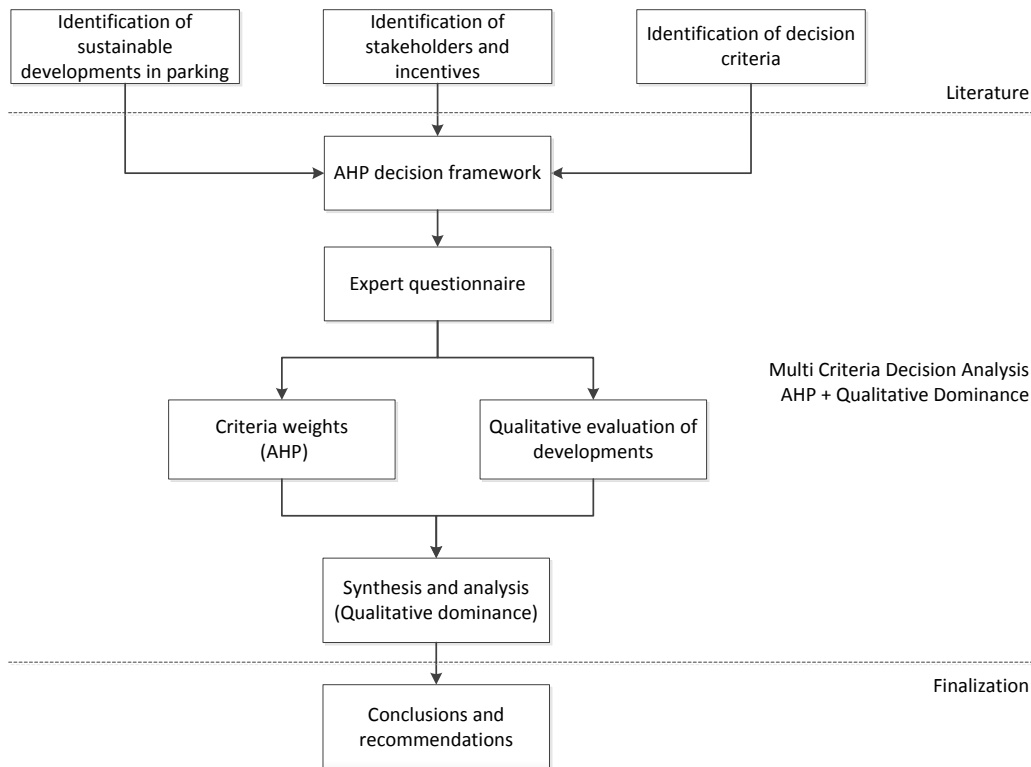
Figure 1: Research framework

FINDINGS

The results of the application of the research framework (figure 1) are presented in this section. First, the results from the review of literature, the selection of stakeholders, developments and criteria, are presented. Next, the criteria weights are established using the analytic hierarchy process and an example of a development evaluation is provided. Finally, Qualitative dominance scores provide a ranking of developments for governmental and commercial stakeholders.

Review of literature

Extensive review of literature took place to find the most important decision makers in parking that influence sustainable developments. Next, criteria are elaborated which enable one to evaluate developments. Finally, six development are presented which are evaluated in by the experts using a questionnaire.

Selection of stakeholders

Stakeholders in parking are divided in 'Government', 'Market', and 'Society'. The first two stakeholders influence decision making in parking. Municipalities (Government) enforce parking policy and Parking operators (market) exploit parking facilities and provide management services. Users (Society) and other stakeholders are indirectly involved. Generally speaking, decision making in parking is controlled by the government who develops policy and market parties that perform activities with facilities, services or products related to parking. Two parties decide directly on the implementation of new developments in sustainable parking: Municipalities (government) and parking operators (market). Other stakeholders, for example investors, are indirectly involved in this process. The direct and indirect relationships to the subject are presented in figure 2. As a result of this analysis, this research focuses on municipalities and parking operators.
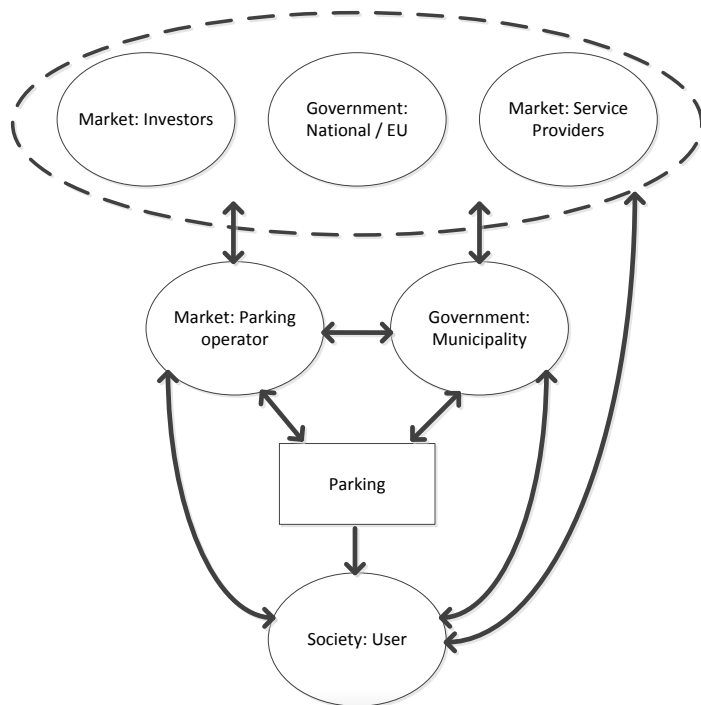
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Figure 2: Relationships between stakeholders

Selection of developments

The developments are categorized by type of sustainable development as suggested in the introduction. A recent publication (KpVV, 2013) about noteworthy developments in parking provided six important developments. These developments are described below and reflect on a theme of suggested by the KpVV publication (2013).

1.   Improving the sustainability of the existing parking stock (Theme: Sustainability): Replacement of facilities and equipment by new and more sustainable solutions, e.g. LED, innovations and efficient technology, at on-street and off-street parking locations;

2.   Developing charging networks for electricity driven vehicles (Theme: Alternative energy sources): A charging network at on-and off-street parking locations is introduced for hybrid and electric cars such as low and high voltage charging stations;

3.   Introduction of electronical navigation, way finding and payment systems (Theme: influence of IT): An electronic navigation and payment processing application introduced by payment providers offers customers the ability to navigate to an available on-or off-street parking location, to make a reservation and pay wireless;

4.   Increasing number of P+R and K+R areas in order to support Car-Sharing (Theme: Car-Sharing): The number of Park and Ride (P + R) and Kiss and Ride (K + R) areas with favorable rates and services increases for the purpose of Car-Sharing initiatives;

5.   Introducing policy in order to enable flexible parking standards (Theme: location specific parking standards): The introduction of flexible parking standards which are strongly related to the function, the use and configuration of urban buildings in the immediate vicinity;

6.   Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping (Theme: functional change of the built environment): The number of properties in inner city areas with a store function decreases due to shrinkage and internet shopping.

Selection of criteria

Review of literature showed that multiple decision criteria are available that represent stakeholders' incentives, sustainable goals in society, en presumed effects of developments. In this research, potential sustainable developments are evaluated to find differences and similarities in opinion between stakeholders.

Selection rules are used to find the most important criteria involved in the assessment of the developments in parking: criteria should be applicable to evaluate all types of developments; criteria represent incentives of both stakeholder groups; and vagueness of criteria has to be prevented. Payoff and outcomes of developments related to the decision criteria can be divided as impacts and effects. An 'impact' is described as the influence that something has on a situation or person. While 'effect' describes a more direct and intended result of a development.

The two definitions described above help to define the final decision criteria for this research. Impact criteria are used to describe the impact on the stakeholders' business plan: the 'financial aspects' and 'control aspects' that may be affected by the developments. On the other hand, effect criteria, are used to describe the outcome of a development regarding mobility and sustainability. The criteria, presented and described below, are selected from business planning and control criteria, policy criteria and EMAT criteria for parking (3).
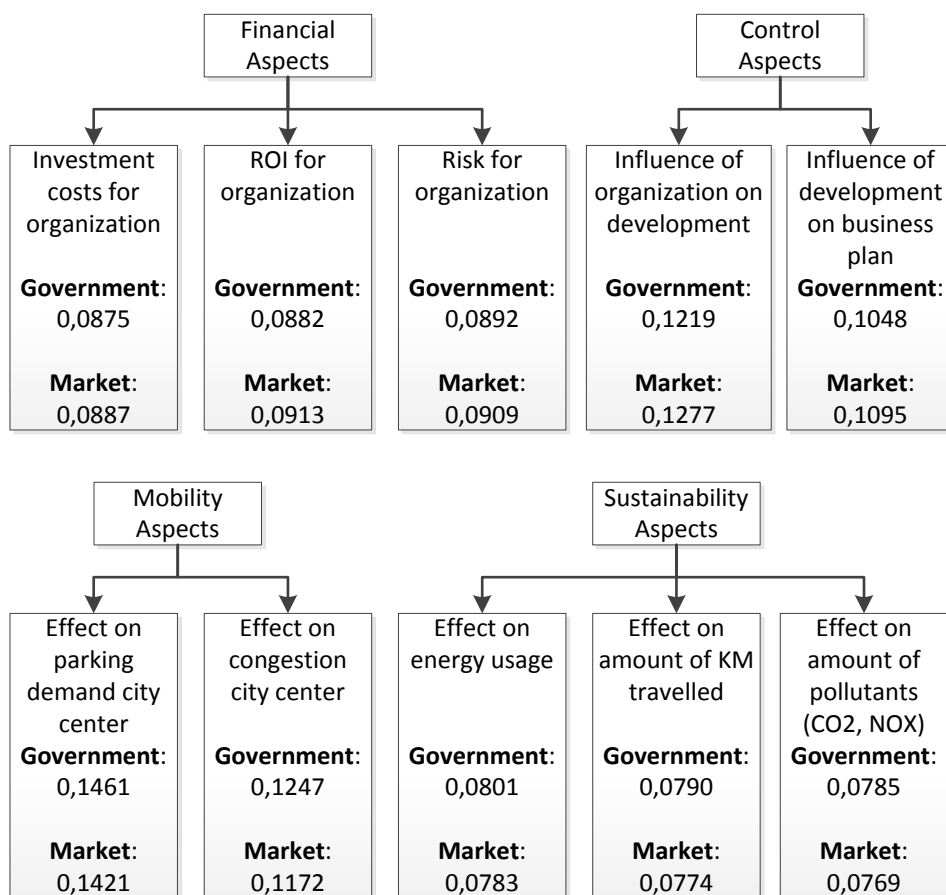

Figure 3: Hierarchy containing criteria and weights by government and market

Analysis

The approached expert respondents are selected from a group of decision makers from municipalities and parking operators. A third group, 'Consultants', was targeted which experts provide services to both key decision makers. A total of 109 respondents was approached. Approximately, 30% of the respondents finished the questionnaire. 45% of the respondents provided results that are usable for the prioritization of criteria. Background variables confirm that the majority of the experts are considered decision makers given their working field and professional activities.

AHP analysis is performed to find the weights of the decision criteria. First, a consistency check is carried out on the individual datasets of the questionnaire. It appeared, a consistency index of 0,15 is necessary to incorporate at least 10 respondents per stakeholder group. The AHP analysis on the stakeholder groups results in criteria weights (figure 3) that slightly differ from each other. Small differences in priority are presented for the 'criteria-groups', 'control aspects' and 'mobility aspects'. On criteria-group level, municipalities prefer the 'effect on mobility' above others while parking operators consider 'financial aspects' of more importance. Consensus is reached for 'control aspects'. The 'influence of the organization on the development is considered more important compared to the 'influence of the development on the business plan'. It emerged from the results for 'mobility aspects' that both stakeholder groups consider 'effect on parking demand in city center' more significant compared to 'effect on congestion in city center'.

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-9	High	-1	-6
ROI for organization	Low	-1	-1	Medium	0	3
Risk for organization	Medium	0	2	Medium	0	2
Influence of organization on development	Medium	0	-1	Medium	0	-1
Influence of development on business plan	Low	1	3	Medium	0	-5
Parking demand city center	Neutral	0	5	Increase	1	8
Congestion city center	Decrease	1	14	Decrease	1	6
Energy usage	Decrease	1	12	Decrease	1	9
Amount of KM travelled	Decrease	1	13	Decrease	1	12
Amount of pollutants	Decrease	1	16	Decrease	1	14

Figure 4: Example of evaluation scores: introduction for electronic navigation, way finding and payment systems.

By combining the criteria weights (figure 3) and modes of the evaluation scores (figure 4) for these criteria. The Qualitative Dominance scores (QD scores) are calculated. The QD scores (figure 5) for the governmental and market stakeholder result in a first priority for 'introduction of electronical navigation, way finding and payment systems'. 'Introducing policy in order to enable flexible parking standards' is prioritized second for the governmental stakeholder followed by 'improving the sustainability of the existing parking stock. The latter is prioritized second by the market stakeholder. A third position is given to 'increasing number of P+R and K+R areas in order to support car-sharing'.

Development (prioritized by government)	Si	Rank
Introduction of electronical navigation, way finding and payment systems	0,0496	1
Introducing policy in order to enable flexible parking standards	0,0054	2
Improving the sustainability of the existing parking stock	-0,0019	3
Increasing number of P+R and K+R areas in order to support Car-Sharing	-0,0022	4

Developments (prioritized by market)	Si	Rank
Introduction of electronical navigation, way finding and payment systems	0,0427	1
Improving the sustainability of the existing parking stock	0,0161	2
Increasing number of P+R and K+R areas in order to support Car-Sharing	0,0131	3
Increasing number of functional changes in inner city built environ-ment as a result of demographic change and internet shopping	-0,0189	4

Figure 5: Ranking of developments by QD scores for stakeholder groups

DISCUSSION

The selection of decision criteria and sustainable developments in parking are important results from this research. The selected criteria can be used to evaluate and characterize sustainable developments. The results, summarized in the previous paragraph, answer the sub-questions in this research. These sub-questions provide the basic elements that are required to conclude on the main question in this research: *"What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?"*

The results of this research (figure 5) showed which developments regarding sustainable parking are preferred most by the governmental stakeholder group (represented by decision makers of municipalities) and the market stakeholder group (represented by decision makers of parking operators). The rankings of developments by both stakeholder groups show the 'introduction of elektronical navigation, way finding and payment systems' as highly preferred. The prioritizations confirms the high number of related developments the parking industry such as the integration of parking information, mobile payment services and reservation services of parking operators.

On one hand, this research showed which developments are most promising regarding both stakeholder groups. On the other, the evaluation of the developments provide underlying criteria scores that affected the final prioritization. These underlying expectations of decision makers could be considered as strengths and weaknesses for the implementation of sustainable developments in parking.

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PERSONAL INFORMATION

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"Parking involves elements of real estate management, urban development, process management and technology. The topic is very interesting regarding the scope of CME."

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HOME BUYERS APPRECIATION OF INSTALLED PHOTOVOLTAIC SYSTEMS
A discrete choice experiment
Author: Thomas Wissink

ABSTRACT

This paper contains the most important findings of researching the preferences of dwelling buyers regarding dwellings on which the former owner installed a photovoltaic system(PV system). These preferences are determined using a discrete choice model on stated preference data of dwelling buyers in the Eindhoven region. The most important conclusions are that a PV system is on average highly appreciated by dwelling buyers and that this appreciation is relatively larger by dwelling buyers that live in more urban/central neighborhoods.

Keywords: PV, photovoltaics, solar panels, Eindhoven region, dwelling buyer behavior, owner occupied dwellings, discrete choice

INTRODUCTION

The increasing global wealth and population lead to an equal increase in energy use. Due to limited fossil resources and reputed climate effects, energy efficiency has become a challenging present-day problem.

Since the built environment has a large share in energy use, all sorts of measures that increase energy efficiency have been invented for buildings. A problem is however, that the building stock is not renewed as fast. Energy efficiency in the built environment is therefore focusing on both the design of new energy efficient buildings and on the improvement of energy efficiency in the existing stock. (AgentschapNL, 2012) Photovoltaic systems(PV systems) are an energy saving solution that is easy to integrate with this existing building stock. PV systems generate electric current from energy of the sun in a way it can be used in the socket (EPIA, 2010). The energy produced by PV cells as share of the total Dutch energy use, including transport, industry and households, is only 0,038%. However, the Dutch growth in PV power generated is not small: 64% growth in from 2010 to 2011(CBS, 2012) and 138% from 2011 to 2012(Cobouw, 2013).

Due to energy legislation, households pay the highest price per KWh. Saving energy for households has consequently the highest yield. Since rental dwellings have the problem of a split incentive between the investor in PV systems (the landlord) and the tenant that saves

the energy, owner occupied dwellings produced 60% of all PV energy in the Netherlands. Because in the case of an owner occupied dwelling, the investor in the PV system is the same entity that saves the energy and thus the money.

The amount of installed photovoltaic systems on owner occupied dwellings is growing rapidly in the Netherlands. The influence of a PV system on the market position of a dwelling is however unknown. The main question to be answered is: What is the behavior of dwelling buyers regarding installed PV systems? Researching this has practical relevance for the following reasons:

- Because little is known about the value effect of PV cells installed on owner occupied dwellings, risk averse investing is only possible if the investor expects to stay in the dwelling during the payback period. More knowledge about the value once installed could change this situation.
- The expected lifespan of PV panels is at least 25 years(Natuur&Milieu, 2013). It is thus very likely that dwellings with a PV system will enter the market. But so far it is unknown how buyers, sellers and realtors should deal with this new dwelling attribute.
- There could be differences between groups of dwelling buyers and their appreciation of PV. Mapping these differences helps to estimate how, where or by who the deployment of PV is mostly appreciated.

LITERATURE STUDY

There are only two research cases with limited relevance regarding the value effect on dwellings of PV systems. There has been a research in San Diego (United States), but this research is not based on transactions, but on valuations from before the credit crisis and thus the found premiums are not realistic anymore. However premiums of around 10% were found (Farhar, 2006).

Secondly through directly asking (Kets, 2006) researched the acceptable earning back periods for PV systems as attribute of a dwelling. The results are an average acceptance of 4 years. This means that people want to pay four times the yearly energy savings for a PV system. Sormani(2011) researched the preferences of dwelling owners when investing in PV panels on their roof. But the effect of the presence of a PV system once the dwelling is offered on the house market remains unknown.

METHOD

Since there is almost no market data of dwellings with PV panels, a revealed preference experiment is not possible. Therefore a stated preference method is used. This means that true behavior is not observed, but respondents are asked to indicate how they would behave in a hypothetical situation. This is done by two sub methods of stated preference: direct surveying and indirect surveying. Direct surveying means asking directly to respondents what their preferences are about a certain subject. Indirect surveying asks respondents questions and derives the preferences form the answers given. There are different types of indirect surveying. Discrete choice analysis (DCA) is the method chosen here.

DCA starts with analyzing the important attributes and it's levels. Secondly hypothetical products (dwellings in this case) with variations of these attribute levels are presented to

respondents. Respondents are asked to repeatedly make a choice between options or to choose "none of them". To keep the experiment simple for respondents the effect on choice was researched of a PV system that is feasible on the roofs of almost all rowhouses in Eindhoven, and that saves €600 in energy costs per year. All hypothetical dwellings are rowhouses. The attributes and levels are displayed in Table 1.

ATTRIBUTES AND ATTRIBUTE LEVELS

Attribute	Attribute level	Nr of levels
Price	€180.000	3
	€210.000	
	€230.000	
PV	Yes	2
	No	
Dwelling size	100m2	3
	120m2	
	140m2	
Location	Within Ringroad	3
	Outside Ringroad	
	Outskirts	
Building period	>1990	3
	1945-1990	
	<1945	

Table 1 The attributes and levels.

The underlying theory of Discrete choice modeling is the random utility theory(RUT). RUT assumes that all individuals when they are able to choose between alternatives, for example a house with a PV system and a house without a PV system, will always choose the alternative with the highest utility(1).

$$U_{in} > U_{jn}, \forall j \neq i \qquad (1)$$

Where U_{in} is the utility of the chosen alternative and U_{jn} are the other alternatives in the choice set that individual n can choose.

RUT assumes that the utility of a certain alternative exists of a systematic part that is explainable and a random part that is not explainable.(Hensher et al., 2005)

$$U_{in} = V_{in} + \varepsilon_{in} \qquad (2)$$

In equation (2) U_{in} is the unobserved utility that an individual n perceives from alternative i. V_{in} is the systematic, explainable component and ε_{in} is the random component. Because of the random component, the probability that an individual will choose a certain alternative can be calculated, but the exact choice cannot.

The systematic component can be modeled as the sum of part- worth utilities that depend on the different attributes and their levels.

$$V_{in} \;=\; \beta_0 + \beta_1 X_{in1} + \beta_2 X_{in2} + \cdots + \beta_k X_{ink} \;=\; \sum_k \beta_k X_{ink} \tag{3}$$

Equation (3) states that the systematic utility V_{in} of an alternative exists of the sum of part-worth utilities. X_{ink} is the value of attribute level k of alternative i that is in the choice set of respondent n. β_k is a parameter that indicates the contribution of attribute k on the utility of the alternative. Such an attribute could for example be the presence of a PV system.

With NLOGIT software it is possible to make estimations of β_k. With these estimates the probability P that alternative i will be chosen from choice set j can be predicted. This probability is the e-power of the systematic component of i divided by the sum of the e-power of the systematic utility (V_{jn}) of all alternatives.

$$P(i|j) = \frac{e^{\beta_k X_{ink}}}{\sum_j e^{\beta_k X_{jnk}} + e^{\beta_k X_{ink}}} \quad = \frac{e^{V_{in}}}{\sum_j e^{V_{jn}} + e^{V_{in}}}, \forall\, j \neq i \tag{4}$$

For consumer products DCE is also used to calculate willingness to pay for certain attributes of the product (Hensher, 2005; Breidert, 2006). This can be calculated by dividing the beta of the attribute of which the WTP is calculated, for example for the PV attribute, by the beta of a monetary attribute; β_{price}. These betas must be significant and the monetary beta must belong to a linear coded X_{ink} (Hensher et al., 2005). One might need to convert to the right unit by multiplying with a constant c (Breidert, 2006; Hensher et al., 2005).

$$WTP = \frac{\beta_k}{\beta_{price}} * c \tag{5}$$

It is however doubtful if this method is applicable on dwellings since preferences and financing are much more complex for dwellings than for a product in, for example, the supermarket.

SURVEY
18 treatment combinations, i.e. the constructed hypothetic dwelling alternatives, are presented in random order in 6 choice sets of three alternatives plus a "no choice" alternative. The variation of the attribute levels are orthogonal, this means that they are uncorrelated. With this design main effects and even two interaction effects can be modeled. The design is balanced, this means that all attribute levels occur an equal amount of times.

On top of the 6 choice sets there are 5 direct questions about:
• The location of the respondent
• The amount the respondent would be willing to pay extra for the standardized PV system.
• Whether the respondent had noticed PV panels in his or her neighborhood.
• The appreciation of the aesthetics of PV.
• The most important motive one would have if one would invest in PV.
These questions deliver the descriptive statistics of the respondents.

RESULTS

The MNL-regression of the dwelling alternatives on choice resulted in the effects on systematic utility V_{in} displayed in table 2. The rho squared is 0,06. If the location of the respondent is put in the model, rho squared is 0,14.

PARTH-WORTHS OF ATTRIBUTE LEVELS

Attribute	Attribute -level	Worth	
Choose	Choose a dwelling	+ 0,223	*
	Choose "no option"	+ 0,000	*
Price	€180.000	+ 0,000	*
	€210.000	- 0,265	*
	€240.000	- 0,530	*
PV	PV present	+ 0,308	*
	PV absent	- 0,308	*
Size	100m2	- 0,118	*
	120m2	+ 0,076	
	140m2	+ 0,042	*
Location	Within ringroad	+ 0,005	
	Outside ringroad	+ 0,064	
	Outskirts	- 0,069	
Period	<1945	- 0,577	*
	1945-1990	+ 0,056	
	>1990	+ 0,521	*

*Significant with 95% confidence

Table 2 The results of MNL model

If the effect of a PV system on the appreciation of a dwelling is positive and large this could mean that increasing the marketability of a dwelling can become one of the primary drivers behind PV deployment. Maybe the in the future people who sell their house install a PV system to make the dwelling more attractive for possible buyers. Of course the experiment done is only a first initiative that is done only for rowhouses in the Eindhoven region. But it seems that the appreciation is indeed large.

This PV system had the second largest positive effect on choice of a dwelling. The only effect on choice that was larger than the effect of having a PV system instead of not having a PV system was the effect of a dwelling being built after 1990 instead of before 1945.

The main conclusion is that dwelling buyers really appreciate it if the former owner installed a PV system. But more noteworthy dwelling buyers' preferences have been found:

Firstly, the hypothesis that PV systems will be appreciated more on newer dwellings than on monumental dwellings built before 1945 has to be rejected. However there is a problem with the rowhouses built before 1945. These dwellings do not exist much in Eindhoven and their appreciation was very different than comparable experiments in other cities showed. Therefore more research regarding this should be done.

Secondly, it was expected that dwelling buyers who were neutral or positive about the external appearance of PV systems would appreciate the systems more on dwellings than dwelling buyers that indicated they did not like the looks of PV. It appeared, however, that the opinion on the external appearance had no significant effect on appreciation of PV systems on dwellings. Despite this conclusion, the fact that only 4% of all respondents like the appearance of PV systems does show opportunities for companies to increase the appreciation of the aesthetics of PV. This could for example be done through better integration in the dwelling design or through innovative shapes or covers of the PV panels.

Thirdly, if respondents indicated that they had another primary motive to invest in PV(if they would) than the mere investment that earns itself back, they appreciated PV systems relatively more as a dwelling attribute. The explanation for this could be that the investment attributes count for everyone. But an idealist or person that feels independent of energy prices also, perceives extra utility from that. This comes on top of benefits from the investment. It is not the case that idealists do not save energy with their PV system.

This outcome may be helpful for the marketing of PV systems. More focus on the independence of energy prices and the saving of the environment(idealism) is likely to increase the utility that dwelling buyers perceive from PV. This is an interesting matter to research further.

Fourthly, for the Eindhoven region it has been found that people who live more central or urban appreciate PV systems much more. This could indicate that it is wise for PV projects to focus more on urban areas first; at least in Eindhoven.

With this design of the MNL- model it was unfortunately not possible to calculate what premium dwelling buyers would pay if a dwelling has a PV system. However quite some knowledge has been collected about the attitude of dwelling owners regarding PV technology. It is surprising how positive people react on the uninvited presence of a PV system on the roof of a dwelling one is considering to buy. The output of the discrete choice experiment together with the results of the direct surveying of the WTP leads to the conclusion that people are probably willing to pay at least the replacement value of the system: €5000-€7000. This is exceptional when one keeps in mind that a dwelling buyer wanted to buy a dwelling, not a PV system. Only 22% of all respondents did not want to pay anything for the system.

Reasons for this high willingness to pay might be:
- Socially desirable bias often seen in sustainability research(Banfi, 2005)
- Respondents paid extra attention to the PV attribute because they expected the research was about this.
- Respondents perceive risk when thinking of installing a PV system. An operative system actually saving €600 per year diminishes this perceived risk and leads to higher perceived utility.
- Respondents do not only value the PV system itself, but also the orientation of the house that apparently is suitable for installing PV. Just like dwellings with sea view cost a fortune, not because of the window but because of the orientation. Parallel to

this in the future it could be that not the presence of a PV system is valued, but the orientation to the sun.
- Stated preference data leads to less price sensitivity compared to true market behavior or revealed preference (Wardman, 1988).

CONCLUSION

Of course this research was only a first step in investigating this subject, but it seems that installing PV is very well possible when one is not sure if one will move in the near future.

In fact, there is quite some reason to believe that the high positive influence in the DCE model on choice, caused by a PV system installed, may result in a very welcome incentive for buyers that is relatively cheap. In this stuck dwelling market allowing sellers to be able to sell their dwelling quicker is very valuable.

RECOMMENDATIONS FOR FURTHER RESEARCH

This first research to the effect of PV systems on the dwelling market has found some interesting relations. However a realistic willingness to pay has not been found with this MNL-model. A more advanced choice experiment that also takes into account the demographics of the dwelling buyer and his or her financial position and mortgage- and tax situation may result in a more realistic WTP outcome.

But what is this research worth if it does not lead to any action? What would a policy maker do with it? A nice experiment project could be that a government subsidizes a total PV system on dwellings that have been for sale for a long time. Then it should be checked, with a control group of comparable dwellings that are also for sale, if the dwellings with a PV system are sold earlier. After the sale the seller can pay off the PV system.

Policy makers in the Netherlands always talk about two important problems they want to solve: 1. the stuck dwelling market and 2. the unsustainable way energy is generated and used. This experiment would, if successful, help to solve both problems. And the investments costs are limited. Another recommendations for further research is to investigate whether the relations that are found, such as between idealism and appreciation of PV, are causal or not. And lastly the research could be done in other regions and dwelling market segments.

ACKNOWLEDGEMENTS

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Thomas Wissink

In this thesis I was able to research something totally new. This has two sides: It was hard to have little guidelines to follow. But the upside is that I had quite some liberty because I was off the beaten track. This made me feel that this thesis was really my project. And I was always proud to tell people about it either in a bar or at a job interview.

Short CV

2005 – 2009	Bachelor Bouwkunde, Eindhoven University of Technology
2009 – 2010	Deficiency program Business Economics, University of Amsterdam
2010 – 2013	Master Construction Management and Engineering
2010 – Now	Master Finance, University of Amsterdam
2009 – Now	Derivative assistant, NYSE Euronext

ENERGY SERVICES FOR BUSINESS DISTRICTS

Author: Has van der Zanden

Graduation program:

Construction Management and Urban Development 2012-2013

Graduation committee:

prof. dr. ir. W.F. Schaefer, Eindhoven University of Technology
Drs. P.H.A.M. Masselink, Eindhoven University of Technology
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Ir. J. Krijgsman MRE, Brabantse Ontwikkelings Maatschappij

Graduation date:

28-08-13

ABSTRACT

Business districts account for the largest part of energy use in the Netherlands. However, these districts have up to now received little attention with regard to their energy use and efficiency. The mid-sized manufacturing industry is characterized by high energy intensity and high saving potentials. The high and concentrated energy use of these companies makes them interesting clients for the energy service industry. The feasibility of these ESCos is influenced by the factors; ''Demand of energy'', ''Energy prices'', ''Subsidies'' and ''Technology development''. To study the influence of these factors, a system dynamics (SD) model was made. From this study can be concluded that outsourcing energy related services to an ESCo by the mid-sized manufacturing industry is certainly interesting for both parties.

Keywords: ESco, business districts, renewable energy, energy efficiency, system dynamics, Morris analysis

INTRODUCTION

Business districts are important areas in the Netherlands because they provide 30% of total employment. Circa 3600 business districts provide suitable space for companies to vest. Businesses need space for production, offices, showrooms, storage facilities, infrastructure and for the possibility to grow in the future (Farla, et al., 2006). In past years, business districts received little attention with regard to their energy use and efficiency. Obsolescence, deterioration, accessibility and security of these areas have been the subjects in the spotlights. This is remarkable, taking into account the high use of energy on business districts (Mulder & Lindt, 2010). The energy saving potential on business districts is estimated in the range of 30% based on experiences in foreign countries (PeGO, 2009).

Current electricity- and gas price trends show increasing expenditures on the energy bill. To maintain a competitive position on the global market and guarantee the continuity and profitability, the implementation of energy efficiency measures and renewable energy is of growing importance (Ministerie van Economische Zaken, Landbouw & Innovatie, 2011). The EU has set objectives regarding climate change mitigation, aiming for a reduction of 20% in greenhouse gas emissions compared to 1990 along with a 20% share for renewables in the

final energy demand by 2020. To reach this, the Dutch government has an important role as initiator and policy maker. Therefore, several agreements have been made with varying industries considering the type of business activity and the amount of energy use. These agreements obligate companies to implement energy efficiency measures and renewable energy individually while the government leaves the responsibility to take action with the companies (ECN, Energie-Nederland and Netbeheer Nederland, 2012).

Despite the enormous saving potential within business districts, developments regarding energy efficiency and renewable energy are slow and fragmented. Awareness of the possibilities is growing but development is often constrained by the complex environment of stakeholders and responsibilities, rules and regulations and uncertainties. In the face of rising energy prices and binding regulation, energy efficiency and renewable energy will inevitably become more important. The high and concentrated energy use of business districts makes them interesting clients for the energy service industry. An energy service company (ESCo) is specialized in delivering energy services and can relieve these companies from implementing and financing energy efficiency measures and renewable energy sources (Ministerie van Economische Zaken, Landbouw & Innovatie, 2011).

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

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

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

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

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

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

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

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

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

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

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

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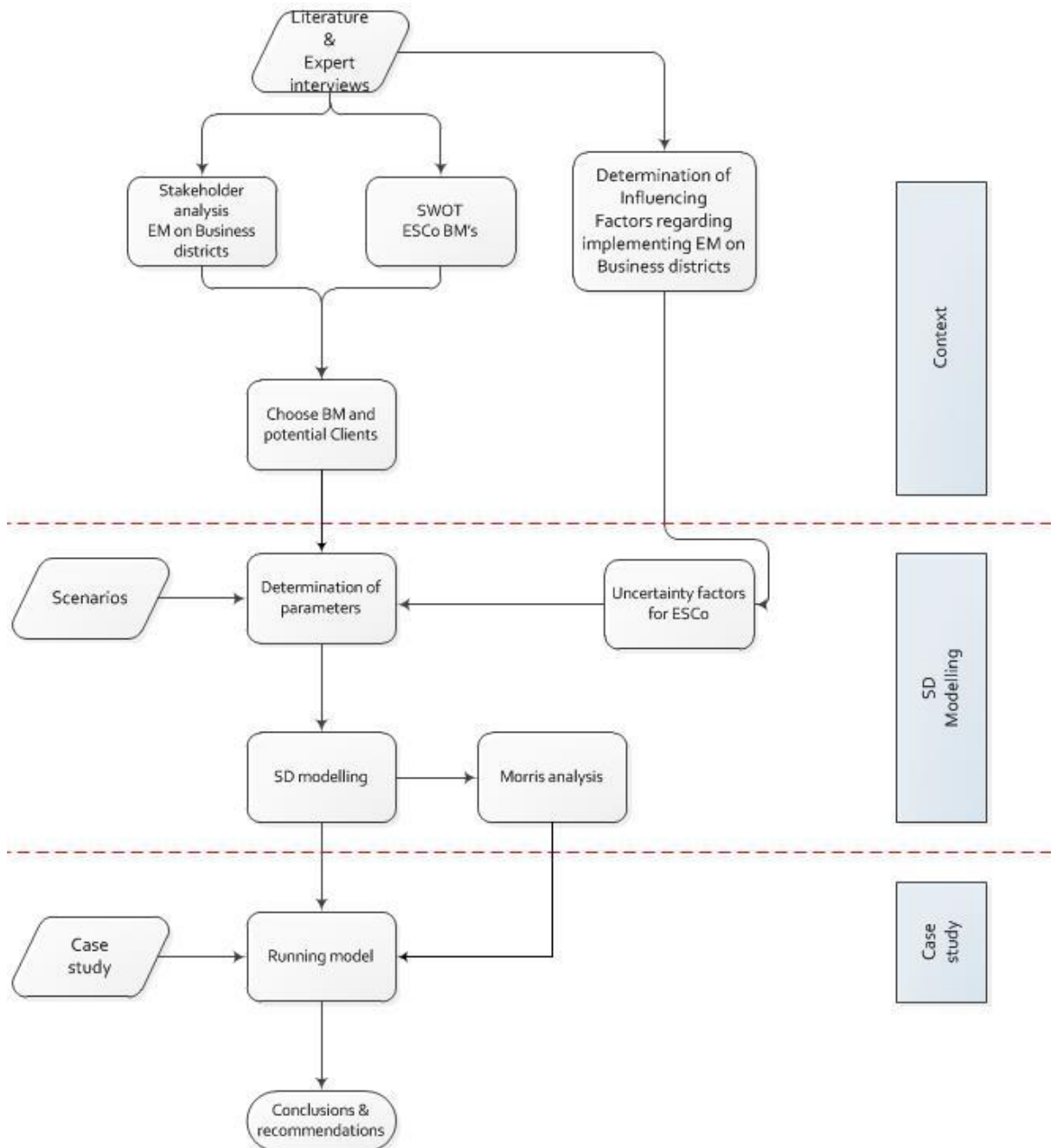
Figure 1 Research Design

LITERATURE

Business districts

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

This research focusses on existing mixed industry or mixed business districts because the majority of districts (62%) is of this category. Furthermore, high-end industry and heavy

industry parks have often already adopted their own specific programs to save energy and are outside the scope of this research.

The saving potential on business districts is estimated to be in the range of 30% of current use based on experiences in foreign countries. (PeGO , 2009) This potential can be achieved by implementing energy efficiency and renewable energy measures.

The energy use of companies in business districts correlates strongly with the type of industry they are in. As stated in the introduction, awareness of the importance with regard to the sustainable use of energy is growing. For commercial companies, becoming more environmentally involved is by itself not an objective. Sustainability can however contribute to improving financial results. Corporate social responsibility (CSR) regarding energy efficiency is found to be inferior to a company's primary objectives; its continuity and profitability. To reach these objectives, companies constantly aim for higher market share and cutting costs (Vaal- van Hooren, et al., 2012). However, the CSR of companies is growing in importance. This is pointed out by research done by the ministry of economic affairs and ''MVO Nederland''. As part of this research, companies in each branch of industry were asked if their customers raised requirements regarding their CSR. Figure 2 shows the results over 2008, 2009 and 2011.
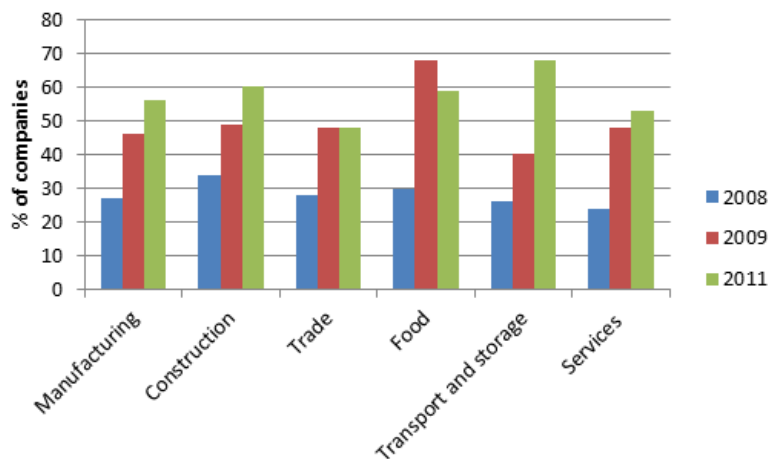

Figure 2 Percentage of companies that experienced increased requirements from their customers regarding CSR (Ministerie van Economische Zaken, Landbouw & Innovatie, 2011)

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

The following table shows the share of energy costs with regard the total overhead of different branches of industry. To see is the importance of this cost within the manufacturing industry. Therefore, there is chosen to select this branch as target group for the energy service industry.

Branch of industry	B Mining and quarrying	C Manufacturing	D Energy supply	F Construction	G Trade	H Transport and storage
Totals	8980 (100%)	42412 (100%)	2812 (100%)	8988 (100%)	66451 (100%)	24368 (100%)
Energy	94 (1%)	6084 (14%)	28 (1%)	361 (4%)	1769 (3%)	364 (1%)

Figure 3 Overhead cost of energy

Based on the conclusion that the manufacturing industry in Dutch mixed industry business districts offers the highest potential for saving on energy expenses, the question arises how this can be reached. Clearly, energy needs to be managed in a better way. Energy management includes planning and operation of energy-related production and consumption units. This research aims on improving energy efficiency on buildings level and implementing renewable energy systems as an energy management approach.
The figure below shows influencing factors that hinder development of this approach in the current situation, so without using an ESCo.
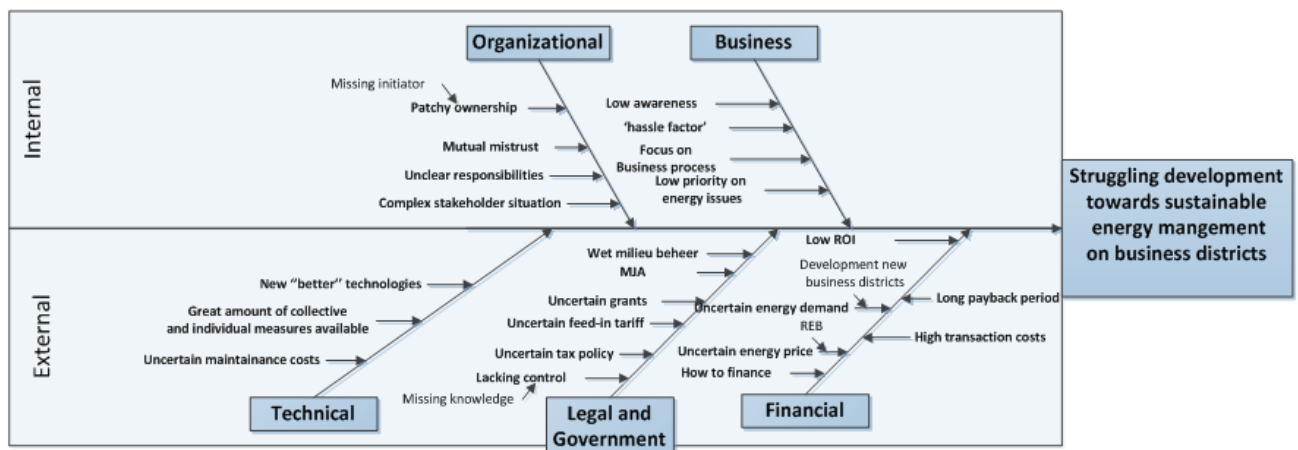

Figure 4 Causal diagram regarding "Sustainable energy management on business districts"

An Energy Service Company (ESCo) is specialized in energy management. It can cope with many factors that hinder development towards energy efficiency and renewable energy supply in business districts.

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

Several business models are used within the ESCo industry divided in Product-service-Systems (PPS), business models based on new revenue models and business models based on new financing schemes. The PPS models are relevant for this research because they consider energy efficiency and renewable energy and are determined to be applicable in the

industrial sector (Würtenberger, et al., 2012). This group contains; Energy performance contracting, Energy supply contracting, Integrated Energy Contracting. The IEC model appears to be the most promising for business districts. Therefore, it is adopted as the model of choice in this research. The further use of the term ESCo in this paper refers to this specific business model.

When the services and organizational specifications of this business model is used in business districts, it can cope with almost all factors as shown in figure 4. However, some uncertainties can affect the success of the ESCo as well. These uncertainty factors will be further assessed within this research and are reformulated as; ''demand of energy'', ''energy prices'', ''subsidies'' and ''technology development''.

For energy service projects to succeed on business districts, the integral approach is important. There are many stakeholders that are important to consider when implementing energy services in business districts. To assess the most important parties involved, a stakeholder analysis is made. This analysis is based on expert interviews and literature. When implementing an ESCo in a business district, several stakeholders are important to take into account. The ESCo itself has high interest in clients with large energy use and potential to save on energy use. They can arrange the technology, expertise and financial means to reach the saving potential. However, companies have low awareness with regard to the ESCo industry. Park management and public development agencies can help raise awareness about the possibilities of outsourcing energy related services. Furthermore, since the ESCo industry in the Netherlands is relatively new, the financial institutions are skeptical and require a sound business case to invest in such projects.

RESEARCH METHOD
System dynamics (SD) is used to create a net present value (NPV) model that includes these uncertainty factors. To learn more about the impact each factor has on the financial result, a sensitivity analysis (SA) has been incorporated.

System Dynamics
The uncertainty factors; ''demand of energy'', ''energy prices'', ''subsidies'' and ''technology development'' are represented by parameters than can be used in the SD model which is shown below. The factor ''technology development'' is described in the capacity and price of the implemented renewable energy system. The ESCo will use PV panels for electricity- and UHV panels for heat generation.
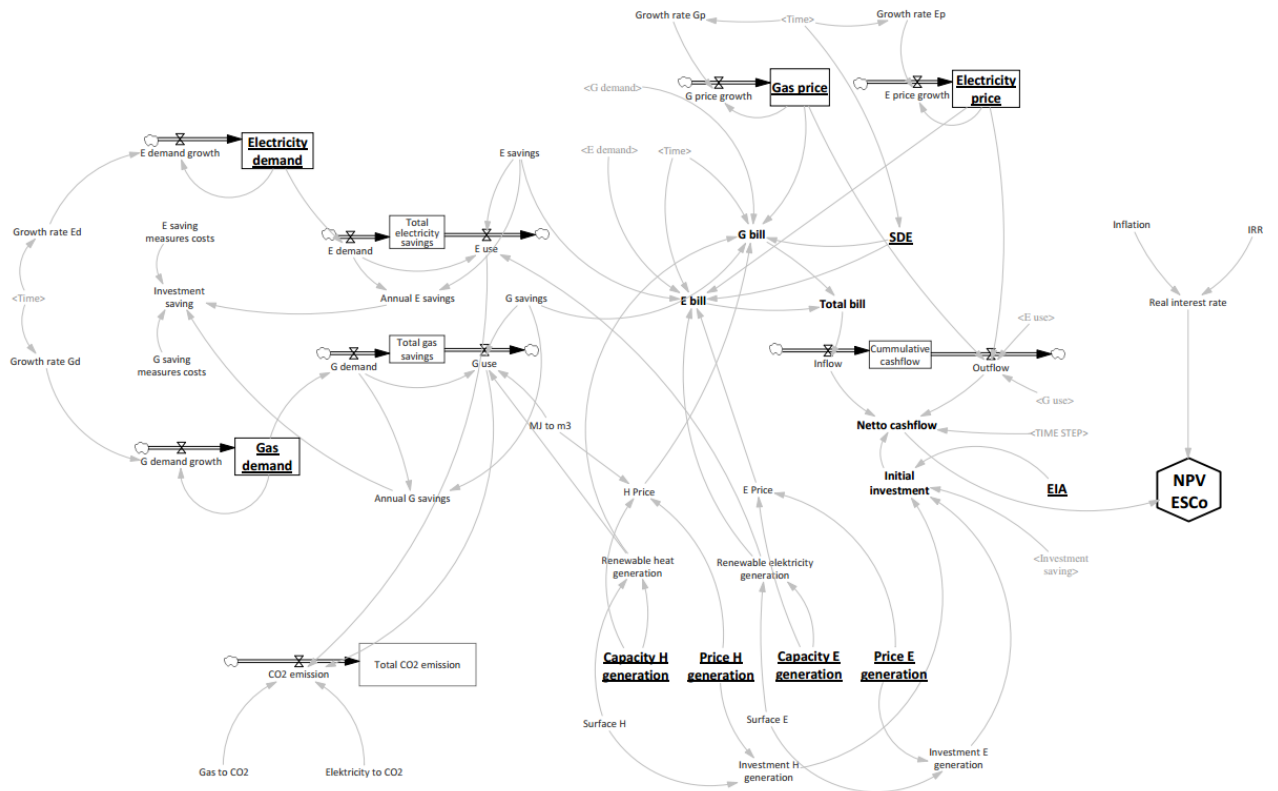
Figure 5 SD model

Morris analysis

To assess the extent of influence each factor has on the NPV, a Morris analysis is performed. The Morris analysis calculates the change of the NPV in relation to the initial values for each parameter. From this analysis is concluded that the factors ''subsidies'' and ''technology development'' are most important for the financial success of the ESCo.

RESULTS

With the generated model, a simulation of an energy services project in a business district can be run. This simulation will provide a better understanding of the uncertainties and risks involved, based on realistic input.

To assess the uncertainty of the factors over the life span of the ESCo project, scenarios are used. The model is run using the macro-economic scenarios, ''global economy'' (GE), ''global economy high oil price'' (GEH), ''strong europe'' (SE), ''transatlantic markets'' (TM) and ''regional communities'' (RC). For the technologic development, trends are used with regard to system's capacity and price.
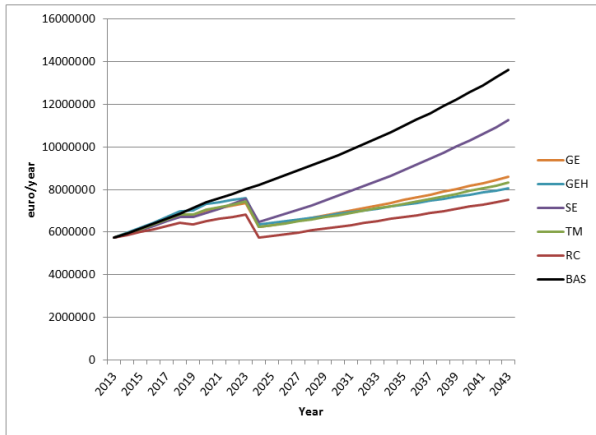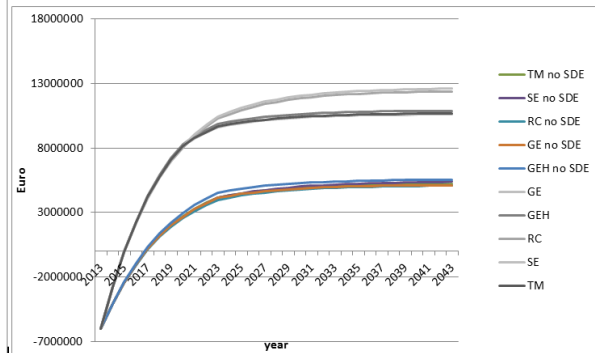
Figure 6 Energy bill

Figure 7 NPV with and without SDE+

Figure 6 shows the total energy bill to be paid by the ESCo clients. The black line represents the business as usual trend where no energy efficiency and renewable energy systems are implemented. To see is that the ''NDMA'' principle where clients never pay more than the used to is satisfied. Figure 7 shows the importance of the SDE+ subsidy because the NPV drops 50% on average.
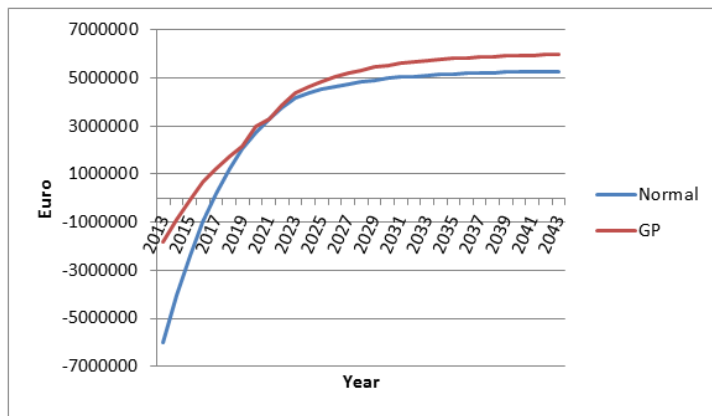

Figure 8 Grid parity vs. normal case

Figure 8 shows the effect of technologic development in a case were grid parity is assessed and used as the investment moment for renewable energy systems are installed in year 2020 and the energy efficiency measures are installed in the base year. The new NPV in this case is compared with the normal case were all measures are installed in the base year. To see is that the grid parity case has a higher performance.

CONCLUSIONS

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

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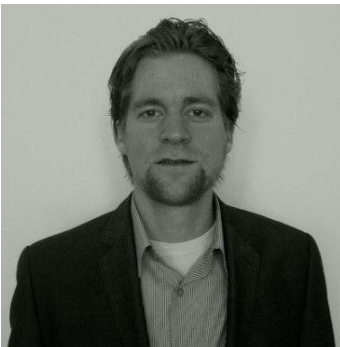
Has van der Zanden

Thank you for reading my thesis about energy services for business districts. I enjoyed graduating on this topic and I want to thank the BOM for providing me the means to do this. I have high expectations for the success of ESCos on the Dutch market and I hope my research can contribute to the development of this ''new'' industry.

2006 – 2011 Bachelor Construction Technology, TU/e
2012 – 2013 Certificate Technology Management, TU/e
2011 – 2013 Master Construction Management and Engineering, TU/e
2012 – 2013 Graduation Internship, Brabantse Ontwikkelings Maatschappij (BOM)

APPENDIX

INHOUD

Voorwoord

De master of Science opleiding **C**onstruction **M**anagement & **E**ngineering (CME) aan de TU/e is gericht op bedrijfskundige benaderingen voor ontwikkeling en beheer van gebouwen en technische systemen in relatie tot stedelijke gebieden. Onderwijs en onderzoek hebben zich geprofileerd ten aanzien van procesaspecten en innovatieve ondernemingsconcepten. In de afgelopen jaren werd voor deze aandachtsgebieden een specifiek kader gekozen: energiemanagement voor stedelijke gebieden. Het gaat daarbij om implementatie van nieuwe technische systemen voor alternatieve energie opwekking en voor energiedistributie in stedelijke gebieden. Dat levert een grote verzameling vraagstukken en afstudeeronderwerpen voor bedrijfsvoering, risico's en gebruikers analyses en start-up's voor ondernemingen.

Om de inhoud van de afstudeerprojecten af te stemmen met samenwerkende overheidsinstellingen (Provincie NoordBrabant en gemeenten) en deelnemende bedrijven instellingen zoals corporaties, is sedert door CME aan de TU/e 2009 het 'KENW2IBrabant ' programma ontwikkeld: Kenniskluster voor Energieneutraal Wonen en Werken in Brabant (zie www.KENWIB.nl). Binnen dit programma zijn inmiddels ca. 40 afstudeerprojecten voltooid, in samenwerking met bedrijfsleven en instellingen en zijn tevens een viertal workshops en congressen georganiseerd als mede drie buitenlandse studiereizen: naar Denemarken, Freiburg en China. In elk van de bezochte gebieden zijn er 'best-practices' projecten bezocht voor energie neutrale stedelijke (her-) ontwikkelingen. Nu is er met deze trip, de vierde evenzo leerzame studiereis voltooid: naar London en omgeving, in november j.l. Deze studiereis is mogelijk gemaakt door bijdragen van de Provincie Noord Brabant en van de bedrijven en instellingen, die betrokken zijn bij de afstudeerprojecten.

De verschillen tussen de toegepaste technische systemen in voornoemde bezochte regio's zijn niet heel groot. De wijzen waarop maatschappelijke inbedding van deze systemen is gerealiseerd in termen van overheid subsidies, wet-en regelgeving en bewonersparticipaties blijken nogal verschillend en navenant leerzaam te zijn. Met name in die maatschappelijke inbedding, daarin vind je de verschillen. Regionale technische oplossingen voor energie neutrale stedelijke gebieden blijken veelal maatschappelijk maatwerk te zijn.

Wim Schaefer

Leerstoelhouder Construction Management & Urban Development
Faculteit Buil Environment
Technische Universiteit Eindhoven

1. Beknopt overzicht en toelichting reisprogramma

4 november

Reis Eindhoven – Londen

- Bespreking reisdoelen programma
- Toelichting van studenten op afstudeerprojecten
- Introductie deelnemers

5 november

Ochtendprogramma

- Bezoek aan BedZED (Beddington Zero Energy Development)
  - Uitleg over het project
  - Rondleiding door modelwoning
- London 2012: Towards a One Planet Olympics
  - Expositie over de duurzaamheidsaspecten van de Olympische Spelen 2012

Middagprogramma

- Bezoek aan het Mayville community centre, ontworpen door Bere:architecten.
  - Presentatie van Bere/architecten over het project en onderzoeksresultaten
  - Rondleiding door het Mayville community centre

6 november

Ochtendprogramma

- Bezoek aan the Crystal, een informatiecentrum om de kennis over stedelijke duurzaamheid te bevorderen. Het centrum is opgezet door Siemens.

Middagprogramma

- Eigen invulling in het centrum van Londen.

7 november

Reis Londen – Eindhoven

- Nabeschouwing bezochte projecten
- Inhoudelijke discussie over de bezochte projecten

2. Inleiding

Vanuit het platform KENW^{2}IB$_{rabant}$ 2.0 is een delegatie bestaande uit studenten en afstudeer-begeleiders naar Londen afgereisd om hier in 2 dagen verschillende duurzame bouwprojecten te bezoeken.

Londen is een vooruitstrevende wereldstad die volop mogelijkheden biedt voor duurzame bouwprojecten. Vooral de afgelopen jaren staat duurzaamheid hoog op de agenda. De belangrijkste reden hiervoor zijn de Olympische Spelen 2012 die afgelopen zomer in Londen plaatsvonden. Toen Londen in 2005 de Olympische Spelen kreeg toegewezen, sprak de toenmalige minister-president Tony Blair de volgende woorden:

"De titel voor de groenste Spelen ooit gaat naar het oude Athene. Maar wij kunnen ernaar streven om de groenste Spelen van de moderne tijd te zijn. We zullen duurzame bouwmethoden, duurzame energie en schone voertuigen gebruiken, allemaal met als doel onze CO2-uitstoot zo laag mogelijk te houden." [2]

Dit streven naar duurzaamheid is terug te vinden in meerdere projecten in Londen. Tijdens onze eerste dag in Londen hebben we in de ochtend BedZED bezocht, het eerste en grootste Zero Energy Development project van het Verenigd Koninkrijk. Dit project is een wijk met gemixt ruimte gebruik en sinds zijn opening als voorbeeld gebruikt voor vele andere CO^2-neutrale projecten. Na een uitleg over het project hebben we rondleiding gehad door een modelwoning. Binnen deze woning werden op interactieve wijze verschillende duurzame maatregelingen naar voren gebracht die huiseigenaren kunnen toepassen om hun eigen huis en leven duurzamer te maken. Binnen de modelwoning hebben we ook een expositie van BioRegional bezocht over de duurzaamheidsprincipes van de Olympische Spelen 2012.

In de middag hebben we het Mayville Community Centre bezocht. Dit buurthuis is in 2011 door Bere:architecten gerenoveerd tot een passivhaus, het eerste duurzame utiliteitsgebouw in de Verenigd Koninkrijk. Het is gebouwd met slechts 3% meer kosten dan een standaard gebouw, terwijl het een energiebesparing van 95% heeft. In 2012 heeft het project al meerdere prijzen gewonnen, waaronder de 'Green Build Awards 2012, Leisure category'.

De volgende dag hebben we in de ochtend een bezoek gebracht aan *The Crystal: A Sustainable Cities Initiative by Siemens*. Dit duurzame gebouw biedt ruimte aan een interactieve expositie over duurzame stedenbouw. We hebben een uitgebreide rondleiding gehad door het gebouw en de expositie, waarbij er ook tijd was om zelf de interactieve expositie te verkennen. Het middag- en avondprogramma waren in te vullen naar eigen keus. Met de hele groep zijn we naar het centrum van Londen gegaan, waarna iedereen naar eigen keus de hoogtepunten van deze bruisende stad kon bezoeken.

In de volgende hoofdstukken zal uitvoerig op de bezochte projecten worden ingegaan.

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[2] Ketelaar, T. (2012, 7 18). *Hoe groen zijn de Spelen?* Opgehaald van NRC: http://www.nrc.nl/wereld/2012/07/18/hoe-groen-zijn-de-spelen/

3. BedZED (Beddington Zero Energy Development)

Inleiding

BedZED is vooralsnog het grootste CO_2-neutrale project met gemixt ruimte gebruik, een woonfunctie van 92 eenheden, (eengezinswoningen/ maisonnettes/ appartementen) en 1405m^2 kantoorruimte, gesitueerd in de wijk Hackbridge te Londen. De toepassingen binnen het project lijken hedendaags veel voorkomend (passief huis/ collectieve energie voorziening t.b.v. warm tapwater/ optimale kierdichting i.c.m. geavanceerd ventilatie systeem/ grijs water systeem) maar zijn in de tijd van het ontwerp en de realisatie zeer revolutionair.

Figuur 1. Luchtfoto BedZED

Buiten de technische toepassing is er ook een maatschappelijke focus, het geheel is ontwikkeld op een oude vervuilde industriële locatie, de wijk is autovrij, wordt het gebruik van een gezamenlijke auto gestimuleerd en was er in de eerste jaren een energiecoach aanwezig.

Locatie

BedZED is gelegen aan de oostzijde van London welke gemakkelijk te bereiken is per auto (snelweg A237) en openbaar vervoer (500 meter van het Hackbridge station). Om het totaalpakket van duurzaamheid te verankeren zijn auto's verboden op het terrein. Buiten bovenstaande aspecten van bereikbaarheid zijn de gebouwen naar het zuiden georiënteerd om middels de dubbele façade optimaal gebruik te maken van het passief huis concept.

Anderzijds is de omgeving belangrijk geweest ten tijde van de bouw van het project. Er is gekozen voor lokale materialen uit de regio, de metalen spanten zijn hergebruikt uit het Brighton Railway Station.

Figuur 2. De BedZED locatie

Figuur 3. Revolutionair ventilatiesysteem BedZED

**Figuur 4. Parkeerplaats elektrische auto**

Figuur 5. Autovrije zone

Project doelstellingen en maatregelen

De doelstellingen op het gebied van duurzaamheid lagen ten tijde van de ontwikkeling van dit project erg hoog. Zeker gezien de tijdsgeest, in 2002, was dit een zeer vooruitstrevend project. Gezien de omvang van woonwijk (92 woningen) werd dit project in het Verenigd Koninkrijk als een groot 'pilot project' gezien. Men had de volgende ambitieuze doelen (Corbey, 2005):

1. Energieverbruik voor verwarming van de woning met 90% reduceren;
2. Elektrisch energieverbruik met 33% reduceren;
3. Op gebiedsniveau energie neutraal blijven en het gebruik van fossiele brandstoffen vermijden;
4. Promoten van het gebruik van elektrische auto's;
5. Gebruik maken van lokale en gerecyclede bouwmaterialen; om verbruikte energie voor transport te reduceren.

Er zijn verschillende maatregelen getroffen om het energieverbruik voor verwarming van de woning te reduceren. Alle woningen zijn voorzien van een verbeterde thermische isolatie dan gebruikelijk in die tijd (30 cm thermische steenwol isolatie). De woningen zijn georiënteerd op de zuidzijde en bevatten grote raamoppervlakken waardoor het zonlicht efficiënt gebruik wordt. De woningen worden passief opgewarmd door de zon en door middel van de volledig glazen façades aan de zuidzijde. Verder is elke woning voorzien van een gebalanceerd ventilatiesysteem met warmteterugwinning. In figuur 6 zijn de maatregelen schematisch weergegeven.
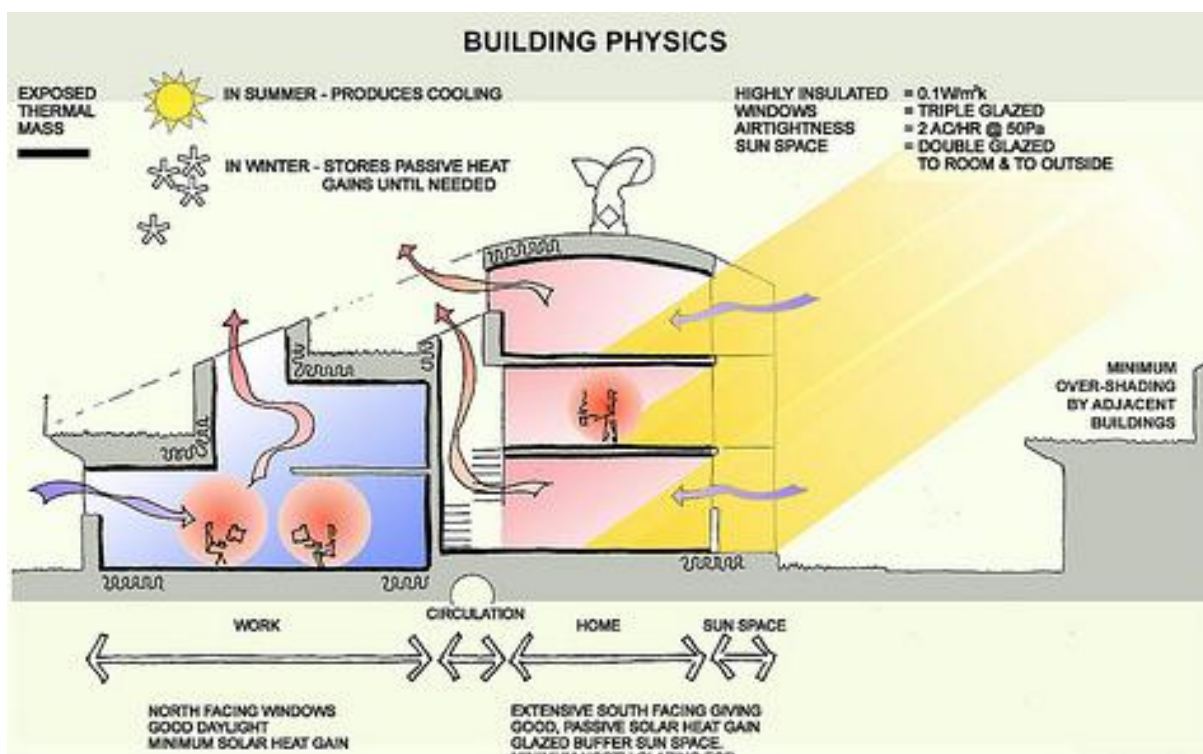
Figuur 6. Genomen maatregelen om energieverbruik ter verwarming van de woning te reduceren in BedZED.(Abdalla, 2012)

Op het gebied van waterverbruik en het vermijden van het gebruik van fossiele brandstoffen zijn er ook verschillende maatregelen toegepast. Zo is er een collectieve warme tapwatervoorziening opgezet door middel van een lokale biomassa centrale (gepland niet gerealiseerd). Ook is 33% van het drinkwater gebruik, ten opzichte van normale woningen, verminderd door besparende maatregelen (watergebruik reducerende spoeltoiletten, douchekoppen en kranen) en het gebruik van grijswatersysteem waarmee het opgevangen regenwater (door middel van groene daken) voor huishoudelijk hergebruikt wordt. Om het elektrisch energieverbruik te reduceren zijn pv-panelen geplaatst op de daken van de woningen. Deze waren bedoeld om de elektrische auto's op te laden maar dragen nu (na het uitblijven van het gebruik van de elektrische auto) bij aan de elektrische energievraag.

Het laatste ambitieuze doel van het BedZED project was om alle bouwmaterialen te verkrijgen binnen een straal van 35 mijl rondom het plangebied. Hierbij is gebruik gemaakt van een oud spoorwegstation (Brighton railway station) waarvan de stalen constructie is gebruikt in de woningen. Zie figuur 7 voor een overzicht.
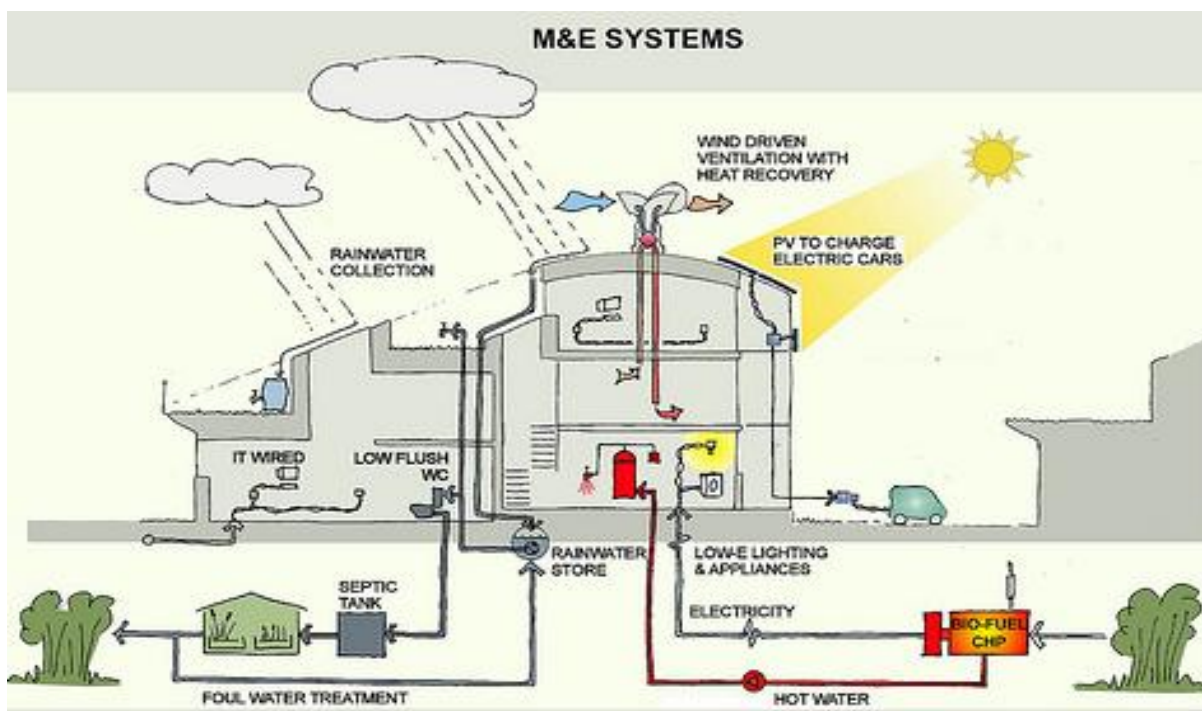
Figuur 7. : Overige genomen maatregelen om energieverbruik te reduceren in BedZED.(Abdalla, 2012)

Terugblik op behaalde resultaten

De plannen van het BedZED project waren enorm ambitieus en hadden als doel om ook te leren van het hele proces. In 2009 is er door Hodge & Haltrecht teruggekeken op het BedZED project en zijn er verschillende lessen uit getrokken en is er gekeken naar welke maatregelen niet doorgevoerd zijn of niet effectief waren.

Hierbij waren de volgende leerpunten interessant:

- De biomassa centrale heeft verschillende technische problemen ondervonden. Uiteindelijk is vanuit financieel perspectief gekozen om de woningen te voorzien met gas boilers. Vandaar dat BedZED aan de ambitie, om energie neutraal te zijn, niet heeft kunnen voldoen.
- De bewoners klaagden in het begin over het ventilatie en verwarming systeem. Door het passiefhuis concept was de regeling van de temperatuur lastig volgens bewoners. Door bewonersparticipatie is ervoor gezorgd dat bewoners goed geïnformeerd zijn over het gebruik van de woning. Dit heeft het probleem verholpen.
- De ontwikkeling van het gebruik van elektrische auto's heeft zich niet doorgezet zoals gedacht. Vandaar dat de pv-panelen op dit moment gebruikt worden voor de opwekking van elektrische energie die gebruikt wordt in het gebied.
- Het BedZED project was een voorbeeldproject op het gebied van gerecyclede bouwmaterialen en bouwmaterialen uit de omgeving. Echter, bleek het onmogelijk om alle bouwmaterialen binnen een straal van 35 km buiten het gebied te halen. Zo is het 'triple glazing' glas geïmporteerd uit Duitsland omdat het nog niet leverbaar was in het Verenigd Koninkrijk op het moment van bouwen.

Proces (stakeholders) en financiering van het project

De ontwikkeling met de voorgestelde ambitieuze doelstellingen om de wijk energieneutraal te ontwikkelen op een oude industrielocatie heeft vele voeten in aarde gehad. Hierbij spelen 'geld' en 'ambitieniveau' een belangrijke rol. Een groot gedeelte van het budget was gereserveerd ten behoeve van onderzoek en ontwikkeling. Daarnaast is er door de Architect 'Bil Dunster' aan de voorzijde een hoog ambitieniveau uitgesproken. Uiteindelijk is het project gefinancierd door Peabody (Woningbouw coöperatie in Londen, 20.000 woningen in bezit in Londen) gefinancierd. Het project heeft uiteindelijk £15.000.000, - gekost, wat neer komt op +/- £150.000, - per woning. Uiteraard is de gemeente een belangrijke partij geweest met de flexibiliteit omtrent wet en regelgeving en commitment.

Maatschappelijke spin-off

Uit onderzoek blijkt (Vringer & Blok, 1995) dat energieverbruik te verdelen is in direct en indirect gebruik. Direct verbruik in de vorm van gas, elektriciteit en andere brandstoffen en indirect in de milieubelastende materialen en afval. Hieruit blijkt dus dat niet alleen het terugdringen van het verbruik van fossielen brandstoffen een belangrijke opgave is, maar ook de CO^2 voetafdruk van de bewoners.

Het toepassen van technische besparingsmogelijkheden is niet alleen de sleutel tot een energie neutrale wijk. De gebruiker bepaald uit eindelijk of hij wel of niet met de auto of het openbaarvervoer forenst en hoelang er gedoucht wordt. Dit wordt benadrukt in het onderzoek 'social and behavioural aspects of energy use', (Lutzenhiser, 1993). Hierin wordt gesteld dat het menselijke gedrag grotendeels wordt onderschat binnen energieanalyses, dit

ondanks het feit dat het significante invloed heeft op het energieverbruik en het dempt mogelijk toe te passen energiebesparing mogelijkheden.

Om het menselijk gedrag te beïnvloeden is er een maatschappelijk spin-off effect gecreëerd in de wijk BedZED enerzijds door in de beginjaren een energiecoach aan te stellen om het gedrag van de bewoners te coachen. Waarbij de energiecoach/ woonconsulent sowieso benodigd was om de specifieke werking van het passiefhuis door de seizoenen heen uit te leggen. Anderzijds doordat de gemixte functies zorgen voor een maatschappelijk samenhang en controle waarbij onbewust de focus ligt op energiebesparing. Bewoners delen kennis en ervaringen uit. Uit onderzoek van de Bioregional development Group blijkt dat er een hoge sociale cohesie is binnen de wijk BedZED ter illustratie. De gemiddelde inwoner van London kent 3 buren bij naam, de gemiddelde inwoner van de wijk Hackbridge kent 5 buren bij naam, en de gemiddelde inwoner van de wijk BedZED kent 8 bij naam.

Ter stimulatie van geïnteresseerde buiten de wijk (nationaal en internationaal) heeft de Bioregional development Group een informatie centrum opgezet ter bewustwording van de gewone mens, dit om kennis te maken met de wijk BedZED maar tegelijkertijd ter bewustwording van het huidige energie verbruik en de besparingsmogelijkheden.

4. London 2012: Towards a One Planet Olympics

In 2005 hebben BioRegional, WWF en London 2012 een gezamenlijke visie opgesteld voor de meest duurzame Olympische en Paralympische spelen. Deze visie genaamd "Towards a One Planet Olympics" maakte deel uit van de uiteindelijke London bid voor de Olympische spelen. De visie is gebaseerd op het uitgangspunt dat we slechts een planeet hebben en de spelen in Londen dienen de ecologische limieten hiervan te respecteren om uiteindelijk een waardig nalatenschap te creëren voor zowel de sport, de planeet en de mensen.

De spelen in Londen boden gezien de grote schaal van het project, de grote investeringen en de enorme publieke aandacht voor het project een unieke kans om een nieuwe standaard voor duurzaamheid te ontwikkelen. Binnen het project is middels een nauwe samenwerking tussen stakeholders, stedenbouwkundigen, grote bedrijven, lokale gemeenschappen, sportverenigingen en sportfans getracht om bestaande consumptiepatronen te doorbreken en richting te geven naar een duurzamere leefomgeving.

Sinds het opstellen van de visie in 2005 hebben BioRegional en het WWF een belangrijke rol gespeeld in het promoten van de visie waarbij zij als ondersteunende partij fungeerden voor alle duurzaamheidonderwerpen gedurende het gehele project. Het traject kende naast verschillende uitdagingen en tegenslagen ook behoorlijke successen. Onderstaand een opsomming van de behaalde successen en tegenslagen.

Figuur 8. Olympisch stadion Londen

Successen:
Het in kaart brengen en managen van de CO_2 emissies (carbon footprinting) tijdens het besluitvorming traject heeft een cruciale rol gespeeld in het project en heeft de potentie om een standaard te worden voor alle grote projecten. Er blijkt een direct verband te bestaan tussen de mate van efficiency (lage CO_2 emissie) en het tijdstip waarop dit wordt meegenomen in het ontwerptraject. De materiaal gebonden CO_2 belasting van de stadions en infrastructuur is drastisch verminderd ten opzichte van de originele ontwerpen:

Olympisch Stadion	38% minder dan in het originele ontwerp
Zwemstation	10% minder dan in het originele ontwerp
Velodrome	15% minder dan in het originele ontwerp
Bruggen en infrastructuur	14% minder dan in het originele ontwerp

Deze innovatieve aanpak voor het verminderen van de materiaal gebonden CO2 belasting leidt eveneens tot een behoorlijke kostenbesparing.

Het gebruik van gehuurde tijdelijke bouwwerken, lichtgewicht stadions en duurzame materialen heeft een basis gevormd voor toekomstige mega sportevenementen.

Het was de eerste keer dat voedsel deel uitmaakte van de duurzame strategie. Samenwerking met Coca-Cola en Heineken heeft geleid tot een stimulerende marketing campagne gericht op afvalinzameling en tot de ontwikkeling van een nieuwe recyclebare bierfles. Deze aanpak kan de nieuwe standaard worden voor toekomstige evenementen.

De targets voor hergebruik en recycling tijdens de sloopfase (90%) en voor hergebruik, recycling en herstel tijdens de bouwfase (>90%) zijn ruimschoot gehaald met respectievelijk 98,5% en 99%.

Tegenslagen:
De doelstelling om 20% van de benodigde energie lokaal op te wekken uit duurzame bronnen is niet gehaald. Dit veroorzaakte niet alleen een enorm gat in de CO^2 emissie strategie, maar gaf ook een negatief signaal af m.b.t. de moeilijkheden voor het implementeren van duurzame energieoplossingen in Engeland.

De samenwerking tussen de organisatie van de spelen, commerciële sponsors en leveranciers hebben niet geleid tot optimale duurzame veranderingen. Deze overeenkomsten zullen worden geëvalueerd om bij toekomstige spelen grotere winsten op het gebied van duurzaamheid te boeken.

Geconcludeerd kan worden dat de hoge duurzaamheidambities een positieve invloed hebben gehad op de spelen en een nieuwe duurzame basis hebben gevormd voor toekomstige spelen.

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5. 'Mayville Community Centre' Londen

Beschrijving project

Het 'Mayville Community Centre' is het eerste gebouw dat als niet-woonhuis is gerenoveerd en het certificaat 'passiefhuis' ontvangen heeft. Het gerenoveerde en energie efficiënte gebouw fungeert als samenkomstplek voor de gemeenschap waar het in gelegen is. Het gebouw heeft 95% energiebesparing behaald in de eerste winter, en op hetzelfde moment is het niveau van het ervaren comfort in de winter als ook in de zomer enorm verbeterd. Het gebouw heeft verschillende prijzen op het gebied van duurzaamheid gewonnen.

Het gebouw is gebouwd in 1890 en deed dienst als energiegebouw voor een nabijgelegen tramlijn. Het is gelegen in een van de minder goede delen van de stad. Voor de renovatie was het uiterlijk van het gebouw somber en oogde vervallen. Ook de indeling van het pand was ongunstig en het was te klein. Het was moeilijk om een comfortabele situatie te creëren in het gebouw. Dit kwam onder andere door het enkele glas, tochtende ramen en een niet-geïsoleerd dak. De energierekening was meer dan 10.000 pond per jaar, wat niet meer op te brengen was voor de gemeenschap. Bij de renovatie is gefocust op het creëren van meer ruimte van een hogere kwaliteit, maar dit zonder de lay-out van het gebouw te veranderen zodat de investering zo laag mogelijk blijft. De isolatiewaarde van het gebouw is enorm verbeterd door isolatiemateriaal tegen de buitenkant van het gebouw aan te brengen.

Figuur 9. Gebouw voor renovatie

Beschrijving bezoek

Na het projectbezoek aan de energie neutrale woonwijk vertrokken we weer met de bus door het drukke verkeer van London. Voor dit projectbezoek (Mayville Community Centre) moesten we aan de andere kant van de stad zijn, dus het was even rijden. We kwamen hier

ruim op tijd aan en vanwege de lange busrit had nog niemand gegeten. Daarom hebben we met de complete groep nog even geluncht in de buurt van het 'Mayville Community Centre'.

Na een korte wandeling aangekomen bij het 'Mayville Community Centre', werden we hartelijk ontvangen. De zaal waar we konden plaatsnemen bevond zich direct bij binnenkomst naast de receptie. Hier stond koffie en thee met koek klaar. Nadat iedereen voorzien was van een drankje en zijn zitplek gevonden had, werden we welkom geheten door Justin Bere. Justin Bere is directeur en oprichter van Bere:architects, een architectenbureau dat zich tegenwoordig gespecialiseerd heeft op passief bouwen. Hij vertelde ons kort wat er op het programma stond voor de middag. Na zijn korte openingswoord namen twee van zijn collega's, Nick Newman en Mila Durdev, het woord over en ging meneer Bere weer terug aan het werk. Hij zou na de presentatie terug te komen om voor ons de rondleiding te verzorgen.

Het eerste deel van de presentatie werd verzorgd door de heer Newman. Hij ging in op zaken zoals:

- Geschiedenis van het gebouw
- Gebouw van voor de renovatie
- Ontwerpdoelen en strategie
- Gebouwgebruikers

Vooral interessant zijn natuurlijk ook de prestaties van het gebouw. En of deze voldoen aan de verwachtingen en de doelen die gesteld zijn. Over de prestaties van het gebouw en de monitoring hiervan heeft mevrouw Durdev ons meer verteld. Hierbij sprak ze over ventilatie lekken in het gebouw, temperatuurverloop, energieverbruik, ventilatie etc. Het viel op dat Bere:architects enorm veel data hierover verzameld heeft, waarvan ze de resultaten in grafiekvorm presenteerde. Zelfs data van omliggende flats is beschikbaar om de resultaten te vergelijken.

Na de presentatie kwam de heer Bere weer terug om samen met zijn 2 collega's een rondleiding in en rond het gebouw te verzorgen. Allereerst gingen we naar buiten. Vanuit hier konden we een aantal opmerkelijke punten van het gebouw bekijken. Bijvoorbeeld de kelder met daglicht, de dikke muren en de in- en uitlaat van het luchtcirculatie systeem. Vervolgens liepen we door naar de grote zaal (zie onderstaande foto) welke gebruikt wordt voor een scala aan activiteiten, zoals yoga lessen. Gaandeweg de rondleiding werd er een hoop verteld over het ontwerp van het gebouw en er konden direct

**Figuur 10. Rondleiding door het gebouw**

vragen gesteld worden. Het laatste deel van de rondleiding betrof de kelder. Bere:architects heeft hier sinds enkele weken haar kantoor gevestigd. Op deze manier kon de heer Bere ook het Mayville Community Centre helpen aangezien op deze manier huurinkomsten genereert worden. Opmerkelijk was dat het plafond in de kelder vrij laag was en de temperatuur aan de hoge kant was. De meeste technische installaties bevonden zich ook in de kelder en ook over deze kon meneer Bere genoeg vertellen. Een geluidstudio die nog in aanbouw is, bevindt zich ook in de kelder.

De algemene opinie van de groep over dit projectbezoek is zeer positief. Het was interessant om te zien hoe hier met duurzaamheid om wordt gegaan in het ontwerp, maar ook hoe het in de gebruiksfase uitpakt. De heer Bere en zijn collega's namen alle tijd voor vragen en vonden het ook leuk om over het gebouw te vertellen. Een klein puntje van kritiek van dit projectbezoek is dat het deel van de presentatie wat over de prestaties van het gebouw ging, een beetje langdradig was. Over de rondleiding was iedereen zeer enthousiast!

Analyse gebouw prestaties

Het is duidelijk dat het ontwerpteam de lat voor energiereductie op een zeer ambitieus niveau heeft gelegd. Maar zijn de inspanningen ook de moeite waard en presteert het gebouw zoals ontworpen? Om dit uit te vinden, is een uitgebreide prestatie-analyse uitgevoerd bij het Mayville community centre. Een dergelijke analyse kan desillusionerend zijn: het energieverbruik blijkt vaak twee tot vijf keer hoger dan waar bij het ontwerp vanuit gegaan was.

Natuurlijk kan de energierekening veel vertellen over de prestaties van het gebouw, maar er werd hier voor een uitgebreidere aanpak werd gekozen. Sensoren voor temperatuur, luchtvochtigheid en CO_2 werden opgesteld in vijf ruimtes en één buiten. Ook zijn er sensoren geïnstalleerd die het verbruik meten van de warmtepomp, ventilatiesysteem en de productie van de zonnepanelen. Daarnaast zijn er ook opnamen gemaakt met een thermografische camera: De temperatuur van gebouwdelen wordt hiermee in beeld gebracht en problemen bij aansluitingen konden worden opgespoord. Met deze totaalaanpak kan energiegebruik nauwkeurig worden herleid én kan er ook wat worden gezegd over het comfort niveau.
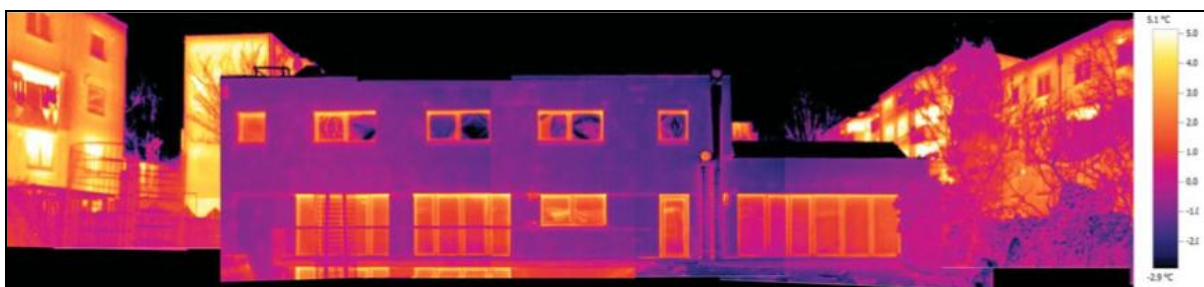
Figuur 11. Opname van de thermografische camera. Gebouwdelen die lichter van kleur zijn stralen

Het resultaat van de metingen liegt er niet om, maar liefst 85% reductie is er bereikt na de renovatie. Dankzij de analyses konden bepaalde mankementen worden opgespoord en verholpen. Wanneer meetwaardes afweken van de norm kon er worden gezocht naar een oorzaak. Vaak waren afwijkingen in de metingen terug te leiden tot gebruikers: een deur die open blijft staan of de verwarming die niet uit was gezet in het weekend. Bij passieve

gebouwen die zo goed geïsoleerd zijn en grote ramen op het zuiden hebben kan oververhitting in de zomer een probleem zijn. Uit de metingen bleek dat oververhitting wel voorkwam, maar binnen de marges die zijn gesteld voor passieve gebouwen. Uit de metingen was ook af te leiden wat het effect is als ramen of deuren open bleven. Zo wordt er steeds bijgeleerd wat de beste methode is om met het gebouw om te gaan, zodat het comfort maximaal is het energiegebruik nog verder naar beneden kan.
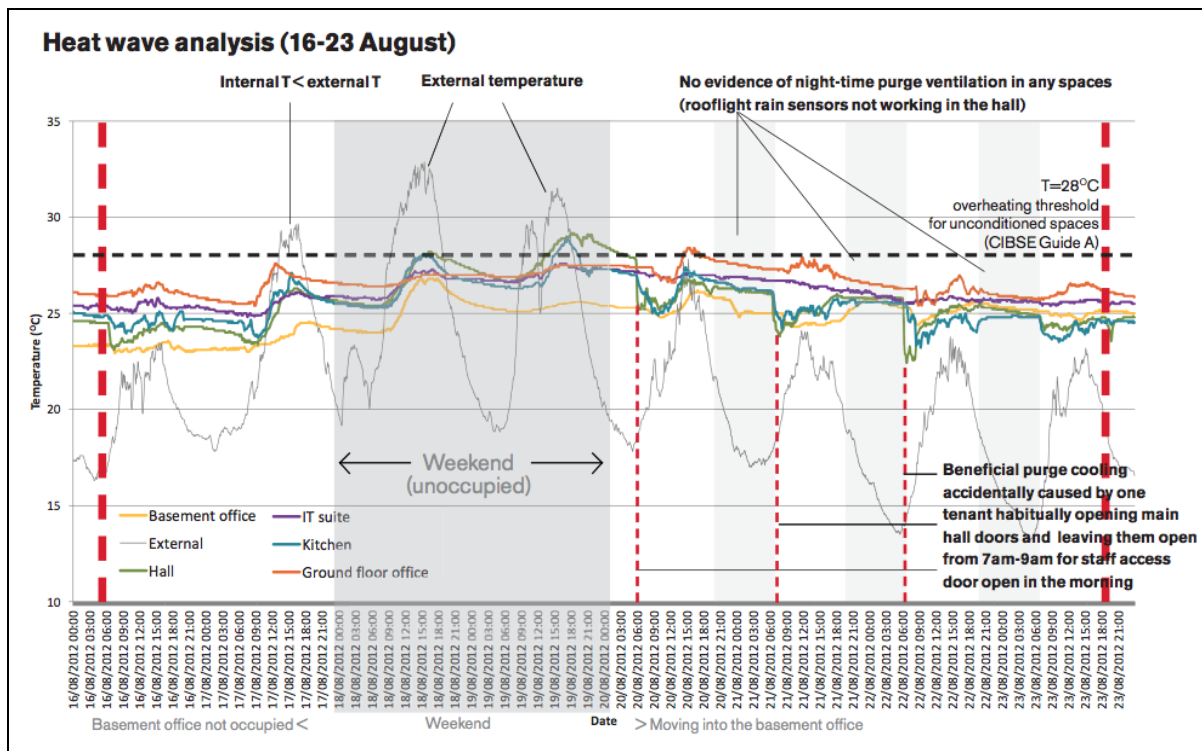
Figuur 12. Analyse van de meetgegevens tijdens een hittegolf

'Learned Lessons'
Een project als het 'Mayville Community Centre' in Londen zou ook in de Nederlandse markt als een spin-off project gebruikt kunnen worden om het product duurzaamheid te verspreiden. Voordat je een concept in de markt wil en gaat zetten is het erg belangrijk om voorafgaand relevante projecten goed te analyseren. Wat is goed gegaan en misschien nog wel belangrijker, wat ging er mis en zou beter kunnen. In dit hoofdstuk zal kort worden ingegaan op de goede en naar onze mening minder goede aspecten van het 'Mayville Community Centre'. Hiermee kan de Nederlandse markt (samenleving) haar voordeel doen.
Bewustwording gebruiker
Tijdens het bezoek van het 'Mayville Community Centre' kwam sterk naar voren dat de gebruiker centraal staat binnen duurzaamheids projecten. De gebruiker zal uiteindelijk moeten omgaan met de verschillende maatregelen die worden of zijn geïmplementeerd. Een gebouw kan perfect geïsoleerd en afgewerkt zijn met de beste installaties, toch zal de mens er goed mee om moeten gaan wil het concept (gewenste reductie) slagen.

Ook het zetten van nieuwe concepten zoals het 'passive house' concept in de markt gaat gepaard met kennismakingsproces door de gebruikers. Het 'passive house' concept is in London toegepast op een bestaand vastgoed dat in de nieuwe functie dient als buurthuis. Vele 'verschillende' doelgroepen, toekomstige gebruikers, komen hier samen en maken

naast de activiteiten kennis met het 'passive house' concept. Van jong tot oud zal moet leren omgaan met de verduurzaming van de gebouwde omgeving, de keuze voor een buurthuis als spin-off project is dan ook slim. Zo is er bij het 'Mayville Community Centre' voor gekozen om geen automatische systemen te installeren die het klimaat regelen, maar de gebruiker hierin verantwoordelijk te maken. Bij de overdracht werd er veel aandacht geschonken aan de omgang met het gebouw. In workshops en in een handleiding wordt de gebruiker duidelijk gemaakt hoe er met systemen om moet worden gegaan en ook waarom. Ook zijn er door het gebouw heen bordjes waar uitleg wordt gegeven over de verwarming, ventilatie en wanneer je het best de ramen open kan laten en wanneer juist niet. Zo leren de gebruikers hoe je effectief met energie om kan gaan en kunnen ze dit thuis ook toepassen.

Figuur 13. Gebruikers krijgen uitleg met handleiding. Rechts informatiebordjes voor thermostaat en dakramen

Ontwerp en gebruik grondstoffen

Zoals in veel literatuur wordt besproken, de grote uitdaging ligt voornamelijk in de verduurzaming van de bestaande vastgoedvoorraad. Met name de vraag of het slopen van een bestaand object om vervolgens er een duurzaam object neer te zetten wel zo duurzaam is. Ook de gebruikte materialen in het ontwerp spelen hierbij een belangrijke rol. In het project van het 'Mayville Community Centre' is hierover nagedacht en werd in de presentatie naar voren gebracht. De herkomst van de verschillende materialen is zorgvuldig bestudeerd en meegenomen in de keuze voor een bepaald materiaal. De oorspronkelijke constructie is behouden en gebruikt als positieve inbreng in het volgende ontwerp. De bestaande constructie was van beton, beton heeft niet de beste isolatiewaarde maar heeft wel meer thermische massa dan bijvoorbeeld hout.

Naast de dikke isolatie, hoogwaardige beglazing en uitstekende installaties is het erg belangrijk om goed naar het ontwerp te kijken. In het ontwerp ligt de basis voor een goed werkend concept. In het 'Mayville Community Centre' zijn grote raampartijen geplaatst aan de zuidzijde van het object, oorspronkelijk waren dit kleine raamopeningen. Niet trippel glas maar dubbel glas is gebruikt om de warmte van de zon te gebruiken voor het binnenklimaat. Mocht de zon dan toch teveel warmte geven in de zomer, konden lamellen (aan de buitenkant geplaatst!) naar beneden worden gehaald en zorgen voor verkoeling.

Gebruik duurzame energiebronnen

Zoals we weten uit de Trias Energetica is het naast energie reductie ook belangrijk om te kijken naar de opwekking van de resterende energievraag. Bij het 'Mayville Community Centre' is aan de zuidzijde van het gebouw, het hellende dak volledig vol gelegd met PV zonnepanelen en zonnecollectoren. Hierdoor voorziet het gebouw in principe in de gehele energievraag. Overcapaciteit in de zomer werd niet over gesproken. Een koppeling met omliggende functies zou hier een aandachtpunt kunnen zijn. Verder werd het plat dak gebruikt voor het opvangen van regenwater waarmee bijvoorbeeld de toiletten worden doorgespoeld. Reductie van het waterverbruik draagt mede bij aan de verduurzaming van de gebouwde omgeving. Echter werd met de duurzame energiebron wind niets gedaan. De ventilatie bij het 'Mayville Community Centre' is geregeld door mechanische ventilatie, hierin had ook gekozen kunnen worden voor natuurlijke ventilatie. Het project eerder op de dag maakte hier wel gebruik van.

Figuur 14. Aanzicht zuidzijde 'Mayville Community Centre'

6. The Crystal

Inleiding

Op 6 november 2012 hebben de studenten van de opleidingen Construction Management & Urban Development en Real Estate Management & Development "the Crystal" bezocht. The Crystal is een initiatief van Siemens met als doel om betere toekomstige perspectieven te creëren voor steden.

Centraal staan hierbij het onderzoeken, opleiden en bespreken van de uitdagingen waarvoor steden staan en hoe dit tegengegaan kan worden door middel van de duurzame technologie. In het onderhavige hoofdstuk zal the Crystal verder uitgelegd worden samen met de bevindingen die de studenten hebben ervaren. In de eerste paragraaf zal the Crystal in algemene zin beschreven worden, waarna in de tweede paragraaf de insteek van the Crystal aan de beurt komt. Hierin zullen de voornamelijk de aspecten; het onderzoeken en expositie aan bod komen. In de derde paragraaf zal de typische architectuur van het gebouw besproken worden, deze paragraaf zal verder de nadruk leggen op de duurzaamheid van het gebouw. In de vierde paragraaf zal de exposities van the Crystal in het kort teruggekoppeld worden met Nederland. Paragraaf 5 laat zien hoe middels opleidingen en exposities de duurzame stedenbouw meer aandacht krijgt. In de zesde en zevende paragraaf zijn de bevindingen van de studenten betreffende de rondleiding en de leerpunten beschreven.

Figuur15. The Crystal

Insteek van "The Crystal"
Algemeen
Op de kop van de Royal Victoria Dock, een oud scheepsdok welke inmiddels grotendeels is herontwikkeld tot woon-, werk- en recreatiegebied, heeft Siemens, in samenwerking met enkele partners the Crystal gerealiseerd. The Crystal is een extreem duurzaam gebouw waar onder andere de grootste expositie ter wereld is te vinden over duurzame stedenbouw, wat

bewustzijn moet creëren onder de verwachte 100.000+ bezoekers per jaar (zie par. 5). Tevens wordt er door Siemens het concept "de duurzame stad" onderzocht, wat er voor moet zorgen dat er in de toekomst kwalitatief betere, duurzamere steden ontstaan (zie par. 3.2). Het idealistische doel van Siemens is dat the Crystal als platform en kennishub gaat dienen waar allerlei doelgroepen samenkomen om te discussiëren over de toekomstige duurzame stad en alles wat daar mee te maken heeft. (Tissink, 2012)

The Crystal wordt sinds haar opening in september dit jaar gezien als het 'vlaggenschip' van the Green Enterprise District: een gebied in Oost-London waar het Royal Victoria Dock deel van uitmaakt en welke op het gebied van duurzaamheid wereldwijd een leidende functie moet krijgen door het huisvesten van bedrijven die zich bezig gaan houden met de thema's CO_2-reductie, afval management en herstel, recycling en hernieuwbare energie. (BBC News, 2010)
Het is niet zo verwonderlijk dat Siemens juist in de zomer van 2012 the Crystal wilde openen. Gedurende de Olympische Spelen 2012 in London, waarbij duurzaamheid en energie hoog in het vaandel stonden, diende the Crystal al als 'hospitality center' voor diegenen die in deze topics geïnteresseerd waren. (Brodocz, 2011)

Tot slot ziet Siemens het als maatschappelijke plicht vanuit The Crystal lokale scholen te stimuleren om te verduurzamen, zodat dit als trigger gaat dienen voor het energiebewustzijn van jongeren; een uiterst belangrijke doelgroep gelet op de toekomst. Meer hierover in paragraaf 5.1 (Brodocz, 2011)

De expositie
Steden huisvesten meer dan de helft van de wereldbevolking en er vindt maar liefst 80% van alle economische activiteit ter wereld plaats. Dit aantal gaat in de toekomst toenemen, wat direct bij binnenkomst van de expositie duidelijk wordt gemaakt met cijfers van Siemens' research team. Het is dan ook niet verwonderlijk dat steden verantwoordelijk zijn voor het leeuwendeel van de CO_2-uitstoot. The Crystal richt zich op verduurzaming van de wereld en de maatschappij, en in het bijzonder in op de verstedelijking en hoe één ieder kan bijdragen aan een betere toekomst. Elk individu kan een bijdrage leveren door zijn eigen gedrag te veranderen, geholpen door goede bestuurlijke kaders. De 2.000 m^2 grote expeditie wil dit bewustzijn creëren en laat dit op een interactieve manier zijn, door middel van interactieve informatieschermen, spelletjes en activiteiten, welke in paragraaf 5.2 verder worden toegelicht. (Siemens, 2011)

Research
The Crystal herbergt eveneens het "competentiecentrum voor steden", een divisie van Siemens waar experts zich bezighouden met onderzoek en ontwikkeling gericht op technologieën en innovaties voor de stedelijke infrastructuren van morgen. Siemens ziet dit zelf als haar plicht, maar is zich er tevens van bewust dat duurzaamheid en energie nog een enorme groeimarkt is waar volgens Siemens een potentieel volume van € 300 miljard is te behalen. The Crystal moet hiertoe een eerste aanzet geven als etalage, contactpunt en brein achter deze sector. Om het bereik te vergroten is Siemens van plan vergelijkbare kleinere centra te ontwikkelen in Shanghai en Washington DC. (Siemens, 2012)

Als voorbeeld is in figuur 16 is een door Siemens opgezet model weergegeven, genaamd "Sustainable Green Growth". In dit model, waar enkel bestaande technologieën worden gebruikt, willen zij aantonen dat er nu al forse reducties in CO_2-uitstoot kunnen worden gerealiseerd. Het competentiecentrum in The Crystal wil hier op voortborduren door innovatieve ideeën te combineren met deze bestaande technologieën. (Brodocz, 2011) Als dit competentiecentrum op volle kracht is in 2013, zal er een totaal van 160 werkplekken bezet zijn door duurzaamheidexperts, planners, vormgevers, onderzoekers, et cetera.
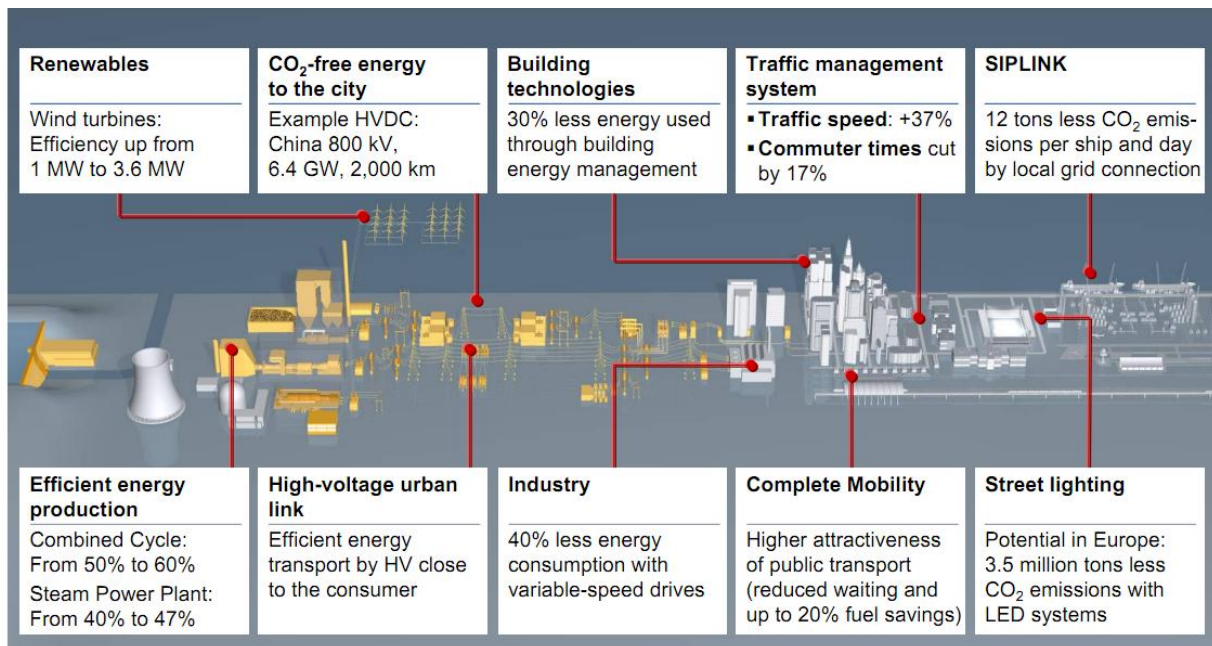
Figuur 16. "Sustainable Green Growth", Siemens' voorbeelden om CO2-uitstoot terug te dringen (Brodocz, 2011)

Architectuur en duurzaamheid
Architectuur
Het gebouw heeft een erg duidelijke en typische vormgeving gekregen, het concept achter "the Crystal" was gedreven door een visie dat een stedelijk gebied bestaat uit verschillende facetten. De gekozen kristallijn (in het Engels "crystalline" vandaar "the Crystal") staat voor de vele facetten van duurzaamheid en de complexiteit van het leven in een stedelijke omgeving. "Crystal" heeft nog een grote historische en culturele verwijzing naar het "Crystal Palace" welke in 1851 bezoekers van de London's Great Exhibition versteld deed staan door zijn vormgeving en gebruik van bouwmaterialen als gietijzer en glassegmenten. Dit gebouw herbergde de nieuwste innovaties en technieken die waren ontwikkeld tijdens de industriële revolutie die toentertijd vol aan de gang was. Het bouwen van dit gebouw was ook pas mogelijk door de nieuwste technieken die in deze periode ontwikkeld werden, een echt innovatief en vooruitstrevend gebouw voor die tijd.

Het gebouw is gelegen in het hartje van Londen, in het Green Enterprise District. Hier vormt het een middelpint voor lokale stedelijke ontwikkeling projecten welke in dat gebied gaande zijn en moet het andere bedrijven aantrekken die zich bezighouden met duurzaamheid. Door de ligging op de Royal Docks nabij de Thames een opvallend geheel tussen de omringende skyline. Het gebouw is ontworpen door de architecten van Wilkinson Eyr, waarvan de volgende quote is:

"The crystalline geometry of the architecture derives its inspiration from nature. The building responds to its location, visually contrasting the curve of the O2 center beyond. The massing of the two interlocking triangular forms generates an exciting and dynamic building from every angle as you move around the site."
Chris Wilkinson, Architect

Figuur 17. Render van "The Crystal"

Duurzaamheid
Het gebouw is zo ontworpen dat het tot de top behoord met betrekking tot de LEED en BREEAM scores, de strengste normen met betrekking tot duurzaam ontwerpen en bouwen. Het gebouw is zo ontworpen dat het zelf geen fossiele brandstoffen gebruikt voor de energie of warmtevoorzieningen in het gebouw. Elektriciteit wordt opgewekt door middel van zonnepanelen en koude-warmte opslag ik diepe grondlagen. Het gebouw heeft zelf een soort grote batterij waarin energie kan worden opgeslagen wanneer er energie opgewekt wordt wanneer er een lagere vraag is. Verder wordt er nog gebruik gemaakt van het opvangen van regenwater, een eigen afvalwaterzuivering welke afvalwater omzet in grijswater, zonne-verwarming en geautomatiseerde gebouw management systemen. Door de opvang van regenwater en het terugwinnen van grijswater uit afvalwater voorziet het gebouw voor 90% in de totale watervraag van het gebouw. Voor de ventilatie wordt gebruik gemaakt van natuurlijke ventilatie, maar wanneer het nodig is kan toch er toch geventileerd worden door middel van een mechanisch ventilatiesysteem.

Bewustzijn creëren
Hoewel, zoals eerder aangegeven, the Crystal bekend staat om zijn exposities, architectuur en duurzaamheid is het hoofddoel van the Crystal om mensen te stimuleren en te inspireren op het gebied van het verduurzamen van steden. De steden waarin een ieder leeft kamt met verschillende problemen, van sociale veiligheid tot milieuverontreiniging. Dit zal indien er niet ingegrepen wordt alleen maar verergerd worden. Op initiatief van Siemens zorgt the Crystal ervoor dat hier meer aandacht aan wordt besteed door middel van het creëren van een bepaald bewustzijn betreffende de huidige en toekomstige leefomstandigheden in steden.

Het creëren van het bewustzijn geschiedt middels twee manieren, namelijk: opleidingen en exposities. Deze zullen hierop volgend verder beschreven worden

Opleidingen

Een van de wijze waarop dit bewustzijn gecreëerd wordt, is doormiddel van studenten te motiveren om een opleiding *Sustainable Engineering* te volgen. Door samen te werken met verschillende nationale en lokale opleidingsinstituten kunnen er verschillende opleidingen op maat gegeven worden (voor verschillende leeftijdscategorieën en leerniveaus). Dit kan zowel op the Crystal zelf als via het internet.

Daarnaast is the Crystal ook gericht om toekomstige steden bouwers te inspireren door het begrip duurzame steden ontwikkeling op de kaart te zetten en welke mogelijkheden dit allemaal met zich meebrengt.**Expositie**

Naast het creëren van bewustzijn door middel van het inspireren en stimuleren op een educatieve wijze, biedt the Crystal een immense expositie waar globale uitdagingen en trends, waar steden mee te kampen hebben, uitgezocht kunnen worden. Deze expositie is meer dan op het gewone oog lijkt. Naast dat het ideeën en technologieën tentoonstelt, stimuleert het anderzijds ontdekking.

De expositie bestaat uit twee aspecten; het aankaarten van de problematiek en het interactief bezig zijn met deze problematiek.

Figuur 18. Filmzaal + film

Het aankaarten van de problematiek gebeurt middels het tonen van een film (figuur 18, laat de buitenkant van de filmzaal zien, waarbij de groei van verschillende problemen te zien is indien er niet ingegrepen wordt. Vergrijzing, demografische ontwikkelingen en milieuverontreiniging zijn hierbij belangrijke thema's.

Het tweede aspect bestaat uit een negental zones, waarbij door interactiviteiten, films, animaties en installaties verschillende problemen dieper uitgezocht kunnen worden betreffende water, transport, stad ontwikkeling en management, energie, milieu, gebouwen en licht, veiligheid en gezondheid (welke in de volgende paragraaf verder besproken zullen worden). Bezoekers krijgen hierbij sterk het gevoel wat hen bijdrage betekent voor het duurzaam leven.

Tevens zijn verschillende case studies van verschillende innovatieve steden van de wereld tentoongesteld, zodat een ieder hiervan kan leren. Figuur 19 geeft een aantal foto's weer die

de interactiviteiten van de zones weergeeft.

Figuur 19. Interactieve zones gedurende expositie

Door zowel op een educatieve wijze als middels een expositie de nadruk te leggen op duurzame steden ontwikkeling wil the Crystal het bewustzijn van een ieder vergroten, aangezien de bevolking samen sterker staat dan alleen.

Het volgende hoofdstuk zal er verder op het creëren van bewustzijn proces gaan middels de rondleiding dat de studenten in the Crystal hebben gehad.

De rondleiding

De gids Dexter van the Crystal liep met ons mee om de verschillende exposities in the Crystal nader toe te lichten. Het doel van de tentoonstelling is niet alleen het ten toon spreiden van ervaringen en technologieën die de duurzaamheid kunnen verbeteren, maar ook het stimuleren en het zelf ontdekken. Allereerst werd gestart met een meeslepende film waar in getoond waarom verduurzaming noodzakelijk is aan de hand van de huidige trends en uitdagingen. Deze trends en

Figuur 20. Interactive touch screens

uitdagingen zoals, vergrijzing, bevolkingsgroei, verstedelijking, vervuiling en consumptiegroei werden gepresenteerd en welke dramatische gevolgen dit kan hebben. De kernboodschap die wordt uitgedragen is; dat er veel moet gebeuren om toekomstige generaties van een leefbare wereld te kunnen voorzien. Vervolgens kon na de film op interactieve wijze worden gekeken naar de bevolkingsgroei per werelddeel en demografische trends per wereld gebied. Echter was de onderbouwing en oorsprong van deze data niet terug te herleiden.

Vervolgens werden de andere thema's van de tour aan ons getoond en verduidelijkt met spelletjes, interactieve touchscreens, animaties, case studies en talloze voorbeelden. Waar ook ruimte was voor vragen. De volgende negen thema's komen in the Crystal aan bod.

- **Water (Water is Life)**
  Water is een belangrijke en eindige bron. In dit thema wordt de toegang tot drinkwater duidelijk gemaakt en gerelateerde zaken zoals; waterwinning, waterzuivering, ontharding, lek detectie en vermindering van water gebruik.
- **Transport (Keep Moving)**
  Dit thema maakt duidelijk welke infrastructuur nodig is om mensen te transporteren bij de steden. Ook is er aandacht voor de keuze mogelijkheden in elektrisch- en vergroend transport.
- **Stedelijke planning en management (Creating Cities)**
  Hier wordt duidelijk wat er allemaal bij de besluitvorming omtrent steden komt kijken en hoe stedelijke groei gemonitord wordt over de jaren.
- **Energie (Go Electric)**
  Dit thema wijst op de moeilijkheid van matching energievraag en -aanbod en het verstrekken van schone energie. Hier wordt ook de omslag verkend naar een nieuwe elektriciteit opwekking. Oplossingen omvatten gedecentraliseerde en gecentraliseerde opwekking van energie, smart grids, energieopslag en het gebruik van hernieuwbare energie
- **Milieu (Clean and Green)**
  Dit onderdeel vertoont de druk die afval, vervuiling en verminderde luchtkwaliteit veroorzaken op ons milieu. Eigenschappen en manieren van de luchtkwaliteit, afvalbeheer en de CO2-uitstoot worden getoond om tot verbeteringen te komen.
- **Slimme Gebouwen (Smart Buildings)**
  Dit thema wijst op de hoge niveaus van inefficiënties in de meeste gebouwen. Oplossingen zoals slimme gebouwen en het maken van efficiëntere gebouwen komen ook aan bod.
- **Gezondheid (Healthy Life)**
  Een groeiende en vergrijzende bevolking legt meer druk op de gezondheidszorg. Oplossingen omvatten het personaliseren geneeskunde, het voorkomen van ziekten en het verminderen van de kosten door middel van efficiënte processen en infrastructuur.
- **Veiligheid (Safe and Sound)**
  Dit thema presenteert de diverse risico's in een stad en manieren waarop deze risico's kunnen worden opgespoord en voorkomen. Aandacht richt zich ook veiligheid en beveiliging, met aandacht voor incidenten zoals misdaad, toegangscontrole en brand.

Al deze thema's vormen samen de kijk op duurzaamheid in brede zin en er wordt duidelijk gemaakt hoe je zelf duurzamer kunt gaan leven. Enkele voorbeelden van de prestatie stands zijn in figuur 21 weergegeven. De tour werd afgesloten door de: Final Gallery. Hierin werd getoond hoe de toekomstige (duurzame) stad in 2050 kan zijn. Dit werd gedaan aan de voorbeelden; New York, Kopenhagen en London.

Figuur 21. Impressies van de tentoonstelling (Bron: thecrystal.org)

De manier waarop informatie beschikbaar wordt gesteld is erg fijn. Voor de bezoeker is het mogelijk informatie te vinden op de thema's die hem aan gaan. Ook het gebruik van interactieve systemen en spelletjes zorgen dat deze informatie gelijk kan worden gebruikt. Helaas was de tijd om zelf uitgebreid te ontdekken vrij kort omdat de gids overal uitgebreid uitleg gaf. Echter is tijdens het bezoek aan de crystal duidelijk geworden dat er ons nog veel te doen staat om tot een duurzamere stedelijke omgeving te komen. Maar wat nog belangrijker is, is dat er heel veel mogelijkheden zijn om dit te bewerkstelligen.

Vergelijkbare exposities in Nederland
Op dit moment zijn er in Nederland geen vaste exposities van dezelfde grootte zoals de Crystal. De enige exposities zijn tijdelijke tentoonstellingen zoals het jaarlijkse "Reset the Future" en "Re-Action" uit 2011, of de reizende tentoonstelling uit Duitsland "Train of Ideas" (2011). Een gebouw als de Crystal en de moderne interactieve manier van presenteren van de onderwerpen zou in Nederland een impact kunnen hebben op de acceptatie van concepten omtrent duurzaamheid. Vooral de interactieve manier van ontdekken is een eyeopener, bij verschillende onderdelen wordt meteen duidelijk wat de effecten zijn als een bepaalde techniek geïmplementeerd wordt of niet.

Lessons Learned
- Toekomstige trends zoals vergrijzing, groeiende consumptie en bevolkingsgroei zullen zorgen voor een onhoudbare situatie.
- Duurzaamheid heeft niet alleen betrekking op energie, vervuiling en grondstoffen. Er zijn meer thema's die ook relevant zijn zoals gezondheid, veiligheid, water, etc.
- Vandaag de dag zijn er veel mogelijkheden voor het verduurzaming.
- Actieve technische systemen kunnen zorgen voor een zeer duurzaam ontwerp.
- Interactieve games en touch screens maken het mogelijk informatie te filteren die relevant en interessant is voor de bezoeker.

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DEELNEMERSLIJST

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Door de huidig economische crisis zijn veel woningcorporaties genoodzaakt om met minder budget gedateerde jaren 60-70 woningen te renoveren, met minder budget. Door deze problematiek dienen woningcorporaties effectiever om te gaan met het hele proces. Ik zal door middel van een wetenschappelijk onderzoek hieraan een bijdrage leveren. Mijn doel zal voor dit onderzoek zijn, een organisatiestructuur voor een woningcorporatie ontwikkelen waarbij naast het besparen van kosten ook rekening wordt gehouden met duurzaamheid en de toekomstwaarde.

Vincent Heijmans

Het architectenbureau "de Twee Snoeken" heeft de BouwConnect Bibliotheek (BCB) geïntroduceerd in de Nederlandse markt. De BCB is een bibliotheek met bouwcomponenten welke gebruikt kunnen worden in combinatie met BIM. Mijn onderzoek zal zich richten op de toegevoegde waarde van de BCB in de bouwketen. Verder zal ik bekijken hoe de BCB zich verhoud tegenover internationale ontwikkelingen en wat de kansen zijn op uitbreiding naar Duitsland, op een technisch niveau.

Marco van der Spank

Om aan de huidige duurzaamheidsdoelstellingen te voldoen zijn woningcorporaties genoodzaakt een groot deel van de bestaande woningportefeuille duurzaam te renoveren. Om daarnaast de financiële continuïteit van corporaties te waarborgen zijn huurverhogingen na renovatie noodzakelijk. Diverse corporaties passen dit toe, maar velen nog niet, omdat dit niet resulteert in de vereiste instemming van 70% van de huurders. Onderzocht zal worden waar de wensen en eisen van huurders ligt bij duurzame renovaties, tegenover een de daarbij horende wenselijke huurverhoging. Het resultaat wordt vertaald naar een pakkettenmodel, toegespitst op bepaalde doelgroepen, welke door middel van de woonlastenbenadering worden aangeboden aan huurders om zodoende de bereidheid tot renoveren te vergroten.

Falco van den Aker

Met een bezit van 2,4 miljoen woningen zijn woningcorporaties grote spelers op de Nederlandse woningmarkt. Zij kunnen een belangrijke rol spelen in het behalen van de Nederlandse energiedoelstellingen. Naast deze maatschappelijke verantwoordelijkheid voelen woningcorporaties zich steeds meer verantwoordelijk voor de totale woonlasten van hun huurders waarbij de energiekosten een steeds grotere rol spelen. Om de energiekosten beheersbaar te houden begeven steeds meer corporaties zich op de duurzame energiemarkt. In het kader van mijn afstuderen doe ik onderzoek naar de mogelijk organisatie- en financieringsvormen en de relevante wet- en regelgeving voor het

verduurzamen van de woningvoorraad. Deze vormen toets ik op een casestudy "Airey" van Woonbedrijf in Eindhoven.

Gijs Kant
'Financiële situatie van gemeenten in Noord-Brabant ten gevolge van verliezen op grondposities'
Een onderzoek naar duurzame verbeteringen in grondbeleid om een continue, gezondere financiële situatie van gemeenten te creëren.
Ten gevolge van de economische crisis zijn gebiedsontwikkelingen vertraagd, uitgesteld of zelfs stopgezet. Gemeenten hebben in totaal voor €13 miljard euro aan grondposities in bezit. De economische crisis heeft geleid tot grote verliezen op grondexploitaties en gemeenten dreigen daardoor in de financiële gevarenzone te komen. Het onderzoek gaat op zoek naar innovatieve en duurzame oplossingen welke getoetst worden bij een aantal Noord-Brabantse gemeenten. Er wordt gezocht naar de oplossing die de voorkeur geniet en bepalende factoren voor de implementatie ervan bij Noord-Brabantse gemeenten.

Marco van der Spank
'Living costs approach and customer choice in sustainable renovation: improving the willingness of tenants to renovate'.
Housing associations have to renovate their existing housing stock to cope with sustainable goals and to keep the stock competitive with newly constructed dwellings. Moreover, it is a way to raise the rent of dwellings due to an increase in living quality and comfort. This research tries to investigate tenants' needs and wishes against an acceptable rent increase in large-scale sustainable renovations. These needs and wishes will be used to compose renovation packages that will be presented to tenants with the living costs approach, in order to improve their willingness to partake in renovation.

Michiel Loonen
In het afstudeeronderzoek zal gekeken worden naar de duurzaamheid van treinstations. Hiervoor is de Stationsscan Duurzaamheid ontwikkeld, gebaseerd op GPR-Gebouw. Er gaat onderzocht worden waar en hoe de beoordeling objectiever kan plaatsvinden. De verbeterpunten om stations te verduurzamen worden onderzocht en hier worden generieke verbeterpakketten voor opgesteld die aan de hand van casestudies gevalideerd gaan worden.

Elien Bisseling
In het kader van klimaatdoelstellingen is het van belang dat de bestaande huizenvoorraad energiezuiniger wordt. Het blijkt echter lastig, vooral in de tijden van afnemende subsidieprogramma's, om de huizenbezitter te stimuleren energetische verbeteringen aan het huis te laten uitvoeren. In mijn onderzoek ga ik (in samenwerking met HetEnergieBureau) kijken of de bereidheid van particuliere huiseigenaren om over te gaan tot investeringen verhoogd kan worden. Hierbij focus ik op de relatie met de tevredenheid met de buurt, dus: 'In hoeverre kan een verbetering van de buurt de bereidheid van particuliere huiseigenaren vergroten om te investeren in energieke verbeteringen aan het huis?' En zo ja: 'Hoe kan dit geïmplementeerd worden in de strategie van gemeente Eindhoven?'

Paul Jochems

Op dit moment kost weginfrastructuur alleen maar geld. Het doel van mijn onderzoek is om de haalbaarheid van PV-panelen rondom weginfrastructuur te onderzoeken, zodat weginfrastructuur in de toekomst geld kan opleveren. Wat zijn de belangrijkste voorwaarden om dit succesvol te laten worden? De haalbaarheid zal onderzocht worden met behulp van het uitvoeren van een Cost Benefit Analysis waaraan een financieel model ten grondslag ligt.

Simon Lubach

'Smart Grid implementation on industrial areas: A business approach. '

Renewable energy isn't always available, but is depending on present wind and sun conditions. Implementation of renewable energy on a large scale requires smart grids that can match the demand to the supply of energy. Industrial areas consume vast amounts of energy and are looking for ways to reduce cost; therefore, smart grids have great potential in industrial areas. In this research, a case study is performed on the feasibility of a local smart grid.

Ruud Coppens

'Financing energy reduction measures in Dutch swimming accommodations'

Energy performance contracting is a rather new way of financing projects in the Netherlands related to energy reduction and production. Different business models are used abroad regarding performance contracts, these models allocate different rewards and risks. Swimming accommodations are enormous energy consumers and have to become more sustainable for future exploitation. A (financial) model gives the best way of financing energy reduction (production) measures in Dutch swimming accommodations.

Bertine Korevaar

Tijdens mijn afstuderen zal ik me bezig houden met non-revenue water, non-revenue water is het verschil in de hoeveelheid geleverd water aan het distributiesysteem en de hoeveelheid water dat wordt berekend aan de consument. Bij RoyalHaskoningDHV zal ik het verband tussen het non-revenue water component en het waterafnamepatroon onderzoeken. Dit verband zal worden gebruikt in een monitoringsfunctie voor een non-revenue module in het huidige OPIR-systeem. Het verband zal worden onderzocht aan de hand van case-studies.

Welmoed Vollers

'Financieel organisatiemodel voor de plaatsing van publieke laadpalen voor elektrisch vervoer'

Sinds een aantal jaar is het mogelijk om in een elektrische auto te rijden. Om elektrisch rijden te stimuleren is een dekkende infrastructuur van laadmogelijkheden nodig. Gezien 70% van de huishoudens geen eigen parkeerplaats heeft, moeten deze mensen hun auto in de publieke ruimte opladen. Hier zijn publieke laadpalen voor nodig. Momenteel is het voor markt partijen financieel niet aantrekkelijk om in deze laadinfrastructuur te investeren. In mijn onderzoek zal ik een model maken dat verschillende financiële modellen met elkaar vergelijkt. Dit zal leiden tot een advies aan de betrokken partijen over de optimale financiële organisatie voor de plaatsing van publieke laadpalen.

Barry Kroon

Door (inter)nationale regelgeving staan woningbouwcorporaties voor de uitdaging om hun vastgoedportefeuille te verduurzamen zodat de bewoners minder kosten kwijt zijn aan de energiekosten en hun woonlasten zouden dalen. Dit vraagt miljarden aan investeringen, waarvan de terugverdienmogelijkheden voor de corporaties beperkt zijn. Een mogelijke oplossing voor corporaties zijn energy-services: het aanbieden van energiebesparende én energieleverende maatregelen. Energieleverende maatregelen worden slechts door een handvol corporaties toegepast, terwijl er voor de corporatie sector kansen lijken te liggen. Tijdens mijn afstuderen onderzoek ik óf en wáár corporaties verschillen in houding t.o.v. energy services en of de toepassing van energieleverende maatregelen daadwerkelijk voordeel inhouden voor de huurder en de verdiencapaciteit voor corporaties worden vergroot.

Freek van Lier

'The implementation of EPC in the care industry.'
Currently, the care industry houses over 150.000 residents. This number is expected to grow due to the aging of the population and increase in average age. These people are housed in 1700 different locations. However, due to legislation and inefficient use of resources, the owners of care real-estate are limited to optimizing their core-business, namely, provide care. Energy Performance Contracting can help optimize non-core commodities like energy, gas and water through the implementation of energy-saving measures and providing the financial means to do so. The costs of these implementations is redeemed during the duration of the Energy performance contract. However, EPC is relatively unknown. Therefore, my research aims to investigate to attributes influencing the adaptation of EPC in the care industry.

Ruud van Beek

'Risk management'
With the rise of integrated contracts, the core business for executioners shifts together with their responsibilities thus creating new risks. Managing these risks is important to create projects in a viable and a financially sound manner whilst simultaneously securing both margins and the market position. Within this research the method for conducting risk management within Heijmans is redeveloped and improved to address the shifting focusses and to improve the implementation of innovative systems during design, execution and operations. The method will engage in analyses of risks, management of response measures, dynamic scenario modelling, energy case study validation and strategy development to support the implementation of the renewed method.

Geert Lamers

'Een onderzoek naar de structurele over voorraad aan kantoorvastgoed in de provincie Noord-Brabant'
Binnen de huidige markt staat er ongeveer 14% aan kantorenvastgoed leeg waarvan +/- 9% structureel leegstaat en biedt de toekomstvraag geen directe oplossing. Binnen mijn onderzoek modelleer ik eerst middels System Dynamics de markt dynamiek, waarna ik verschillende publieke en private interventies modelleer. Deze interventies worden vertaald naar verschillende scenario's waarbij de preferentie wordt gemeten bij zowel publieke als private partijen.