Exploring energy neutral development for Brainport Eindhoven

EXPLORING ENERGY NEUTRAL DEVELOPMENT FOR BRAINPORT EINDHOVEN part 2

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Contents

INTRODUCTION

During the period of September 2010 till July 2011 sixteen Master of Science graduation students in the interdisciplinary field of building - and management sciences worked on assignments, relevant for development of energy neutral urban districts. Their projects were part of the '**K**enniscluster **E**nergie **N**eutraal **W**onen **i**n **B**rainport' project.

KENWIB is based upon cooperation between governmental organizations, university and entrepreneurial companies. The partners for this project are: the Municipality of Eindhoven, the Province of Noord Brabant, the Promotie Installatie Techniek and Eindhoven University of Technology. The cooperation is established and financial supported for a period of two years. The project started in September 2009 and the final evaluation of the project is planned in February 2012. In the period from start until August 2010 already thirteen Master of Science graduation students elaborated their final studies within the context of this KENWIB project. The summaries of their reports have been published in the 'Part 1' Summary Book.

The societal relevance of this project is obvious and can be stated as follows. Parallel to the ongoing climate discussions, the need for the establishment of a sustainable economy becomes emphatic recognizable. Even the present 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, use of sustainable energy and sustainable water use. The importance of this development is significant, perhaps also links to us personally. We know that the major international conflicts, evoking terrible acts of violence, which we can observe every day, are related with the availability and distribution of raw materials and energy stocks. 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.

Also for this second year in the KENWIB project, the students worked individually at their graduation assignments. Each of the projects was guided by a team of science oriented - and practice oriented specialists. The summaries of their studies are brought together in this book. The general meaning of the presented studies is that they introduce and analyze ideas and concepts that are relevant for developing energy neutral districts. The results of these studies will help to structure public discussions, inform entrepreneurs concerning new market demands and facilitate policy making activities. The individual students were connected to a wide variety of stakeholders and as final graduates they have not only developed knowledge and understanding of the theme, but they also have become a group of 'ambassadors' representing the ideas of energy neutral developments.

Within this second year of the KENWIB project several special activities, such as workshops and an international study trip has been organized. The Appendix holds the report of an international study trip to Freiburg, Germany.

New technologies were explored in terms of business cases for future generation of nuclear power plant and possibilities for deep geothermal source are amongst the reported studies. Also new business cases based on new societal corporation and energy managing companies are discussed and modeled. It is important to notice that, when reading and interpreting all the material of the reported research findings, major changes and challenges for construction and building services industry are to be expected. New concepts for housing and building services components will be brought to the market, and we can expect that these new technologies will be brought to the market by new parties. Interesting is the all over discussed role of the municipalities and national government as central stakeholders in the process of further development of an energy neutral built environment. The position of the local municipality was often referred to as 'launching customer'.

One final and major result to mention is the construction of a network, connecting a wide variety of contacts between real world experts, scientific staff and representatives of the municipalities of the 'Brainport' area. This active connective network will facilitate for example the follow-up workshops for knowledge dissemination and establishing roadmaps for realizing energy neutral development in urban districts.

Appendix:
KENWIB – Report Study trip Freiburg, Germany, November 2011

SUMMARIES

ASSESSMENT OF LOCAL ENERGY COMPANY PERFORMANCE
How to utilize renewable energy techniques locally

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ABSTRACT
Governments have shown that they have no solution to offer. The unstable policy has led to a current bottom-up approach by the municipalities and other local stakeholders, to take the initiative in generation of renewable energy. However, little research is executed is this new dimension of the energy sector. This thesis focuses on benchmarking the new Local Energy Companies in DEA and analysing these businesses on three aspects; organisational, techno-economic and financial. The results are a set of rules for establishing new local initiatives who are utilizing renewable energy. Overall conclusion is for the first time a DEA benchmarking model is set up for this kind of businesses in the Netherlands, there is much to learn and improve from each other. Identifying a "best practice" is difficult in the first measurement, since none of the DMUs had all efficiency scores equal to one.

Keywords: Local initiatives, Utilize RETs (Renewable Energy Techniques), Organisational models, Financial structures, DEA (Data Envelopment Analysis)

INTRODUCTION
Is the transition to renewable energy possible and who should take the initiative? During the climate conference in Copenhagen 2009, governments have shown that they have no solution to offer. The unstable policy has led to a current bottom-up approach by the municipalities and other local stakeholders for example social housing associations. Furthermore, the society is also done waiting for the established large energy companies to act. These fossil based energy companies have different agenda's than the municipalities. One cannot expect that fossil fuel/uranium companies will in general support renewable energy (RE) technologies (Hvelplund, 2006). Mainly because a change from fossil fuel based power system to a solar-, wind- and wave-based RE system implicates that the fossil fuel power companies will lose value added at the fuel level and at the power plant level. Secondly, as joint stock companies, they are very sensitive to even minor changes in turnover, so even if they should want RE technologies, often they would not have the financial freedom to carry through their implementation.

It can be observed that organisations linked to existing technologies will initiate project proposals within their organisational framework. One cannot expect alternatives representing radical technological change to originate from such organisations. It is outside their discourse; it is not within their interest or perception (Lund, 2010). Fossil fuel and nuclear technologies are based on large power stations. In contrast, renewable energy and energy efficiency technologies will typically benefit from a wide distribution throughout their geographical areas of consumption. Along with the implementation of new technologies, new types of organisations are therefore likely to develop (Lund, 2010). These new types are at the moment developing locally and are called Local (Sustainable) Energy Companies.

Establishing a community energy project involves many complexities, whichever model of development is adopted and which Renewable Energy Source (RES) is utilized. These include legal conditions under which organisations or projects can operate, establishing a scheme's economic and technical viability (Dunning and Turner, 2005). Furthermore, it is essential to learn from previous experiences (Walker, et al., 2007); especially the last phrase is where this research associates with.

Problem statement

Transition towards renewable energy is in progress and multiple techniques for generating renewable energy are available and well researched. It can be observed that Local Energy Companies are arising rapidly in diverse locations throughout the Netherlands. These companies utilize renewable energy techniques locally and can also be called decentralized generation. However, creating a healthy business of utilizing renewable energy techniques seems to be difficult. Therefore this research will focus on analyzing and measuring the performance of existing local energy companies. Furthermore, recent research and studies have shown the enormous dimension and diversity of local renewable energy in the Netherlands and abroad. Often there is only a global image sketched of their organizational structure, technique and finance and factors for success and barriers, for example in report of (ECN, 2010). Therefore these new market dimension in energy with different business needs to be further examined.

RESEACH METHODOLOGY DEA

DEA, first introduced by Charnes et al. in 1997, is a linear programming technique for comparing the efficiency of a relatively homogeneous set of organisational decision making units, such as schools, banks or business firms, in their use of multiple resources (inputs) to produce multiple outcomes (outputs) (Camanho, 2011). The comparison with the benchmarks also allows to determine the input and output targets corresponding to an efficient operation. This methodology can be interesting for the analysis of the strength and weaknesses of LEC's. For DEA beginners, (Scherman & Zhu, 2006) provided an excellent introductory material. The more comprehensive DEA expositions can be found in the recent publication by (Cooper, Seiford, & Tone, 2006).

Basic DEA Methodology

DEA compares units considering all resources used and outputs generated, and identifies the most efficient units or best practice units (branches, departments, individuals). This is achieved by comparing the mix and volume of outputs generated and the resources used by each unit compared with those of all the other units. In DEA, the organisation under study is called a DMU (Decision Making Unit). In short, DEA is a very powerful benchmarking technique (Scherman & Zhu, 2006).

The linear programming technique is used to find the set of coefficients (u's and v's) that will give the highest possible efficiency ratio of outputs to inputs for the unit being evaluated. The classical model of DEA is presented in the figure below.

$$\max h_0 = \sum_{r=1}^{s} u_r y_{rj0}$$

$$\sum_{i=1}^{m} v_i x_{ij0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij0} \leq 0$$

$$u_r, v_i \geq 0$$

Figure 1: Classical DEA model, source (Cooper, Seiford, & Tone, 2006)

Where j is the DMU index; r the output index; i the input index; x_{ij} the value of the j_{th}DMU; $y_{rj}$the value of the r_{th}output of the j_{th}DMU; u_r the weight given to the r_{th}output; v_i the weight given to the i_{th} input; and h_0 the relative efficiency of DMU_0, the DMU under evaluation. In this model, DMU is efficient if and only if h_0 = 1.

DEA applications in Energy and Environmental studies

The application of decision analysis in E&E studies has been reviewed by Zhou et al. (2008). Among the wide spectrum of E&E modelling techniques, DEA, a relatively new non-parametric approach to efficiency evaluation, has also attracted much attention. DEA has been accepted as a major technique for benchmarking the energy sector in many countries, particularly in the electricity industry. The first DEA application in the electricity generation sector was the work of Färe et al. (1983), who measured the efficiency of electric plants in Illinois (USA) between 1975 and 1979, in order to relate the scores obtained to the regulation of the sector. Particularly, the analysis made by Pollitt (1996) on the productive efficiency of nuclear power stations using DEA is of relevance to understand this study approach. The general structure of a DEA model as well as the most widely used efficiency measures in E&E studies (Zhou, Ang, & Poh, 2008).

There are also specific studies linked to the efficiency in the renewable energy sector, for example the DEA application of Barros and Peypoch (2007), (San Cristobal, 2011) and (Iglesias, 2010). In the paper of Iglesias et al. (2010) the productive efficiency of a group of wind farms during the period 2001-2004 is measured using the frontier methods DEA and SFA. In that research an extensive definition of the productive process of wind electricity as their starting point is taken. A production relationship is established, which is similar to any traditional electricity generation technology and the researcher could define micro-economic production functions, given by the general formula:

E= $\int(K, L, F)$ Where E is the electrical energy, K the capital, L the labour and F the fuel.

In the study of (San Cristobal, 2011), the (Multi Criteria) DEA model is applied for evaluating the efficiency of 13 Renewable Energy Technologies. The input and output data used to perform the measurement is also discussed during determination of the parameters in this research. These are just two examples of DEA applications in the renewable energy sector, there can be more found on the existing scientific database.

DEA models applied in the research

The executed DEA models in this research are the basic CRR and Allocation models, giving extensive results on efficiency score. The different models are explained in detail below;

CCR-I

CCR is one of the most basic DEA models, which was initially proposed by Charnes, Cooper and Rhodes in 1978 (Cooper, Seiford, & Tone, 2006). The optimal weights of the input and outputs may vary from on DMU to another DMU. Thus, the “weights” are derived from the data instead of being fixed in advance. The weights are chosen in a manner that assigns a best set of weights to each DMU. The term “best” is used here to mean that the resulting input-to-output ratio for each DMU is maximized and relative to all other DMU when these weights are assigned to these inputs and outputs for every DMU. CCR input orientated aim at minimizing the inputs while satisfying at least the given output level. CRR-efficiency exists of two parts Radial and Technical efficiency. Radial efficiency is when the score of the DMU is one but there are nonzero slacks, which are excesses and shortfalls of inputs or outputs. Technical efficiency is when the score of the DMU is one and has zero-slacks, and then the DMU is also called CCR –efficient.

Allocation models

The preceding model focuses on the technical aspects of production. The allocation DEA models can be used to identify types of inefficiency which can emerge for treatment when information on prices and costs are known; this is the case in this research. There are two different situations: one with common unit prices and costs for all DMUs and the other with different prices and costs from DMU to DMU. Since in this research, the prices and costs are expected to be different from DMU to DMU. I will focus on the new cost-efficiency related model. Section 8.3 in the book of (Cooper, Seiford, & Tone, 2006) gives a good explanation of the new cost-efficiency model. The following efficiency models will be executed in the performance measurement of LECs;

$\boldsymbol{\theta}^{*}$ = CCR technical efficiency

$\overline{\boldsymbol{\theta}}^{*}$ = CCR New technical efficiency

$\overline{\boldsymbol{\gamma}}^{*}$ = New cost efficiency

$\overline{\boldsymbol{\alpha}}^{*}$ = New allocation efficiency

DETERMINING THE PARAMETERS

The inputs and outputs for this research are identified in collaboration with companies and combined with recent scientific research. Important to keep in mind is what the practice wants to know about LEC’s and thus validate the parameters. In scientific research the five inputs (I) and four outputs (O) are found from the research of (San Cristobal, 2011) and (Iglesias, 2010), see table below. From the researcher’s theoretical analysis also a number of parameters are concluded, see table below. Finally, the parameters are presented to the practice and discussed is, which parameters are necessary for comparing and establishing a LEC. All the parameters from different sources are presented in table 8 below.

Source	Inputs	Outputs
Theoretical orientation in LECs	Investment, installation size, O&M	Energy, Revenue, Profit, ROI, Payback time
Recent scientific research	Investment ratio, Capital, Implement period, O&M, Labour, Fuel	Energy, Operating hours, Useful life and Tons of CO2 avoided
Additional from experts		revenue per kWh or GJ, Cost of avoided GJ energy,
Conclusion	Installation size, investment ratio, O&M costs	Energy, Revenue

Table 1: Overview of inputs and outputs from different sources.

For the input parameter, indispensable are installation size, investment ratio and O&M costs. Other identified input parameters shown in table eight are incorporated within the three parameters. For instance Labour is taken into account in the O&M costs parameter. Selecting the output parameter is more complex, because it is important for whom the information is and what they want to know about the performance of LECs. Since this research focuses on business approach, therefore Tons of CO_2 avoided and Cost of avoided GJ energy are not important and excluded. Concluded is that Produced energy and Revenue are important in a business approach. Other for example Profit and Payback time can be derived from these output parameters.

DATA COLLECTION

A Local Energy Company is seen as an autonomous entity, independent of the municipality, with the aim of one or more of the following activities to be implemented locally (SenterNovem, 2010):

- Production, delivery and management of renewable energy in their region.
- Financing and / or participation in the renewable energy projects.
- Energy savings.

Local initiatives are in this research initiative where large established energy companies do not have decision making power and can only be involved in the administrative activities. This means that the large energy companies have not got a say in making decisions and do not have investments activities within these local initiatives. Otherwise, the local community does not profit from the benefits. Other pre-conditions for a LEC in this research;

- Local actors (municipality, citizens, housing association and other private local actors) must have the power to make decisions and profit from the economical or environmental benefits.
- The large established energy companies must not have the power to make decisions nor financial involvement.
- The LEC must produce, deliver and manage renewable energy projects, or at least finance and / or participate in renewable energy projects.
- A Local Energy Company is seen as an autonomous entity.

Local Energy Companies in the Netherlands

In total 66 initiatives were found, sorted by Renewable Energy Technique (RET) and also initiators and location of LEC are given. In the figure below the number of LEC per initiator are given. One can see easily that most initiatives are initiated by Residents. Second are the municipalities, which are upcoming actors that started a lot of new initiatives very recently. Within the group of private actors there are mainly waste companies and collective of horticulture and other private companies. The municipalities are already establishing many LECs. However, sometimes these companies are established with other private actors to construct a Public Private Partnership (PPP). Private partners are so far mainly real estate developers and housing associations. In the group others, are research facilities and one nature society represented.

The Decision Making Units

In this paragraph all of the selected businesses are presented. From every DMU the organization, technique and financial structures are analysed. Finally, their inputs and outputs are presented in the parameters table, which will result in the actual performance of these businesses through DEA. The selected DMUs are; Bio energy Eindhoven, Bio energy Fleringen, Patrimonium Energy B.V., Thermo Bello, NDSM N.V., Onze Energie, SVDW Windpark, Windvogel, Meewind, Zonvogel, Zon op Noord, Boer en Buur.

DEA model data sheet

From all the analysed LEC's values per parameter are derived as presented in tables per case above. These values are placed in a prepared data sheet, according to the format of Cooper, Seiford, & Tone (2006). The parameters are the same for each LEC as determined in previous paragraph. Finally there are different kind of data sheet developed, one that includes all DMUs from. This data sheet is presented in the table 2 below.

However, this is the first time energy companies which produce heat or heat and electricity are compared with companies producing solely electricity. Local initiatives in producing heat for use in built environment are still very scarce. Therefore these kinds of companies are outnumbered compared to electricity producing companies. Furthermore, there is more data and knowledge available, for example, at the government about electricity producing LEC. This has led to a second measurement of benchmarking focusing on the LEC that produce renewable electricity locally. In the data sheet the basic amounts determined by AgentschapNL and ECN are also calculated and included in the data sheet, see second table 3 below. In this measurement the in practice operating businesses are compared with theoretical established cases. There are two versions of the second benchmarking, because of the new SDE+ has just been published. The differences are analysed and resulted in a second data sheet for this benchmarking. The differences are mainly found in the financial parameters, the techno-economic have not change with the new SDE subsidy.

DEA RESULTS

The results of the first data sheet as presented in the previous paragraph, are executed in DEA on Technical as well as Allocation and overall efficiency are given in table 4 and 5. From the results, it can be indicated that the best performer is not easily identified because none of the DMUs has all its efficiency scores equal to one. However, a number of results can be derived from this measurement.

Local Energy Company (LEC)	(I)Installation 10^3kW	(C)Installation 10^3Euro/kW	(I)O&M costs 10^3Euro/year	(O)Energy 10^3GJ/year	(O)Revenue 10^3Euro/year
Bio energy Eindhoven	11,500	1,52	880,00	64,19	2.050,00
Bio energy Fleringen	0,416	1,46	66,00	3,24	118,00
Patrimonium Energie	0,400	0,53	29,67	2,28	48,64
Thermo Bello	1,750	0,34	244,37	9,10	258,61
NDSM-Wharf	2,450	0,42	232,44	7,80	282,90
Onze Energie	2,000	2,00	106,00	18,00	480,00
SVDW Windpark	12,600	0,89	611,10	93,60	2.496,00
Windvogel	2,755	0,99	167,79	18,11	448,51
Meewind	165,000	3,72	30.921,00	1.980,00	104.280,00
Zonvogel	0,120	2,13	4,90	0,37	23,46
Zon op Noord	0,015	3,05	1,05	0,05	2,92
Boer En Buur	0,012	2,56	0,31	0,04	2,17

Table 2: Data sheet of inputs and outputs of all DMU

Local Energy Company (LEC)	(I)Installation 10^3kW	(C)Installation 10^3Euro/kW	(I)O&M costs 10^3Euro/year	(O)Energy 10^3kWh/year	(O)Revenue 10^3Euro/year
Bio energy Eindhoven	11,500	1,520	880,000	6.720,000	2.050,000
Bio energy Fleringen	0,170	3,622	66,000	900,000	118,000
Onze Energie	2,000	2,000	106,000	5.000,000	480,000
SVDW Windpark	12,600	0,890	611,100	26.000,000	2.496,000
Windvogel	2,755	0,990	167,794	5.031,660	448,511
Meewind	165,000	3,720	30.921,000	550.000,000	104.280,000
Zonvogel	0,120	2,130	4,900	102,000	23,460
Zon op Noord	0,015	3,050	1,050	12,700	2,921
Boer En Buur	0,012	2,564	0,310	10,000	2,167
Manure fermentation	1,100	3,100	1.083,500	8.800,000	1.601,600
Solid biomass 0-10 MW	2,000	4,445	1.651,000	16.000,000	3.408,000
Solid biomass 10-50 MW	25,000	3,600	14.350,000	200.000,000	24.400,000
Wind on land < 6 MW	15,000	1,350	750,000	33.000,000	3.168,000
Solar Panels 1-15 kWp	0,004	3,105	0,092	2,975	0,991
Solar Panels 15-100 kWp	0,100	2,145	2,125	85,000	23,800
Solar Panels self supply	0,100	2,145	2,125	85,000	19,550

Table 3: Data sheet of inputs and outputs of only electricity producing DMU with old SDE

Regarding the cost-based measures LEC Thermo Bello received full efficiency marks even though it fell short in its CCR efficiency score. Conversely, although Thermo Bello almost has the worst CCR score (0,476), its lower unit costs are sufficient to move its cost-based performance to the top rank. The obtained CCR score of Thermo Bello shows that this LEC still has room for input reductions compared with other technically efficient DMUs. This means that the operation and management costs are too high compared with other LEC, especially considering the relatively small installation size.

No.	Efficiency DMU	CCR Score	New Technical Score	New Cost Score	New Allocative Score
1	Bio energy Eindhoven	0,586025228	0,562856964	0,269831396	0,479396034
2	Bio energy Fleringen	0,68570392	0,754695463	0,44700859	0,59230327
3	Patrimonium Energie	0,60171778	1	0,702884073	0,702884073
4	Thermo Bello	0,475795132	1	1	1
5	NDSM-Wharf	0,320460148	0,84224051	0,62658653	0,743952022
6	Onze Energie	1	1	0,294101494	0,294101494
7	SVDW Windpark	0,901980036	1	0,545506605	0,545506605
8	Windvogel	0,716502545	0,777255169	0,43405252	0,558442758
9	Meewind	1	0,818801033	0,390889664	0,477392734
10	Zonvogel	0,878678233	0,903527777	0,211177287	0,233725285
11	Zon op Noord	0,64060213	0,557457145	0,146899564	0,263517232
12	Boer En Buur	1	1	0,162046514	0,162046514

Table 4: DEA results of first measurement including all efficiencies

On the other hand, DMU Boer En Buur is rated worst with respect to cost-based measures, although it receives full efficiency marks in terms of CCR scores. This gap is due to its relatively high cost structure. This DMU needs reductions in its unit costs to attain good cost-based scores. Derived from this result is that solar panels are still too expensive compared with the other RETs. This result is amplified by DMU 10 and 11, although the results show when scale of initiative is increased the performance also increases. Overall one can derive that DMUs utilize wind energy score the best.

In the second measurement only renewable electricity producing LECs are included as explained in previous paragraph. The results show that the best performer is DMU 10 Manure fermentation, with all its efficiency scores being equal to one. Reason is that although with fermentation the investment costs are high, the O&M costs are lower because manure is a waste product of farmers. Furthermore, the SDE subsidy is relatively high, so the returns are high which leads to a high profit. One remark is that it is the theoretical manure fermentation business with the best performance. Nevertheless the DMU 2, with the same RET also has a performance above average. By comparing the in practice operating DMUs with the theoretical DMUs it indicated that the theoretical DMUs scores are better than the scores of the practical DMUs. Looking at the different scores per RET, it shows that DMUs who utilize wind energy perform comparable with the theoretical case. The largest difference is found in the DMUs utilizing bio energy with solid biomass. The theoretical solid biomass DMUs are performing a lot better than the practical ones. Although it is just one case in practice, it seems that this RET can improve performance in practice by far. Again as in the first measurement solar energy have the highest unit costs and therefore is the most expensive RET.

In comparing the differences between the old en the just new published (9th of June) SDE subsidy, not many differences are found. Overall the practical DMUs perform relative slightly better compared to the new theoretical DMUs, than compared to the old theoretical DMUs.

No.	Efficiency DMU	CCR Score	New Technical Score	New Cost Score	New Allocative Score
1	Bio energy Eindhoven	0,483001857	0,552706027	0,249696671	0,45177121
2	Bio energy Fleringen	0,901157532	0,674992832	0,566391659	0,839107664
3	Onze Energie	1	1	0,484375	0,484375
4	SVDW Windpark	0,901980036	1	0,898430533	0,898430533
5	Windvogel	0,706950719	0,793292305	0,714868559	0,901141426
6	Meewind	1	0,80036182	0,361721612	0,45194761
7	Zonvogel	0,698642527	0,684203459	0,195419311	0,285615789
8	Zon op Noord	0,548426797	0,444583029	0,135937969	0,305765088
9	Boer En Buur	0,764281206	0,764281206	0,149954659	0,196203515
10	Manure fermentation	1	1	1	1
11	Solid biomass 0-10 MW	1	1	0,81620292	0,81620292
12	Solid biomass 10-50 MW	1	0,917125778	0,861111111	0,93892368
13	Wind on land <6 MW	0,9328	0,986343381	0,631481481	0,640224787
14	Solar Panels 1-15 kWp	1	0,961762422	0,169883961	0,176638177
15	Solar Panels 15-100 kWp	1	1	0,236238121	0,236238121
16	Solar Panels self supply	0,958695652	0,958695652	0,194052742	0,202413291

Table 5: DEA results of second measurement including all efficiencies

CONCLUSIONS & DISCUSSION

The second part about "best practices" is difficult to conclude. When looking at the results of the DEA test with all LECs from practice. It shows that heating producing companies are performing the highest in especially the cost efficiency measurement. In the basic technical efficiency measurement LECs with wind energy are performing the most efficient. However, not one "best practice" can be concluded but the LEC Thermo Belle is the closest to full efficiency.

In the measurement with only electricity producing LECs a "best practice" can be signalled. With the assumptions of ECN calculated into comparable LECs also included in the measurement. It shows that one of the government LECs based on assumptions is the "best practice" namely, the manure fermentation. The majority of the LECs from ECN perform more efficiently than the LECs from practice. Only the LECs utilizing wind energy is reaching close to their performance level. Thus the conclusion is that assumptions set by the Dutch government are not yet achieved in practice.

For the benchmarking model I have applied DEA, for multiple benchmarking tools. As discussed in chapter three. DEA is applied in many energy sector related research and also in the field of generation of renewable energy. However, another researcher could choose for a different methodology with maybe different results. Also the application of other DEA models or with other parameters is a possibility and one might obtain different results. For the first time in benchmarking heat producing and electricity producing companies are compared. The sector is usually calculating in a different manner. However, for operating a profitable business in utilizing RETs, information on how much CO_2 is saved is not important. This aspect should be further researched and the benchmarking model should be further elaborated with new knowledge and more LECs.

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After a long search for an interesting and relevant research topic, I finally found a topic that satisfied both demands namely, Local Energy Companies. Completing this master thesis has been an interesting journey.

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THE VALUE OF GEOTHERMAL ENERGY UNDER SCENARIOS
Exploring the potential of geothermal energy in Eindhoven

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ABSTRACT
Heating related energy consumption constitutes the greatest part of the total energy consumption in the Netherlands. However, the heating demand is mainly met by natural gas and only a small part is provided from renewable resources. Besides the emission of greenhouse gasses, this fossil fuel will also deplete eventually. The uncertainty on in the energy supply calls for the development of systems that preferably are based on domestic resources. This introduces the opportunity for utilizing indigenous geothermal energy as a cleaner, nearly emissions free renewable source of heat. However, large-scale deployment still lacks behind compared to other countries. This research presents the results on the study of the exploration of the potential and the feasibility of these systems in Eindhoven, under certain scenarios. Applying system dynamics allowed the discussion on plausible results, and required steps for withdrawing the barriers to the deployment of geothermal energy in the Netherlands.

Keywords: Geothermal Energy, Renewable Heat, Heating Grid, System Dynamics, Scenario Planning, Heating Demand

INTRODUCTION
The Netherlands consumes approximately 3.260 PJ of energy per year; 40% of this energy consumption can be addressed to heating. The energy consumption of households that can be related to heating constitutes the greatest part of the total consumption. Currently, the energy demand for heating in households is mainly provided by a fossil fuel, natural gas. Only a small part of the generated heat comes from renewable resources. This shows a focus on providing a sustainable alternative to consumers is appropriate.

This introduces an enormous opportunity exists for directly utilizing indigenous geothermal energy as a cleaner, nearly emissions-free renewable source of heat whose production characteristics are ideal for local district heating applications. (Thorsteinsson & Tester, 2010) Approximately 40% of the Dutch energy demand is consumed in the form of 'low-temperature' power for heating homes and offices (at the municipal level) and industrial greenhouses. As TNO (2007) explains this demand for low temperature power can easily be supplied by geothermal energy in its various forms. TNO estimated in 2010 the technical and economic recoverable potential up to a depth of four kilometers; the soil holds a potential of around 38.000 Petajoule, where one Petajoule corresponds with the energy use of 25.000 existing dwellings per year. Geothermal energy is insulated from changes in fuel price or supply. This feature leads to long-term, stable space hating rates for GDHS which fossil fuel-fired facilities cannot guarantee. (Thorsteinsson & Tester, 2010) However the potential of geothermal energy in the Netherlands, it still lacks behind compared to countries such as Iceland and Germany. Especially Iceland is considered as leading country on geothermal energy; currently, about 89% of the country's space heating needs is provided by geothermal energy.

Despite the potential of geothermal energy in the Netherlands, there are barriers to the deployment. Seyboth et al., (2008) identified comparatively high up-front cost of installation, a lack of investor awareness, existing infrastructure constraints, and landlord/tenant incentive splits. Moreover, relatively affordable gas and oil supplies and separate, well-developed electricity and fuel delivery infrastructures are also considered as barriers. (Thorsteinsson & Tester, 2010) Additionally, TNO (2007) identified the wealth of the Dutch gas resources, the tariff structure imposed on gas for agricultural application and the lack of a subsidiary instrument for the use of green heat as barrier for deploying geothermal energy.

However, there has been a resurgence of interest in the use of deep geothermal heat in the Netherlands. The sharp rise in gas and oil prices is forcing private enterprises to consider the use of alternative energy sources. (TNO, 2007) As the price of fossil fuels increases, the opportunities for alternative energy will present itself; the value of sustainable alternatives will increase with increasing fossil energy prices. In addition, Lund (2002) states that given the right environment, and as gas and oil supplies dwindles, the use of geothermal energy will provide a competitive, viable and economic alternative source of renewable energy.

Investors, consumers, and governments are currently unaware of the social and financial benefits of geothermal energy in the built environment. To introduce geothermal energy for heating as a substitute of natural gas successfully, the financial benefits of geothermal energy compared to natural gas should be made explicit. Several studies assumed that the feasibility and attractiveness of geothermal energy increases when fossil fuel prices increase; however, the exact effect of scenarios has not been calculated yet. Furthermore, the importance of the identified barriers demand further examination. Applying a dynamic model allows a discussion on the potential and feasibility of geothermal energy in Eindhoven under scenarios.

METHODOLOGY

As stated previously, future events can have an incremental effect on the feasibility of geothermal energy projects. However, the exact effect of these future events requires dynamic modeling tested upon a case study in Eindhoven.

Scenarios

The Welfare, Prosperity, and Quality of the Living Environment (WLO) scenario study from ECN et al. (2006) assesses the long-term effects of current policy, given the international economic and demographic context of the Netherlands. One of its scenario studies focused on the energy consumption in the Netherlands, both on energy demand and the supply of energy in the Netherlands. The qualitative and quantitative results can be applied as reference, for instance, policy-makers involved in spatial planning, housing, natural resources, infrastructure, and the environment. (ECN, 2006)

The reference scenario is considered as the Global Economy scenario; due to the fact it is widely applied and reliable as reference scenario. The other scenario is Strong Europe, since it contrasts the most to the reference scenario in energy consumption and fossil fuel prices. It is interesting to study the effect of the international climate agreement and the policy on renewable energy in the Strong Europe scenario. The WLO scenarios allowed deriving parameters concerning gas price increase, decline in energy consumption, and costs for carbon emission. By applying parameters from the WLO scenarios, the effect of increasing fossil fuel prices on the economic attractiveness of geothermal energy has been examined. The geothermal energy solutions that will be subjected to the scenarios are introduced hereafter.

System Dynamics

The dynamic modeling comprises, the development of technical parameters, the development of scenario parameters and the development of a financial calculation that is subject to changes in the technical and scenario parameters. System Dynamics is suited for this, since it deals with problems that develop over time. The researcher represents the problem situation in a model comprising the variables of interest. The system state at any time is captured by a set of state variables. A fundamental idea in System Dynamics modelling is the "principle of accumulation." This principle says that all dynamic behaviour in the world occurs when flows are accumulated (integrated) in stocks. (Tao, 2010) System Dynamics is applied in this research to support the decision making process, by forecasting the costs and benefits for concerned parties of a geothermal energy solution under certain scenarios.

Applying the system dynamics methodology incorporates the development of a causal loop diagram and a stock and flow model. The causal loop diagram is a visual representation of the feedback loops in the system; it is used to describe basic causal relationships and how these relationships might behave over time, and it is used to create insight how system behavior is generated. One of the greatest advantages of a causal loop diagram is the fact that it is very useful as a communication tool to discuss important feedback processes which involve a problem and hypothesis. Based on the causal loop diagram a stock and flow model will be developed. The stocks are characterized by its flows; it accumulates their inflows less their outflow. It characterizes the state of the system and generates the information upon which decisions and actions are based.

Case Study

The research has been focused on three cases in Eindhoven: Meerhoven, Woensel-Zuid and Eindhoven Airport. The cases have been selected based on the criteria, the composition of the neighborhood (new, existing or commercial buildings), and the presence of a heating grid. The reason why a heating grid is incorporated in this research is due its costs and therefore its influence on the projects feasibility. Furthermore the composition of the neighborhood is a strong determining factor in the number of connections to the heating grid. Based on parameters resulting from the geothermal system solutions design, it is applied on a new built area, because a heating grid is already present in this area. The other case study comprised an examination of geothermal energy on the existing building stock, since this constitutes the greatest challenge in the preservation of the energy consumption and since it is considered as the most realistic one since it addresses the future challenge in the preservation of the energy consumption, and the barrier regarding the existing infrastructure constraint.

MODEL DEVELOPMENT

A causal loop illustrates the reaction of consumers on increasing fossil fuel prices; they will cut their energy consumption. However, the increase in prices will increase the attractiveness of renewable heat for consumers. The greater the attractiveness for consumers, and the more consumers demanding renewable heat the greater the attractiveness for investors to invest in geothermal heat. However, the technical and financial risks for investors limit the attractiveness of the renewable alternative. In order to tempt and attract consumers, the renewable alternative should provide sufficient benefits.

Based on the causal loop diagram, a stock and flow model is designed. This developed stock and flow model comprises four views that are both technically and financially related. The stock and flow diagram can be distinguished in three sub-models; the calculation of the heating demand and the carbon emission for a particular area, the geothermal energy solution and the heating grid, and the calculation of the net present value of the project.

Financial Sub Model

The financial model comprises the calculation of the annual cash flow, and the projects Net Present Value. The cash flow calculation incorporates the annual revenue generated from selling geothermal energy, and the annual costs rate based on the additional connections, the maintenance costs and the energy consumption of the geothermal energy plant. The shadow variables illustrate the relation to the other sub models; the annual sold energy and the additional made connections are related to the energy demand in the particular area and the switching rate of consumers to the renewable alternative.

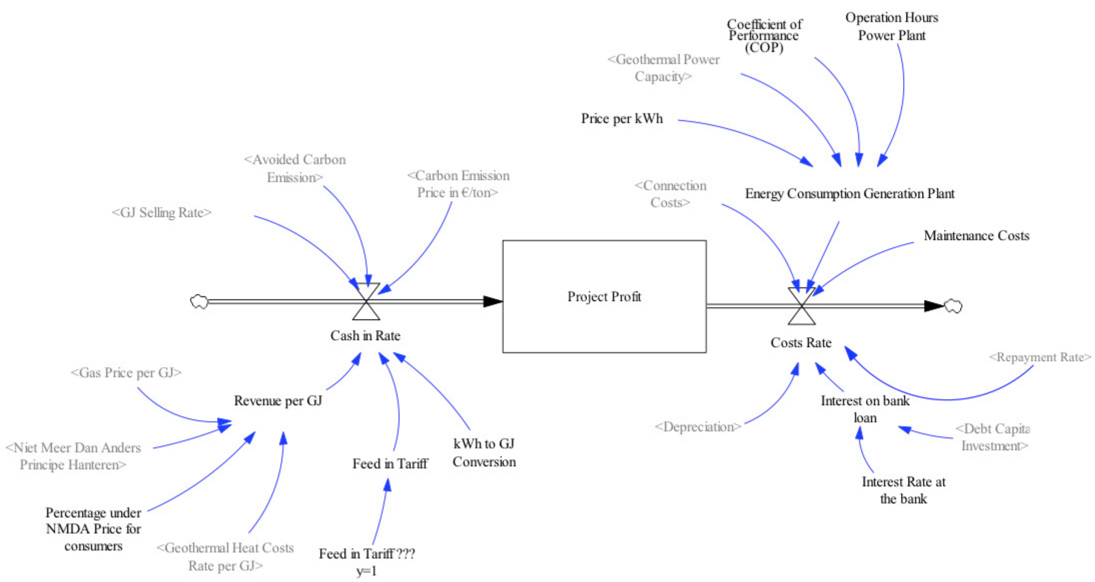


Figure 1: Cash Flow Calculation

The generated cash flow will be discounted with 5% annually by a rate. The stock accumulates the annual discounted cash flow and will present the Net Present Value of the project.

Geothermal Heating Sub Model

This sub-model constitutes the calculation of the power production of the energy plant, the geothermal heat costs for consumers, the switching rate, and the annual rate of sold Gigajoules to customers. The rate of sold energy to consumers is based on number of connections to the heating grid, and the related heating demand. The costs for consumers can be addressed to the gas price, since each produced gigajoule will be sold to consumers at 15% below NMDA (price of gas).

However, the generated income is dependent of the number of connections to the heating grid. The formula illustrates the relationship of the number of connections with the generated income.

$$GJ\ Selling\ Rate = Base\ Energy\ Demand\ from\ industry\ or\ commercial\ buildings + \left(\frac{Gas\ Consumption\ per\ Year}{Total\ Houses\ in\ the\ Area}\right) * Houses\ Connected\ to\ the\ Heating\ Grid$$

It has been assumed that all consumers will switch according to the product diffusion model of Rogers (1962), distributed over eight years. This means each specific group will switch after 1,6 years. The effect of changes in the number of switchers per year, or the number of initial connections will allow a discussion on the importance of the identified barriers and the importance of an initial heating demand on the projects feasibility.

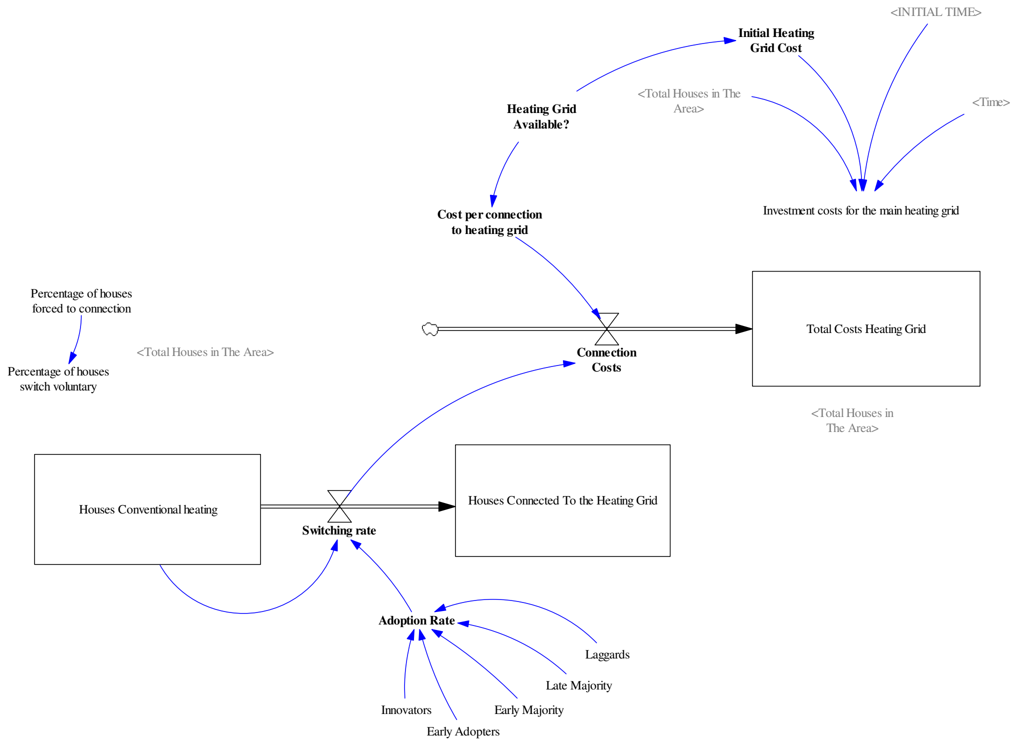


Figure 2: Calculation of the connections to the heating grid

FINDINGS AND RESULTS

By incorporating the derived parameters in the designed system dynamic models, it is possible to present the most striking results. Additionally a sensitivity analysis is performed, since the developed models contain approximations and assumptions. It is therefore mandatory to examine the sensitivity of the results to plausible alternative structural assumptions, including changes in the model boundary. (Sterman, 2000) This examination will incorporate the analysis on the price at which geothermal energy should be sold since this is considered as a study on the subsidy of geothermal heat. It has been executed to discuss the credibility of the results, and to test the robustness of the model and the results.

Profit: Financial results

The graph below illustrates the correlation between the three geothermal energy solutions under the reference scenario. The project with the lowest investment comprises the project at which a heating grid already is present, while the project with the highest investment demanded partly the construction of a new heating grid. The middle line represents the case at which a total heating grid has to be constructed.

Based on the internal rate of return, the project without the investment in the heating grid is far more desired. However, the case, which is considered as most realistic, is not feasible since the return is considered as too low and because it will not reach the break-even moment.

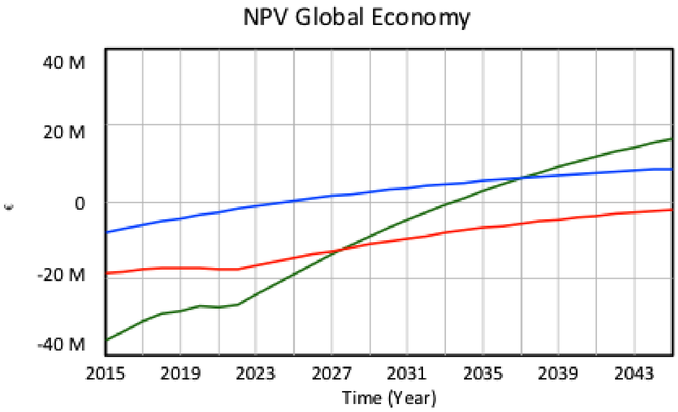


Figure 3: The NPV of three geothermal energy solution

The results from this scenario compared to the Strong Europe scenario shows how these scenarios influence the NPV and the IRR; the GE scenario has earlier break-even moment for all cases and the generated value at 2045 is remarkable higher than in the SE scenarios. Furthermore, the difference between case one and three in the annual discounted income under the GE scenario is greater than in the SE scenario, respectively 3,35 million and 2,54 million euro. This suggest that under the SE scenario the first case is more desired, while under the reference scenario (GE) the third case would be more interesting when considering the annual internal rate of return. However, the reference scenario seems to be more desirable than the SE scenario.

The change in revenue under different scenarios can be addressed to the decline in energy consumption of households, and the increasing prices for fossil fuels. The larger the energy solution in terms of investments, the more advantageous the Global Economy scenario is. In contrast to the GE scenario, the SE scenario favors the smaller energy solutions such as case one. This means the decline in energy consumption has a stronger negative effect on the financial result than the increasing fossil fuel prices, since it decreases the annual sold amount of energy to consumers. However, when the discrepancy between the energy demand and generation of energy is great enough, it could be interesting to expand the heating grid and connect additional houses. This increases the energy demand, so the yearly income will be on its initial level.

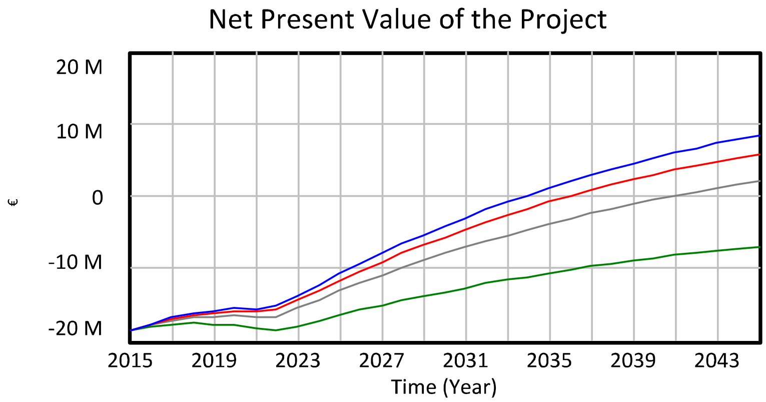
Planet: Avoided Carbon

An interesting focus point for governments is the annual avoided carbon emission. The results show the greater the capacity of the energy plant, and the greater amount of renewable energy that could offset to its consumers the greater the amount of avoided carbon will be. The graphs illustrate that a government could annually prevent the emission of 2.800 – 6.600 tons of carbon.

The fact that two cases have an increase during the first years can be addressed to the fact that the maximum of connections to the heating grid is reached after eight years. After these years the maximum of potential avoided carbon has been achieved. This contrasts to the first case, since a heating grid is already present with all houses connected to the grid from the first year.

Sensitivity of the selling price

The most striking results from the sensitivity analysis are discussed; the price at which geothermal energy. It is interesting to study how this would influence the financial results. The most desired percentage under the gas price could be derived in order to create an interesting financial environment for both consumers and investors.



25% above	11%
15% above	9%
0% below	5%
35% below	3%

Figure 4: Effect of selling prices

Derived from presented table, it should be possible to conclude that at least a subsidy of 15% over the current gas price is demanded; this will increase the projects IRR to 9%, which is considered as feasible. However, to attract investors for this project, higher yields on the financial investments are desired. If the government will subsidize 25%, the project will have an IRR of 11%, which means investors possibly might become interested in geothermal energy projects. Since this represents the most realistic case, it might be assumed that the government has to subsidize geothermal heat by at least 15 percent.

CONCLUSION

By executing a literature review, applying the system dynamics and scenarios methodology, knowledge has been gained on the potential and feasibility of geothermal energy in Eindhoven. The goal of the research was to present the benefits to governments, investors and consumers.

Governments

One of the greatest benefits of geothermal energy is the fact it is independent to seasonal influences, and the security of supply is high. It is therefore very suited to provide the base energy demand in a particular area. It can provide a stable energy supply to consumers all year long, depending on the operational hours of the energy system. Depending on the geothermal plant capacity and the heating demand per house, it should be possible to provide 3.023 – 21.891 houses with geothermal heat. Furthermore, governments and municipalities benefit from applying geothermal energy since it reduces the emission of carbon. Dependent on the case and system solution, it is possible to avoid yearly the emission of 2.800 – 13.000 tons of carbon. This amount of avoided carbon can eventually be higher since peak boilers utilize fossil fuels. When it is possible to provide the peak demand by a renewable alternative, the annual avoided carbon emission increases by 30% -70%.

Investors

Besides the price at which geothermal energy is sold, the financial benefits for investors are strongly dependent on the case characteristics. As the case study illustrated, the presence of a heating grid has an incremental positive influence on the feasibility of the project. However, it is considered not be realistic since it probably will mean that the geothermal energy plant has to compete with the current energy plant. It is more realistic that a heating grid should be constructed in the concerned area, which could be up to four times as expensive as the actual energy plant.

The social benefit of avoided emission of carbon will generate so-called carbon emission rights, which can be traded for money. So, the more carbon emission that is avoided, the greater the revenue on the project. Although the internal rate of return is too little to attract investors, it has numerous benefits for them. Once the plant is operating, it has a stable and guaranteed production of energy and it is insensitive to seasonal influences. The offset of energy is only dependent on the demand for energy in the concerned area. Additionally, if the risks can be reduced by for instance a guarantee on the drill, a geothermal project will probably attract more investors.

Geothermal energy is a proven technology, but it takes additional steps to attract commercial parties to invest in these projects. Opportunities to attract investors are: the possibility to sell carbon emission rights, decrease the risks for drilling, subsidize geothermal heat, or increase the price of natural gas.

Consumers

One of the greatest advantages is the fact that geothermal heat is insulated from changes in prices or supply. The fact geothermal heat is insensible to fluctuations in prices or supply, will lead to stable prices on the long term. However, in it has been assumed that the price for geothermal heat is linked to the gas price according to the NMDA principle; consumers will pay 15% less than they would in the gas-fired situation. This means consumers will benefit from the renewable alternative since the heating costs are reduced by 15% compared to the gas-fired situation.

DISCUSSION

Despite the benefits geothermal energy could offer, governments, investors and consumers, are currently unaware of them. This could be addressed to the barriers that have been identified in the contextual orientation; however, the results from this research allow a discussion on the barriers to the deployment of geothermal energy.

Selling Price of Geothermal Heat

The most important barrier is considered as the lack of investor awareness; this will be increased when the yield on the project is attractive for them. The yield on the investment can be increased by subsidies like the SDE. For the examined cases, a subsidy of 15-25% on the NMDA price is appropriate. Furthermore, government could add up tax to the natural gas so the commercial attractiveness increases.

Existing Infrastructure Constraint

Another strong constraint in the development of geothermal energy is the presence of an existing infrastructure. This constraint could be withdrawn when the existing network is close to its replacement moment, which could create an incentive for grid operators or other investors. However, the greatest challenge in this case is not so much the costs of constructing a heating grid parallel to the existing network, but more the uncertainty in having sufficient connections and demand for geothermal heat. When the latter is the case, geothermal energy should provide sufficient financial benefits in order to tempt consumers to switch to the renewable alternative.

As the sensitivity analysis concluded, an initial number of connections to the heating grid are required for a financial feasible project. This initial number of connections could be provided by the housing stock that housing corporations possess. The incentive for housing corporations could be the energy label improvement. This allows them to recover the costs by raising the rents. However, this is currently not possible for geothermal heat, and other forms of external heat delivery; the energy label only incorporates measures on own property. (Wolferen, 2010) It is expected that this will change in the soon future since a new directive is under construction.

RECOMMENDATIONS FOR FURTHER RESEARCH

This research focused on the supply of heat to consumers, because the heating demand constitutes the greatest part of the energy consumption and holds great potential for its preservation. However, geothermal energy knows also other forms; it can either be applied for the generation of electricity but also for cooling. Considering the current attention regarding the energy transition, a focus on the generation of electricity could be appropriate and it would be interesting to study the possibility of generating electricity from geothermal resources.

Furthermore, due to recent developments further research on a professional organization that manages the geothermal well is appropriate. Currently, there are several projects under construction in the Netherlands. At three drills oil and gas came to the surface, which could have a serious impact on the safety and the environment. This started the discussion whether greenhouse owners have the knowledge, skills and the financial means to manage the subsoil or deal with problems that could occur. Besides the technical knowledge and skills, the organization should also have the financial means to deal with possible problems.

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This research is performed within the context of the KENWIB graduation program, and is the final part of the MSc. Construction Management and Urban Development. Arcadis gave me the opportunity to perform a research according to my interest. I hope this research can contribute the challenge towards preserving the energy consumption in the Netherlands.

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STRIJP-S, PLAYING THE GAME OF ENERGY NEUTRAL URBAN REDEVELOPMENT
The impact of new legislation regarding spatial planning on the behaviour of stakeholders in energy neutral urban redevelopment processes

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ABSTRACT
This paper deals with stakeholders' decisions within energy neutral urban redevelopment processes. The decisions of these stakeholders during the process will make or break energy neutral ambitions. An extensive form of game theory gave insight in the behavioural differences of stakeholders regarding energy neutral ambitions and changing legislation. This paper shows that new legislation regarding spatial planning slightly influences the behaviour of stakeholders. An active behaviour of the municipality will still result in the best outcome. Nevertheless, the municipality becomes more powerful when acting passively and can make use of planning tools to govern towards energy neutral urban redevelopment. Moreover, organizational support, recognizing the necessity for energy neutrality, keeping focused and collaboration among stakeholders are crucial elements to achieve the objective of an energy neutral urban (re)development.

Keywords: energy neutrality, urban (re)development processes, behaviour of stakeholders, legislation, extensive form of game theory

INTRODUCTION
The Dutch governmental organizations have ambitious plans regarding the energy, e.g. reach a share of 20% renewable energy generation. Moreover, the municipality of Eindhoven wants to be energy neutral between 2035 and 2040. If comparing the ambitions with the current performance (2008), can be seen that the total renewable energy generation is about 2% (including net import of electricity). Looking at the total energy generation out of sustainable energy sources, including warmth and biomass the total energy generation will be around 6%. About 20% of the total energy use in the Netherlands can be assigned to the built environment, which is a large share of the total energy use. Still a large share of the energy generation in the energy consumption and built environment can be assigned to natural gas (61%) (TU Delft, Delft Energy Initiative; KIVI NIRIA Stuurgroep Energie, 2010). If the national government wants to achieve its ambitions, a catch up has to be initiated. Therefore, there is a necessity to implement sustainable and/or renewable energy sources

and focus on energy neutrality in the built environment.

In 2008, the national government introduced the 'Wet ruimtelijke ordening (Wro)', which replaced the previous act on spatial planning, 'Wet Ruimtelijke Ordening (WRO)'. This new legislation was introduced because of the indistinctness in roles in spatial planning processes. Furthermore, municipalities did not have a manner for cost recovery under public law. The new legislation clarifies the roles of participants in the spatial planning processes and gives municipalities more power in these processes including a possibility to recover costs by public law.

Problem definition

The Dutch government has ambitious plans regarding energy. However, the transition towards energy efficiency in the built environment is lacking. In spite of the ambitious of governmental organizations, municipalities could not govern towards energy ambitious developments. Municipalities had the feeling that they lost their planning powers in land development projects. Therefore, the national government introduced the Wro in 2008. The power in (re)development process changed. Nevertheless, stakeholders do not know how the new legislation influences their behaviour in energy neutral urban (re)development processes. The following research question is defined out of the previous set up problem definition: *"What is the impact of the new spatial planning act (Wro), and corresponding acts, on the decisions of stakeholders in energy neutral urban development processes?"*

Research objective and boundaries

The objective of this research is two folded. The first objective of the research is to discuss the new spatial planning act regarding energy neutral ambitions. The second objective is to illustrate the impact of new legislation on stakeholders' decisions in energy neutral urban development processes and thereby providing recommendations on energy neutral urban redevelopment processes.

Since this research will be elaborated in a timeframe of around 6 months, therefore boundaries are set up to reach the expected result. The first boundary is that the research will mainly be focused on new legislation regarding spatial planning processes and not on additional legislation. The second boundary is that the game theory model will be evaluated by using only one case; this is because of the time limit of the thesis. The number of stakeholders involved in the process will be limited to three, the landowner, the project developer and the municipality. Otherwise, the thesis becomes too complex. Thereby these three stakeholders are defined as most important.

Research methodology

Game theoretic modelling becomes more and more important in current research on stakeholder behaviour in urban (re)development processes. However, only a few researches make use of extensive form of game theoretic modelling. Samsura (Samsura, van der Krabben, & van Deemen, 2010), makes use of this modelling method and is used as guideline for this research.

Generally, the research consists of four parts: 'theoretical framework', 'case study', 'field research' and 'conclusion and recommendation'. The research start with developing a theoretical framework on sustainability, energy neutrality, the Dutch spatial planning process and the process of urban development. Next to the theoretical framework, a case study will be conducted on the case Strijp-s, which is a large urban redevelopment project. The theoretical framework and the case study will both be the base for the field research. In the field research will a comparison be made between (1) urban redevelopment processes under the 'WRO', (2) energy neutral urban redevelopment processes under the 'WRO' and (3) energy neutral urban redevelopment processes under the 'Wro'. The conclusions will be based on the theoretical framework and the field research. Besides, recommendations on the energy neutral urban redevelopment process will be given.

THEORETICAL FRAMEWORK

Energy neutrality and energy neutral urban development

According to W/E adviseurs, a project is energy neutral: (free translation) if there is no annual net import of fossil- or nuclear energy from outside the system's boundary for the building, use and demolition of this project. This means that the energy consumption within the project boundaries is equal to the amount of generated renewable energy within the boundaries of the project(W/E adviseurs, 2009). When the above stated definition about energy neutrality is implemented in urban development this results in the following definition. Urban development is energy neutral, if there is no annual import of fossil- or nuclear energy from outside the boundaries of the urban area. This means that the energy consumption within the boundaries of the urban area is equal to the amount of generated renewable energy from within the boundaries of the urban area.

The Dutch spatial planning process under the 'WRO'

In the Netherlands, spatial planning is organized in all three layers (national, regional and local) of the governmental organization. Traditionally has the municipality the most power in the spatial planning. However, the national government and the province can influence spatial planning indirectly or even directly. All three levels of the governmental organization develop spatial plans. The national government produces 'Planologische Kernbeslissingen (Pkb's), the provinces develop 'Streekplannen' and the municipalities develop 'Bestemmingsplannen'. Between these three spatial plans is no real hierarchy recognizable. Nevertheless the plans of the lower governmental organizations have to fit in the plans of the higher governmental levels.

The Dutch spatial planning process under the 'Wro'

The 'Wro' became enforced in 2008. However in the 1990s, with the introduction of the 'Vierde Nota voor de Ruimtelijke Ordening Extra (VINEX)' the roles and interest of involved stakeholders changed. Project developers focused on purchasing land strategically, while municipalities lost their power in these processes. These changing roles in the spatial planning were the reasoning for the introduction of a new spatial planning act. Nevertheless, the introduction of this new act took a long time.

Changes in the Dutch spatial planning process

The interest on spatial planning on the three governmental levels remains the same as under the previous act. However, the spatial planning documents per governmental level have been changed. The national government develops 'Structuurvisies' and 'AMvB's' of the national government. The provinces develop 'Structuurvisies' and 'Verordeningen' on provincial level. Municipalities develop ‘Structuurvisies’ on municipal level and ‘Bestemmingsplannen’. The ‘Structuurvisie’ has been introduced with the new Wro, and provides an insight in the future spatial developments of each governmental level. Between the ‘Structuurvisies’ of each governmental level is no clear hierarchy recognizable. However, each ‘Structuurvisie’ has to fit in the ‘Structuurvisie’ of the higher governmental level. The ‘Bestemmingsplan’, still is the most powerful steering tool on the municipal level. With the introduction of the ‘Structuurvisie’ at each governmental level, the transparency between policy documents and binding documents is recorded. The position of the ‘Bestemmingsplan’ and thereby the role of the municipality in the spatial planning process have been strengthened. Next to the introduction of the Wro is the grondexploitatiewet (Grex-wet)’ introduced, which is part of the ‘Wro’. The Grex-wet clarifies the possibilities of cost recovery for the municipality and gives the municipality additional power to set location requirements in the exploitation phase of the development process.

Energy ambitions and new legislation regarding spatial planning
The new legislation regarding spatial planning is introduced to clarify roles in the spatial planning process. However, how will this new legislation influence the governing towards energy ambitions in spatial planning processes? In the ‘bestemmingsplan’ no specific requirements can be set to energy ambitions because all rules in the ‘bestemmingsplan’ have to be spatially relevant. Nevertheless, the ‘bestemmingsplan’ contribute on energy ambitions in the form of the location of buildings regarding sunlight and space reservation for collective sustainable energy facilities. In the Grex-wet, the municipality has a possibility to set location requirements under public law. In these location requirements some requirements on energy can be set, nevertheless, the requirements have to be location-specific and not building-specific. Since October 2010, is the ‘Wet algemene bepalingen omgevingsrecht (Wabo)’ enforced. This act replaces approximately 25 permits by a single permit, the ‘omgevingsvergunning’. For citizens who strive for renewable energy is this permit a solution, because solar energy is exempted from requesting a permit. (van Middelkoop, 2010)

Urban redevelopment processes
Urban redevelopment processes start out of a local context, in which social development takes place. These developments mostly have a negative influence on spatial quality and/or on the socio-economic function of an area. This process stimulates the political urgency for the (re)development of an area. All stakeholders involved, recognize this situation or threats and opportunities differently and will focus on their own objectives. Comparing and generalizing these objectives into one strategy is difficult but crucial. Then the practical redevelopment starts which may result in a sustainable economic growth in the developed area, so the local context (which was the initiative to redevelop the area) has been changed.
Therefore, urban (re)development processes are context-driven, and each stakeholder will indentify these processes differently and behave according its identification and objectives.

Land development in the Netherlands
As earlier described, each stakeholder involved has its own objectives in redevelopment processes and will behave according these objectives. In the Netherlands, municipalities play an important role to govern these processes. Generally, two types of municipal’ behaviour can be described, an active behaviour and a facilitating (passive) behaviour. An active

behaviour indicates that the municipality is actively involved in the process and contributes to the actual development by purchasing land. When the municipality acts passively, it lets private companies take more responsibilities in the land development process. Nevertheless, municipalities will be involved due to their mandatory planning tools in the spatial planning process. Five different land development models can be recognized, three based on an active behaviour or the municipality (public land development model, building claim model and joint venture model) and two based on a passive behaviour of the municipality (concession model and private land development model) (see figure 1.)

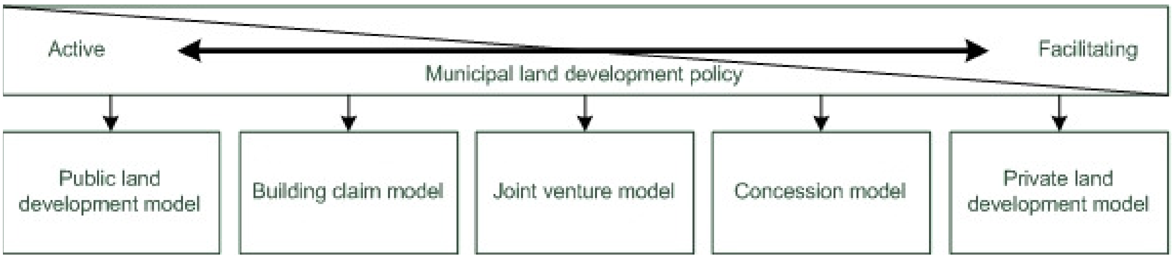

Figure 1: five land development models based on municipal' behaviour

FIELD RESEARCH

Urban (re)development processes are complex, due to the number of stakeholders involved and their behaviour to achieve their objectives. In this part of the research, a current urban redevelopment process will be discussed, followed by modelling stakeholders' decisions in these projects (one model based on the WRO and one model based on the Wro). Thereby three different scenarios will be developed to indentify the differences in the behaviour of involved stakeholders. The decision models will be developed based on game theory. Game theory is a theory of interdependent decision-making in which the decision-makers involved have conflicting preferences and one part or actor only cannot determine the outcome of their decisions. Therefore, game theory focuses on situations in which interactions and interdependency among stakeholders play a role (Samsura, van der Krabben, & van Deemen, 2010). In this research will be focused on the extensive form of game theory. Extensive form of game theory is a manner to display the decision-making process by a game tree.

Process scheme of an urban redevelopment project

To get insight in urban redevelopment processes, a case study is conducted. In this case study, the redevelopment process of Strijp-S is elaborated. Strijp-S is a former industrial area, located near the inner city of Eindhoven. In 2000, the former landowner of Strijp-S decided to leave the area, and initiated the redevelopment of the area by signing an intention agreement with the municipality. The municipality of Eindhoven and a project developer established a joint venture company (JVC), which purchased the land and became responsible for the redevelopment of this desolated area.

Development of game theory models

Based on the theoretical framework and the previous developed process model two game theory models have been developed. Game theory model 1 is based on the decisions of stakeholders in urban development processes under the 'WRO', and game theory model 2 is based on the decisions of stakeholder in urban development processes under the 'Wro'.

Players: Three stakeholders have the largest influence in urban redevelopment projects, namely the landowner (L), the municipality (M) and the project developer (PD). These three stakeholders are the players involved in the game theory models. Their decisions in the process will have the greatest influence on the outcome of the process.

Outcomes: The possible outcomes in the games are derived from the land development models out of the theoretical framework and the development of the process model. In game theory model 1, 45 outcomes are defined, and in game theory model 2, 47 outcomes are defined.

Payoffs: To indentify strategies (following up decisions of players), decisions of players are linked. Each outcome is defined with a combination of decision of each player. Payoffs can be determined when following up decisions of stakeholders are counted.

Scenario analysis
To evaluate the differences in behaviour of stakeholders under both acts, three different scenarios are developed:

- Scenario 1; Current redevelopment of Strijp-S (under WRO) – "**Reality**"
- Scenario 2; Current redevelopment of Strijp-S, with an energy neutral ambition (under under WRO) – "**Reality +**"
- Scenario 3; New redevelopment of Strijp-S, with an energy neutral ambition (under Wro) – "**New +**"

The behaviour of the stakeholders involved in the redevelopment process are prescribed per scenario. The differences in behaviour can be found back in the energy neutral ambition of the municipality in scenario 2 "Reality +" and scenario 3 "New +".

Decisions in the process will be scored on three aspects; (spatial) quality, finance and process time. Each player involved in the game received a list with decisions, which have to be made during the process. The player scores each decision on the three scoring aspects, with figures between -10 (very negative) and 10 (very positive) with 0 as no effect. This is done for all three developed scenarios. Scoring the decisions is based on preferences between decisions.

In total nine experts scored each decisions on the aspects (spatial) quality, finance and process time, whit in mind the prescribed behaviour per scenario. This part of the paper shows the findings out of the game theory models.

Each player focused on different aspects, and the aspects were scored different per scenario. The scorings of scenario one are stated in all aspects including scorings can be found back in table 2.

	Scenario 1 "Reality"			Scenario 2 "Reality +"			Scenario 3 "New +"		
	(spatial) quality	Financial	Time	(spatial) quality	Financial	Time	(spatial) quality	Financial	Time
Landowner	10%	55%	35%	10%	55%	35%	10%	55%	35%
Municipality	48%	32%	20%	68%	15%	17%	68%	15%	17%
Project developer	42%	35%	23%	52%	31%	18%	52%	31%	18%

Table 2: Stakeholders scoring aspects per scenario

The landowner is focused on the financial aspect, and spatial quality is not that important. Thereby is process time another important aspect, which is closely related to the financial aspect. In the first scenario, the municipality focuses on the spatial quality, however, the financial aspect is also of importance. Looking at scenario 2, the municipality lowers their interest in the financial aspect and focus even more on spatial quality, because the municipality has an energy neutral ambition. Scoring the aspects was the hardest task of the experts of the project developer, because there is a strong link between all three aspects. The spatial quality is of great importance, because a good spatial quality will result in financial benefit. However, time process is also strongly linked to the financial aspect. The 10% difference on spatial quality between scenario 1 and 2, can be assigned to the energy neutral ambition of the municipality.

The maximum payoff indicates the best outcome for the stakeholder involved. The stakeholder will strive to follow the pattern out of the game tree to come to the outcome, also known as following a strategy to maximize the utility. Each stakeholder has his own preferred outcome, and thereby preferred strategy. The landowner will follow the next strategy to achieve his objective. The redevelopment starts with the intention of the landowner to leave the area. Thereinafter, the land of the landowner will be sold to a combination of the municipality and project developer in a joint venture model (PPP-construction), with a tender procedure on price. This is due to the financial focus of the landowner.

The municipality follows the next strategy to achieve its objective. The municipality focuses on an active behaviour, in which it buys land from the landowner, together with the project developer. The project developer is selected by a tender procedure with selection criteria. Thereinafter, a joint venture company is set up between the municipality and the project developer. However, the municipality does not want to provide a building claim within this structure and wants to sell serviced land to other project developers. A lot of risk for the municipality will be involved in this scenario, because no buyer is guaranteed. On the other hand, no project developers will join the joint venture company without a building claim.
The project developer follows the next strategy to achieve its objective. The project developer wants to get involved in a joint venture company including a building claim. The project developer is selected by making use of a tender procedure with selection criteria. The project developer focuses on getting a building claim in the redevelopment process.

A subgame Perfect equilibrium is the best outcome for all players involved. The SPE can be found by making use of backward induction, starting at the best outcome for the last player in the process, the project developer. The SPE's per scenario are shown in table 4.

	Subgame Perfect Equilibrium (SPE)			
	Outcome number	Payoff landowner	Payoff municipality	Payoff project developer
Scenario 1 "Reality"	3	12,23	37,38	39,35
Scenario 2 "Reality +"	48	12,00	43,28	39,30
Scenario 3 "New+"	93	11,40	47,27	39,98

Table 4: SPE per scenario

In scenario 1, outcome number 3 is the SPE, in which each player's strategy is a best response to the other players' strategies. This outcome emerges from the strategy that the landowner decides to leave the area, thereby the municipality behaves actively in the development process. The landowner selects the project developer based on selection criteria, and the project developer will buy the land, together with the municipality, from the landowner. The project developer and municipality form a joint venture company (JVC), which will be responsible for the redevelopment of the area. The project developer will get a building claim for joining the JVC. Obviously, the payoff structure at SPE is lower than every player's best payoff. Particularly, the municipalities' payoff is low, but if the municipality chooses to not provide a building claim within the JVC-structure the project developer decides not to join the JVC-structure. Therefore, the municipality has to apply a building claim. For both scenario 2 and scenario 3, the same SPE's can be recognized (scenario 2 outcome 48 and scenario 3 outcome 93)

CONCLUSION AND RECOMMENDATION

Answering the previous set up research question is the most important aspect of this chapter: *"What is the impact of the new spatial planning act (Wro), and corresponding acts, on the decisions of stakeholders in energy neutral urban development processes?"* The Wro and corresponding acts slightly change the behaviour of stakeholders in energy neutral urban development processes. The municipality becomes more powerful and can set location requirements, which may lead to energy neutral areas. Nevertheless, collaboration among stakeholders is the most important aspect to come to energy neutral urban (re)development processes. In the following, the conclusions regarding stakeholders' behaviour are summarized.

Municipalities' behaviour in urban (re)development processes:

- Due to the introduction of the new legislation on spatial planning, the power within the governmental organisation has changed. Municipalities became more powerful in the spatial planning process. Especially, the power to test the 'Bestemmingsplan' with the 'Structuurplan' is a shift in powers between the province and the municipality. Nevertheless, this shift will generate a lot of work for the municipality, thereby raises the question if the municipal organisation can handle this amount of work.
- Municipalities become more powerful in redevelopment processes, private organisations will become less powerful. Especially in cases in which the project developer owns land, and has no intention in collaborating with the municipality. The municipality can set additional location requirements through the 'exploitatieplan'.
- Acting passively was under the WRO not interesting for the municipality, especially in large redevelopments with many landowners involved. For municipalities becomes acting passively more interesting with the introduction of the new legislation.
- A municipality becomes more powerful in (re)development processes. Therefore, it is important that all municipal departments support the same energy ambitions.
- If municipalities have energy neutral ambitions, it is important that they select the right project developer during the process. Three different types of project developers, with different objectives can be recognized:
- Investor-project developer; this type of project developer usually has a long-term objective because the invest in (re)development projects with the intention to have a

long term profit (an example is rental houses). After this long term, the project developer will sell the real estate, and still wants to have a high return on invest. If energy prices keep rising, energy neutral urban areas will become more interesting. Therefore, this type of project developer is interested in energy neutral urban areas.

- Contractor-project developer; this type of project developer usually has a short-term objective, because it aims for building capacity in a certain area. This project developer will sell the area or real estate direct after completion. Energy neutrality will not be the main objective of this type of developer because of the negative or small return on investment.
- (independent-) project developer; this type of project developer is not allied to a contractor or an investor. They will develop the area according the ambitions of the client.

Project developers' behaviour in urban (re)development processes:

- Purchasing land strategically will become less interesting because the municipality will have more power in the redevelopment and can govern towards certain objectives. For the project developer, 'Free-rider' behaviour will not be possible anymore, to what extent this initially appeared.
- With the introduction of the new Wro, acting passively becomes more interesting for the municipalities. Hereby, becomes a passive behaviour of the municipality less interesting for project developers. Nevertheless, collaboration with the municipality will be of even more importance. The project developer needs the municipality's planning power during the planning process of the project.
- Before the introduction of the Wro, some project developers made use of the possibility not to cooperate in (re)development processes (so-called 'Free-riders'). The new legislation will terminate this behaviour, due to the possibility to recover costs and set location requirements under public law.
- The municipality becomes more influential while behaving passively; therefore, it is for project developers important to collaborate with the municipality.

Landowners' behaviour in urban (re)development processes:

- Through the introduction of the new legislation, it becomes for a landowner more interesting to develop its own plot because the simplified and shortened spatial planning process. Nevertheless, how often will this occur in urban redevelopment processes?
- If municipalities focus on energy neutrality, the landowner believes that the revenues of the land become less high, because the municipality will focus more on the spatial development then on the land prices.

The second part of the conclusion is focused on a recommendation on the energy neutral urban redevelopment process. The following recommendation can be made:

- In the initiative phase of the process, the municipality has to point out their ambition on an energy neutral redevelopment. This ambition can be recorded in the EPL. Moreover, political support within the municipal organisation for this ambition is crucial.
- When looking for a commercial partner in the redevelopment process should be aimed on an experienced partner and a partner who is willing to strive for the same

energy neutral ambition.

- During the strategy and master plan development phase, the energy neutral ambition has to be elaborated and recorded.
- In the process of setting up a joint venture company (JVC) should be focused on a voluntary agreement on exploitation, including location requirements on the energy ambition.
- Develop the urban plan and the 'Bestemmingplan' while focusing on the energy neutral ambition.

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A COMPLEX MODEL FOR GENERATING SUSTAINABLE LAND USE PLANS

Determining the spatial location allocations of energy sources in urban planning

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ABSTRACT
The energy demand in the Netherlands will increase until 2020, so also the demand for fossil fuels. According to the European Climate and Energy Package 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. Considering the many required sustainable energy measures it affects the entire spatial environment. An integral vision can provide to deal with the spatial consequences of new energy sources in the environment. Here for, an Agent Based model is established that provide a sustainable urban planning map. This model simulates the spatial location allocations of various energy sources in the SRE-area. Under different scenarios the different energy sources can be compared on their spatial affects. Final, the model can give insights in the development of sustainable areas.

Keywords: Agent based modeling, sustainable urban planning, spatial vision, sustainable energy measures

INTRODUCTION
The energy world is changing. The energy demand in the Netherlands will increase until 2020, so also the demand for fossil fuels. This will result in a increasing of the CO2 emissions due the climate and at the same time the government is realizing to be dependent of foreign countries. According to the European Climate and Energy Package 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. Nowadays a small amount is sustainable but generally fossil fuels are used. It seems to be far away but the preparation of the required innovative energy sources and their infrastructure in the environment is essential. It is possible to conclude that there is sufficient potential to generate sustainable energy out of different sources. Many of these energy measures have a spatial relevance and discourage to invest in sustainable energy measures.

Different municipalities in the Netherlands have the intention to develop an energy neutral environment. The approach of this integral process encounters different critical developments and need different energy sources to become energy neutral. According to the ministry of economic affairs it is necessary to provide early spatial choices so that sufficient space is available for energy production and to utilize the available space fast and efficient if the market needs it. Each source has their features and so also their own geographic implementation in the spatial environment. Because of the high amount of measures that are needed there is a lack of insights how to allocate the locations for these measures. Various activities are set up, but there is not an integral approach how energy is used in the spatial environment. An integral spatial vision is needed to deal with the spatial consequences of new energy sources in the environment. Designing a simulation model that can allocate locations for renewable energy sources in the urban environment can provide a sustainable urban planning map.

METHODOLOGY

As stated previously, a spatial vision is needed to deal with the spatial consequences of new energy sources in the built environment. However, this planning requires modeling tested up on the case-study SRE-area.

Agent based modeling

Agent-based Modeling and Simulation (ABMS) can model complex systems composed of interacting, autonomous 'agents'. An agent has a behavior that interacts and influences other agents, which influence each other's behavior.

A typical agent-based model has three elements:

- A set of agents, their attributes and behaviors.
- A set of agent relationships and methods of interaction: An underlying topology of connectedness defines how and with whom agents interact.
- The agents' environment; Agents interact with their environment in addition to other agents.

So agents interact with their environment and with other agents. This research proposes an agent-based approach because individual agent decisions of land-use location interact with decisions of other lands use agents. These decisions need to be coordinated so that a collaborative plan will be generated. In this research a land-use model will be developed to generate land use plan alternatives in an interactive environment of multi agents. Based on the article of Arentze et al. (2009) the land-use model will be established. This article develops a method whereby a heuristic is introduced for generating land-use plans that combines elements from different approaches in land-use modeling. This integrated model is better able to account for a difference in nature between area-type land uses (for example: housing, industry, agriculture) and facility-type land uses (for example: schools, retail). Therefore a micro-strategy is integrated in a macro-strategy which determines how a macro-strategy is realized in a land use plan. On macro and micro levels, both use different concepts and methods.

The micro strategy is able to solve location-allocation problems which imply to find the location of a given number of facilities that improve the objective function. In general, the microstrategy finds solutions where locations need to be selected out candidate locations. For the algorithm is an initial solution selected, the current solution. The current solution is the set of cells that are currently claimed by the agent for this facility. A candidate cells which is not in the current solution is substituted for each cell in the current solution. If the utility of the next solution has a higher value than the current solution, the next solution becomes the current solution. Otherwise there will be no substitution. For defining the utility score, each measure exists of different variables that each could score different values. By making use of this methodology various criteria and their effects can be considered. For each turtle the different variables (criteria) are put against each other and values are assigned. These values are based on expert knowledge. Experts from Builddesk will perform the validation and credibility. Although, the objective of the model is not focused on precise and exact numbers, it should represent realistic and possible outcomes.

The macro-strategy of a facility agent provides the number and size of new facilities, but doesn’t define locations. By evaluating possible macro-strategies under best possible location choices and identifying the one that maximizes the objective function, the best macro-strategy could be designate. This is an exhaustive process because if facility sizes can vary on a continuous scale the number of ways in which a task size can be subdivided into parts and the number of possible macro-strategies is virtually infinity. Scenario development is assumed to generate plan alternatives. Scenario development is used to simulate different simulation under different conditions. These outcomes are used to compare and finally to make conclusions. The scenarios are divided into each one of the sustainable energy sources that generates 20 % sustainable energy. This means that 525 windmills, or 32.000.000 m2 pv-panels, or 14.400.000 ton biomass are needed to generate 20.1 % sustainable. These amounts are the basic assumptions for the scenarios.

Netlogo

For the development of geo-spatial agent-based models the use of Netlogo is a great simulation/modeling system (Crooks, 2008). Netlogo is a program that is able to modeling an environment by multi-agents. It is well suited for modeling complex systems over time. Interactions between micro-level behaviors of individuals and macro-level patterns can be explored. Also the behavior under various conditions can be explored.

The program of Netlogo exists of agents that can follow instructions. There are four types of agents: turtles, patches, links and the observer. Turtles move around in the environment. The environment exists of a grid of patches. Each patch is a part of the ‘ground’ over which turtles can move. The links agents are turtles that stand in connection. The observer is, like the name all ready describes, someone that observes the environment of turtles and patches. The way the world is connected can change by giving commandos to every agent, which is established in the procedure part. For example the turtle, that's moving over the patches, gets commands which lead to changes in the environment. Also agent variables can be implementing so that values (such as numbers) can be stored in an agent. Various agent variables are possible like a global variable, a turtle variable, a patch variable or a link variable. Each turtle has his own value for every variable and each patch has his own value for every patch. These variables could be for example colors or values. All turtles inside the environment can be handled in any conceivable way the user can think of and all agents can interact with each other. In addition, various buttons can be added so that outcomes can be plot (Wilensky U. , 1999).

THE MODEL

The model is established by determining the turtles, patches and procedures. Below the different parts of the model are defined.

Turtles

This research focuses on the sustainable energy measures windmills, pv-panels and bio-energy installations. These measures have sufficient potential for generating sustainable energy. Besides that, these techniques are adequately developed for applying in the environment. Below, each measure is defined separately.

Windmills

The Netherlands is well suited for generate energy out of wind. Windmills are a sustainable application that contributes in the goal for a sustainable energy system. A difference can be made between offshore and onshore windmills. This research only focuses on the onshore windmills because the case-study approaches an onshore area. Wind turbines convert the kinetic energy of wind into electricity.

The realization of a wind park in the environment takes time and requires a large number of activities of different parties. A wind plan doesn't locate alone but is part of the total urban planning environment. This research focuses on the spatial consequences of windmills. The involvement of nature, ecology and stakeholders will be extended.

Nowadays the new windmills are getting higher and so applying it into the existing structure or hideaway is impossible. So by implementing it into the environment the windmills creates new landscapes. According to Senternovem1 (2004) the visual influence are less in an environment with a high amount of mass, than open areas where buildings are much further away from the observer (SenterNovem1, 2004). If more than one turbine will be located the preference is that they locate in line or in a grid. Sensitive objects are for example buildings and schools, and these objects are sensitive for the implementation of wind turbines. They have nuisance of noise, shadow effects, glare and safety risks. The noises of the wind turbines can't cause impermissible interference. In this case, it's desirable to have a sufficient distance between sensitive objects and wind turbines. Wind turbines also prefer to locate near the consumer with the highest demand (AgentschapNL[3], 2011).

These features are the basic for the establishment of the variables with their scores. Below the requirements and variables are defined.

WINDMILLS

Features		Requirements	Definition	Unit		Variables	Value
Spatial		Pattern: turbines locate in a line or grid pattern. Sufficient available square meters	In the surrounding of the turbine are sufficient turbines locating.		1	Yes	0.7
			Mixed area			No	0
Sensitive objects	Agriculture	Distance visual nuisance (Average)	> 11.000	Meters	2	Long	0.7
		Distance shadow nuisance	12 * 90 = 1.080	Meters		Average	0.3
		Distance noise nuisance	4 * 100 = 400	Meters		Short	0.1
	Industry	Distance shadow nuisance	12 * 90 = 1.080	Meters		Average	0.7

	Distance noise nuisance	4 * 100 = 400	Meters		Short	0.3
Energy supply	Demand and offer, minimal distance between demand and offer	The total supply has a short distance to cover the total demand.	Meters	3	Short	0.7
		The total supply has an average distance to cover the total demand.	Meters		Average	0.2
		The total supply has a long distance to cover the total demand.	Meters		Long	0.1
Visual view	Less visual effects by a high amount of mass	A high amount of mass in the surrounding gives less influence on the visual view. Preference industrial area.		4	Low	0.8
		A less amount of mass in the surrounding gives more influences on the visual view. Preference agriculture area.			Average	0.2
		The windmill is (partly) locate in the residential area.			High	0.0
Technical	Diameter turbine	90	Meters			
	Distance between turbines	6 * 90 = 540	Meters			
Efficiency - return	Wind speed	6,5	M/s			
	Full capacity hours	2.200	Hours			
	Power generate per turbine	3.000	kW			
	Developments costs	1.430	Euro/ kW			
	Netto costs/ year/ turbine (15 years)	574.628	Euro			
	Netto income / year /turbine	462.000 + 211.200 = 673.200,-	Euro			
		Electr. sale 0,07*3000*2200 = 462.000,-	Euro			
		Subsidy 0,032*3000*2200 = 211.200,-	Euro			

Table 1: Features and variables windmills

The first variable defines if sufficient space is available to locate in line or pattern. A windmill park has the preference to locate in line or grid, this variable calculates the possibility and counts windmills in the surrounding of a windmill. The second variable determines the distance between the windmills and sensitive objects (residential area). Dependently on the distance between these objects the value for this variable will be determined. The third variable preferences a short distance between supply and demand of energy. Here for, how higher the distribution in a short distance how higher the measure will score. The last column defines the influence of a visual view. These influences are lower on industrial areas than in the surrounding of agriculture areas. The technical and return features aren't translated into variables because they are useful for defining the variables. For example, the technical numbers are used for defining the distance between a windmill and sensitive objects (variable 2).

The turtle scores a value for each variable, the sum of these values divided by the amount of variables, determines the windmill-score for that turtle.

PV-panels

The sun is shining every day. Besides light it also contains energy. Solar energy can be converted into electricity by making use of pv-panels (photo-voltaic panels). The development of pv-panels makes enormously steps recent years. The technology improves constantly which lead to rapidly decreasing of costs and prices. The spatial requirements influence the integration of pv-panels in the environment. Pv-panels exist of cells that convert the sunlight into energy. These cells are light in weight and so easily to apply on various surfaces. Usually the pv-panels are installed on the roof of buildings. Not all the roofs have the potential for pv-panels and so a total surface is determined that is suitable for pv-panels.

Industrial areas have more potential for locating pv-panels, because of the large amount of square meters of roofs. Also the consumption of electricity is higher and a minimal distance between producer and consumer is desirable.
The return of pv-panels is influenced by several variables. The proportion between the amount of energy generation and investment costs define the final efficiency of a pv-panel.
The amount of energy generation is determined by the following formula:

*Hours of sun * Power * Standard losses * Solarisation percent * Obstacle percent*

These features are the basic for the establishment of the variables with their scores. Below the requirements and variables are defined.

PV-PANELS

Features	Requirements		Unit	Variables		
Spatial	Potential roof surface	17.327.065	m^2			
	Possibility for locating pv-panels. Available square meters.	100 % of the patches are industrial and residential areas.	m^2	1	Yes	0.3
					No	0
Energy supply	Demand and offer, minimal distance between demand and offer	The total supply has a short distance to cover the total demand.	Meters	2	Short	0.7
		The total supply has an average distance to cover the total demand.	Meters		Average	0.3
		The total supply has a long distance to cover the total demand.	Meters		Long	0.1
Efficiency - return	Hours of sun each year	1.010	Hours			
	Power	0,125	kWp/ m^2			
	Standard losses	15	%			
	Return/ m2	1.010*0,125*0,85 = 107	kWh/ m^2			
	Electr. Sale	0,23	Euro/kWh			
	Price / Wp	2,33	Euro			
	Investment	2,33*125 = 291,25	Euro/ m^2			

Table 2 Features and variables PV-panels

Sufficient roof surfaces have the potential for locating pv-panels. Industrial and residential areas have the preference for locating this. Each patch has a surface of 90.000 m2 but isn't suitable to cover the whole patch with pv-panels. According to calculation of available roof space, each residential and industrial area has 5508 m2 potential to locate pv-panels. And so, variable 1 defines the sufficiency of available square meters for locating pv-panels.
The second variable determines if the distance to the demand is short, average or long. Dependently which distance the turtle has to the demand, it will score 'one' of the three values.

Each pv-panel-turtle will score a value for both variables; the sum will be divided by the amount of variables which defines the pv-panel-score.

Bio-energy

Bio energy is energy that is generated out of organic materials (biomass). The energy that comes out of biomass can be used for heating or electricity. There are different processes that convert biomass into energy, like fermentation, combustion and gassing. This research focuses on the fermentation process. The use of bio-energy installations has a double bondage location. Even the transport of the organic materials to the biomass station as the transport of heat is strong committed to their location.

A distinguish can be made in the size of installations. These are subdivided into small installations on owner level, large scale installations on agriculture areas and large scale installations on industrial areas. The small installations are generally located by agriculture companies in the outlying areas. The larger installations on agriculture locations are bigger installations whereby the manure of their own company or local collaboration is used. The larger industrial installations are appropriate for energy production, are generally located on industrial areas or closed to processors or waste treatment installations.

The guide 'Bedrijven en milieuzonering van de VNG' advices a focus distance of 100 meters around installations for fermentation and combustion. This is based on distance of at least 100 meters for the smell and noise, 50 meters for dust and 30 meters for safety. The distances for smell, noise and dust are overestimated, while the safety is slightly underestimated (storage of biogas). The advice is that 50 meters for safety is sufficient. (VNG, 2009). During the transportation of heat the transport losses are very high (Jablonska, 2011). The distance between consumer and producer prefer a maximum distance of 3 kilometers, so that the losses are minimal.

The application of bio-energy is based on biomass which concerns an extended process. This process contains variables which are sensitive for influences. Like the amount of available biomass influences the final generation of energy. This amount can fluctuate and isn't guaranteed for the future. This sensitivity of variables that influences the final generation of energy must be kept in mind.

These features are the basic for the establishment of the variables with their scores. Below the requirements and variables are defined.

BIO-ENERGY							
Features	**Requirements**			**Unit**	**Variables**		**Value**
Spatial	Sufficient available square meters	Located on industrial or agriculture area			1	Yes	0.3
						No	0
Sensitive objects	Distance smell & noise nuisance	100		Meters	2	Long	0.7
	Distance dust nuisance	50		Meters		Average	0.5
	Distance safety nuisance	30		Meters		Short	0.3
Energy supply	Demand and offer, minimal distance between demand and offer	The total supply has a short distance to cover the total demand, maximal 3 kilometers.		Km	3	Short	0.8
		The total supply has an average distance to cover the total demand.		Km		Average	0.5
		The total supply has a long distance to cover the total demand.		Km		Long	0.3
Technical	Average square meters	An average of 100 * 100 meters. This means one patch (300 * 300 m).		M^2			
Efficiency - return	Biomass	Liquid manure	0.3	GJ/ton			
		Solid manure	0.8	GJ/ton			
		Corn	15.1	GJ/ton			
	Electric power		980	kWe			
	Netto costs		1.633	€/ kWe			
	Netto Benefit		0.06	€/ kWh			

Table 3 Features and variables bio-energy

The variable spatial defines the available square meters for locating a bio-energy installation. The preference is on an industrial or agriculture area. The variable sensitive objects defines the distance between the installation and sensitive objects (residential areas). The energy supply wants to have a short distance between the demand and offer of energy, how shorter the distance how higher the turtle scores.

Each bio-energy turtle scores for each variable a value, the sum of these values divided by the amount of variables defines the bio-energy-score.

Patches

The study area is represented by a raster of grid cells. Attribute values that vary continuously over space, are allowed to be recorded at cell location. For the SRE-area the raster represents the various land uses. The use of land is divided into residential area, industrial area and agriculture area. By making use of GIS (Geographical Information Systems) the different land uses can be represent in a map and finally implement in Netlogo.

The SRE-area has a surface of 153.000 ha, which implies a diameter of 60 kilometers by 45 kilometers. A grid of 300 m x 300 m uniform cells is used. Thus, the study-area contains of 200 cells by 150 cells, in total 30.000 cells. Figure 1 shows the land-use map of the study-area in existing situation.

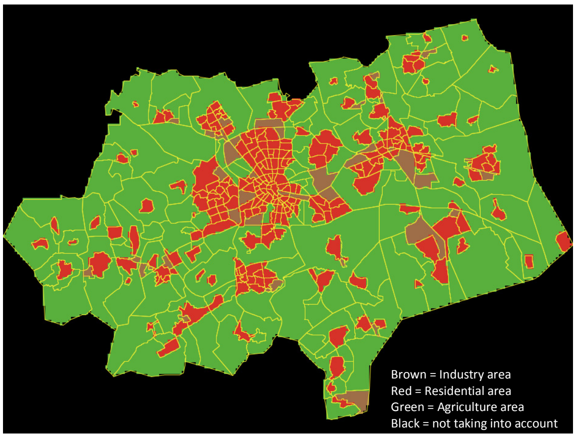

Figure 1 Land-use map SRE-area

Each grid exists of cells which also called patches. Each patch contains features that influence the utility of a facility agent on that location (patch). The features of the patches are land-use, gas demand and electricity demand.

Design model

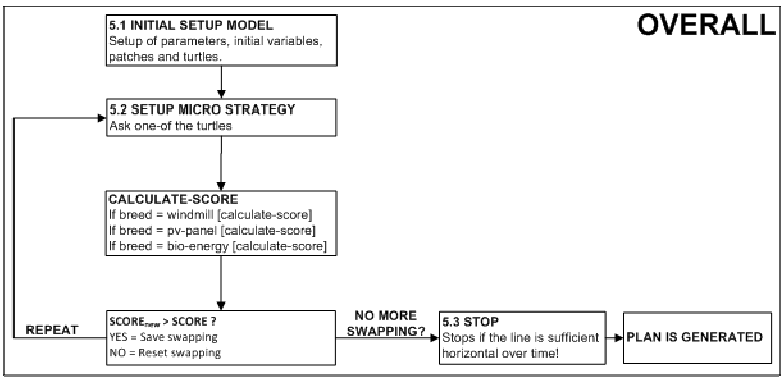

Figure 2 Flowchart Netlogo model

The model is divided into two steps; the setup and go part. The setup button set the model in a state from which it can be run. After pushing the setup button, the model starts simulating by pushing the Go button. Below, the flowchart determines the steps which the model takes.

SIMULATION AND FINDINGS

The model is established and the various scenarios can be simulated. Each scenario implies one of the sources separately. This means that the first scenario only exists of windmills, the second pv-panels, the third bio-energy and finally a mix is made. Each scenario achieves the 20 % sustainable energy generation. Below, one of the maps is showed for example.

From these maps, the variables can be evaluated. Insights are giving about the location allocations of these measures and their spatial influences.

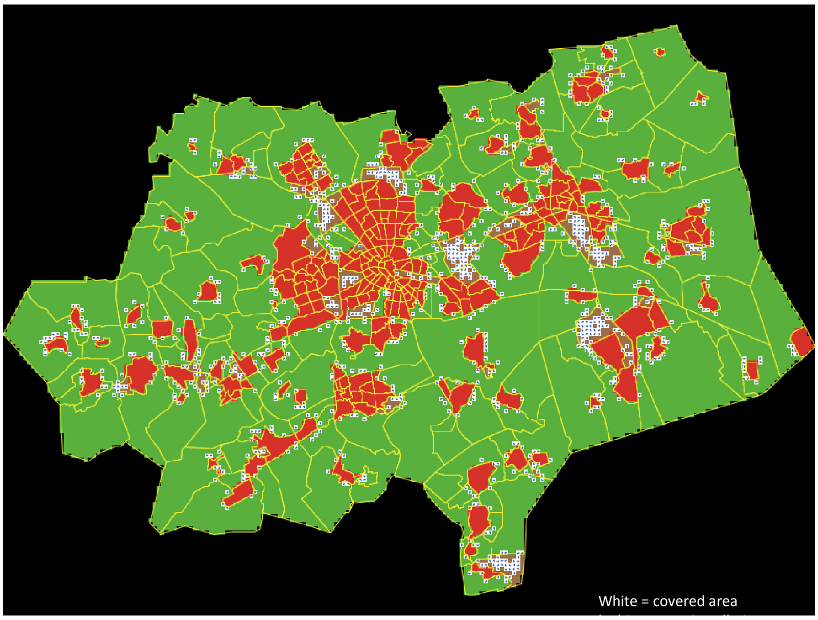

Figure 3 Sustainable urban planning map

The locations of windmills have high spatial influences but financial benefits. PV-panels have the opposite, low spatial influence but high financial investments. For bio-energy installations are suitable to locate in the environment and have financial benefits. The constraint is the dependency of available biomass.

CONCLUSION

The general conclusion that can be made is that the ABS approach and the Netlogo platform resulted in a model that simulates the location allocation of sustainable energy measures. In the model, these measures are controlled by spatial variables, resulting in insights in the location allocation and the spatial influences of sustainable energy measures. The model provides urban planning maps and is suitable to negotiate in sustainable spatial visions. Furthermore, it can be used as a communication and decision tool by giving insights into the spatial behavior of sustainable energy measures in the built environment.

Decision makers have the possibility to define the variables by their own insights and preferences. This means that the model allows the implementation of the perspective of the involved stakeholders.

By simulating different scenarios the model shows the spatial impacts of each scenario. This gives the model the possibility to compare the spatial influences of each energy measure. Also the technical settings could be change and so the spatial influences of these changes could be compared.

DISCUSSION AND RECOMMENDATION

In further research, the model can be extended with other layers and variables. In view of the fact that the model is capable of multiple layers and variables to be added. Expanding the model with a more detailed land use map can contribute in a more specify location in the environment. The black area on the map is unknown and the energy measures next to this area can't see the possible constraints. An important conclusion on this research shows that the final locations need to be customized by zooming in on the map.

Furthermore, the variables that determine the scores contain indicators on the *spatial constraints*. These variables are subjective and suitable to change and add new ones. This is too much specified to make a general conclusion of the behavior of these energy measures. The fact that the model shows suitable and realistic maps allows assuming that the model is a realistic valuable simulation model.

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A lack of understanding is completed, new insights have been given and for me a new world has begun.

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THE BENEFITS OF DH IN THE NETHERLANDS
A research study on main aspects of DH and RE in the Netherlands, based on experiences in Denmark

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ABSTRACT
The energy sector will change radically in the next years. The implementation of renewable energy sources will be fundamental. The implementation will ask for changes in political, organizational and in financial ways. The oil/gas based energy supply will change to a renewable one. What are the main characteristics of the Netherlands? How are other countries doing? Most of our daily energy use is ending in heat, how are we dealing with heat and what are the prospective for the Netherlands?

Keywords: District Heating, Renewable Energy, Environmental science, Heat supply system

INTRODUCTION
The worldwide energy sector will change in the future. Some fundamental changes will arise in this sector. High class renewable energy projects will be arise, the transport sector has to deal with other energy sources and the normal life of an inhabitant will change due to the low energy houses, while we still want to heat our spaces and tap water, and probably electric cars. In other words, an exponential economic growth, associated with increasingly consumption, could not be sustained on the long run on a planet with the current resources.

Energy in the world

We have been using energy in the past and we will continue to do so in the future. Which consequences are expected for the worldwide energy problems? Global warming, carbon dioxide (CO2) pollution and melting ice caps; these are raising problems nowadays without a solid and clear solution. How did we use energy in history, how much energy are we using in ratio to the continents? Which part of the world uses the most?

We, the people in this world, are using in one year approximately 460 EJ. This is equivalent to the amount of solar energy reaching Earth in only one hour (Crabtree and Lewis, 2007). Therefore the sun is a powerful source of energy, which we can use a lot.

The stock of the primary energy worldwide is changing. While our grandparents used less than 1000. 10^6 tons coal equivalent, the energy use grew with a factor 20 between the year 1900 and 2000. We still need to use energy in the future, because of heating our houses and using an increasing amount of (electrical) apparatus. We will need energy for the economical values, and for a sustainable living climate, but we should consider our society for the very far future. Although the world primary energy consumption consists mostly in oil, coal, natural gas, nuclear power and hydro energy even more green energy sources has been introduced. Contrarily to fossil fuels, which give us a completely controllable energy flow, renewable energy sources are more uncertain, they are often unavailable at the time of demand and incompliant with the specification of demand.

The energy use in Europe is, in according to the world energy use, a smaller amount, but even an alarming factor. Our current energy sources in Europe are not sufficient for the future. For an energy policy, a mutual EU energy strategy for Europe is made up for the time period until 2020. In March 2007, the European Council presented their targets: 20% renewable energy, 20% reduction of CO2 emissions and 20% energy reduction in 2020. Although in these days, many countries are still lagging behind in reaching these targets. Many possibilities are launched in renewable energy solutions. Different pilot projects have been initiated, implemented and evaluated; nevertheless, due to the economic crisis starting from 2007, more and more countries refuse to put more effort in reaching these targets in 2020. In order to limit the energy losses, countries with cold climates, such as the Scandinavian countries, Poland and Estonia, the district heating technology in urban areas has been used for many years and its use is widespread (Froning, 2003), while the investments in sustainability in other countries, where mild climates prevail, are lagging behind.

Apart from that, some projects are successful, especially in Denmark. Wind power, solar power, water power and smart distribution methods are widely used. An important amount of the Danish export market is related to renewable energy.

DISTRICT HEATING

District heating is a centralized system for distributing heat to consumers, for and by consumers. The heat can be obtained by different sources, such as fossil fuels, biomass, geothermal heating, central solar heating, heat-only boiler systems and even nuclear power stations. Centralized district heating plants in high density area have higher efficiencies than smaller localized boilers (scaling). District heating systems are often owned by the consumers, so they make direct profit out of it.

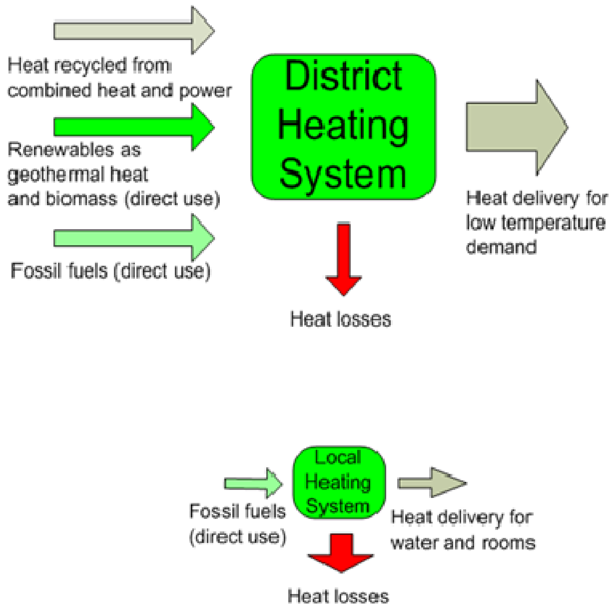

***Figure 1: Fundamental idea of District Heating and Local Heating, less heat loss and better pollution control. (Adapted figure from Euroheat and power, 2009*)**

Apart from that, an advantage of centralized energy distribution is, that is will reduce heat losses (fig 1). District heating has a big potential in the European countries, but the use of DH systems is at the moment not balanced between the different countries. Denmark is one of the key-players in the district heating and the systems seem to be fruitful after a long term period of implementation district heating as a cornerstone of the Danish Energy Policy. Currently, the system is introduced in 60% of all the Danish households, and in the Copenhagen area in almost 98% of the households (DBDH, 2010). The companies in this system, district heating companies, are owned by the consumers. Thus, all the benefit will go to the consumers and this will lead to a lower energy price. A strong support from the municipalities and authorities is required. Nowadays, in most research the technical or financial aspect are most highlighted in applications of district heating.

Apart from that we can see some developments in DH system for low energy buildings. More passive energy houses can be expected and the implementation can be adapted in the new DH systems in Europe. In theory it is possible to obtain a low network heat loss although all houses connected to the DH system have a very low heat demand (Olsen et all., 2008).

During the years, the relatively simple principle of district heating has shown large benefits. However, the implementation of DH systems in European countries is diverse; some countries employ district heating, others not. The Netherlands lies quite far behind others in distribution networks, because the policy is mainly focusing on electrical energy, not on heating (Stichting Warmtenetwerk, 2010). However, if we compare the Netherlands with for instance Denmark, we can see large similarities, especially in the density of the population, and the high scale of urbanization. DH can be an interesting system in the future in the Netherlands. However, a successful implementation of this system will require insight in several important challenges that can be expected.

The successful implementation of district heating systems in the Netherlands requires a stable political and organizational approach, in which governmental agencies are responsible for improving the attractiveness of the system through policy, and in which the organizational structure should provide for the right stimuli for consumers. What kind of stakeholders, suppliers and constructers are required? Such a justified approach is missing in the current Dutch energy policy. Therefore the research design is about DH in the future and about RE in the future.

RESEARCH DESIGN

Research Questions:

In order to give an answer on the problems mentioned, two research questions were set up.

Research question 1

RQ1: How became District Heating a success in Denmark and what kind of new developments can we expect in the future?

Research question 2

RQ2: What changes in an organizational* way should be made for implementing district heating in an effective way in the Netherlands and how can we see DH in Europe in the future?

*Organizational will even focus on the different renewable energy sources in future prospective in 2050 the Netherlands

Goals

We can expect several 'sub-solutions' for our energy problem, one of the potential solutions is District Heating. DH can be found in Denmark, and is widely installed in the country. I would like to gather information about the future of DH in Europe, even in combination with the low energy houses.

And if there is a full RE future, how can we implement DH systems in the Netherlands. Which problems do we have to deal with? What are the companies/partners who will be interested?

Next to this, how is the Netherlands in RE resources at the moment, if we compare our neighbor countries? Last of all, how can we see our future scenario?

Method

Through the fact that I had the opportunity to take part in the DTU research group, I was able to gather information about the current research of the professors on DH.

Next to this, a QFD method is used to compare the implementation of RE in the countries like Germany, England, Belgium, France, the Netherlands and Denmark. Within this scheme a stable insight can be generated. Last, some future lines can be drawn for the energy future of the Netherlands. What can we expect in the future about fossil fuels, taxes and energy developments?

A case study is done to find the best DH system or heat use in the municipality of Eindhoven, the Netherlands. Gas data will be converted to big spenders with MAPinfo.

DENMARK AND THE NETHERLANDS

Denmark

The Danish energy sector sets an example for other countries due to its rapid change from a 100% energy importing country to a net exporter of energy. The power of the government in this transition was vital. Therefore, the share of main energy institutions in Denmark is still powered by the government or regards it as a major shareholder. The energy sector has targets which are exceeding the European rules. Another main aspect is the export of energy related products and knowledge. The energy sector of Denmark is important for neighbor countries, since, through this cooperation, the expectation of changes in the energy sector will be easier to estimate.

From the 20's and 30's DH solutions with diesel was established. During the time until WW II, these plants or systems were quite modest and only limited to a small area, and still running on diesel. These plants created a basis for expanding the heating supply networks. After the world war, large central power plants were introduced for the electricity. The smaller heat plants were still used for the heating systems. We can see the steam based DH system as the first generation DH.

Actually, just in 1973 the Danes realized their vulnerability of energy supply, and the energy consumption per inhabitant was extremely high. Energy savings were important, while the energy at this time was almost 100% imported from fossil fuels to generate heat. The second DH generation can be seen in the form of heating water in tubes. This water will have at least a T_{supply} of 100° C, up to around 120 °C. Today, this way of DH is used in the big pipes from the primary heat to the secondary heat generation, in the transmission network in city level.

The third generation is most common nowadays in the build environment and supplies the houses of heat on a lower temperature. A T_{supply} of 80-90 °C with a T_{return} of 40-50 °C is normally used with a ΔT of 30-50 °C. This is more efficient than the previous one and well connected to the radiators in our houses.

The fourth generation is based on a much lower temperature. This generation is not yet implemented on a wide scale. It has a great opportunity to save energy in the build environment. Different possibilities can be used, but the main idea is a T_{supply} of 55 °C and a T_{return} of 20-30 °C. The supply has a limit, due to the existence of the bacteria legionella. Research is going on in Dresden University to find solutions to use water of a lower supply temperature without or a lower risk of legionella.

Most of the networks are mixed networks of the second and third generation. The fourth generation is based on the new low energy houses and future houses with a very low energy use.

The existing DH projects have proven their success. The new generation of DH networks within a T_{supply} of 55 °C is developed with a very low energy use. At the moment, the limit is the bacteria. Large-scale building projects have a preference for these networks, for it is the easiest way to implement the pipes. The organization behind one of the biggest heat transmission networks in Europe is complex, but has proven its success. In conclusion, DH projects require, in the beginning, high financial investments and, apart from this, have a long payback period. Nevertheless, one should not underestimate the need for sustainability nowadays and, hence, should think more of long-term benefits rather than fast, but environmentally destructive profits. In future DH will be a main energy focus point, next to the increasing share of RE sources for a future of 100% RE in 2050.

The Netherlands

The Netherlands is a gas nation. Their heating and energy use history consists of natural gas. Unfortunately, within 20 to 30 years, gas can no longer be attracted from their fields and so, new ways of energy supplying and heating the houses should be found. New initiatives and RE sources have big possibilities in the close future. The Netherlands is lagging behind in the European targets, but there are many possibilities for new projects. DH is one of these possible future investments. The 'Warmtewet' is a step forward to the implementation of DH.

Undoubtedly, the next years will we focused on changing or a transition in the energy supply sector. Technically, we have enough experience. Political and organizational aspects are mainly controlled by the government. From the new possibilities for heat, DH would be an interesting market in the future. The financial aspect is the most problematic, because high investments should be done, which would be earned back years later. The consumer and the inhabitants of the Netherlands will play a more active role in the next years.

Next to these unclear plans for 2050, the discussion of nuclear power is still going on. The next years will be crucial for the plans to build a second nuclear power plant. Delta wants to expand their business from a 2% share of nuclear power, to a 10% nuclear power share of it in the future (VARA, 2011).

The decision of this reign period can be crucial for the next decades and for the approach toward a CO2 free, environmental friendly way of generating our energy.

Eindhoven
A case study for the Municipality Eindhoven is done. The municipality of Eindhoven has ambitions, mainly on the Brainport concept, a business area with an innovative character. The RE ambitions are high of the municipality. What is established in Eindhoven in the last years? A short summary:

- 1 windmill
- 13 TS installations, within the TU/e (Biggest of Benelux)
- 31 Solar installations
- 2 Biogas installations

Code	Category	GAS USE (M3)	Big spenders
DA	Manufactoring Food + Drink	796919	0
DB	Manufactoring Textile	90491	0
DC	Manufactoring Leather	1242	0
DD	Wood industry	189202	1
DE	Manufatoring Paperindustry	1133395	9
DG	Chemical industry	58311	0
DH	Manufactoring rubber	60555	0
DI	Manufactoring glas/cement	125922	0
DJ	Manufactoring Metals	1134180	6
DK	Manufactoring Apparatus (big)	567972	4
DL	Manufactoring Apparatus (small)	248118	0
DM	Manufactoring cars/combinations	20024	0
DN	Preparation for recycling	770731	1
Total		**5197060**	21

Table 1: Gas use, and the amount of big spenders in Eindhoven by category D of SBI 93.

Eindhoven was actually established by Philips. Nowadays it has several industrial areas. The Eindhoven university of technology is official not part of the industrial areas, but business areas. These are important for the employment and economy of Eindhoven. Ekkersrijt also has an important value for Eindhoven, but is not part of the Eindhoven industrial areas. The table shows the big spenders in the municipality Eindhoven.

FINDINGS

In the nearby future, energy, water and food will be scarce in many countries. We are running out of fossil fuels, this meaning for transport sector a possible change into electrical transport. Electric transport will lead to a high demand of electricity and therefore difficulty in supplying it from the grid. The base load of electricity will be huge, and probably not sufficient with only RE sources. In the future, not only the way we use energy will change, but also the way to generate it. The fact that the energy prices are raising should make us aware of a need to reduce energy demand.

For Eindhoven, the big spenders are located and with making use of them and other heat sources, DH can contribute in the municipality of Eindhoven.

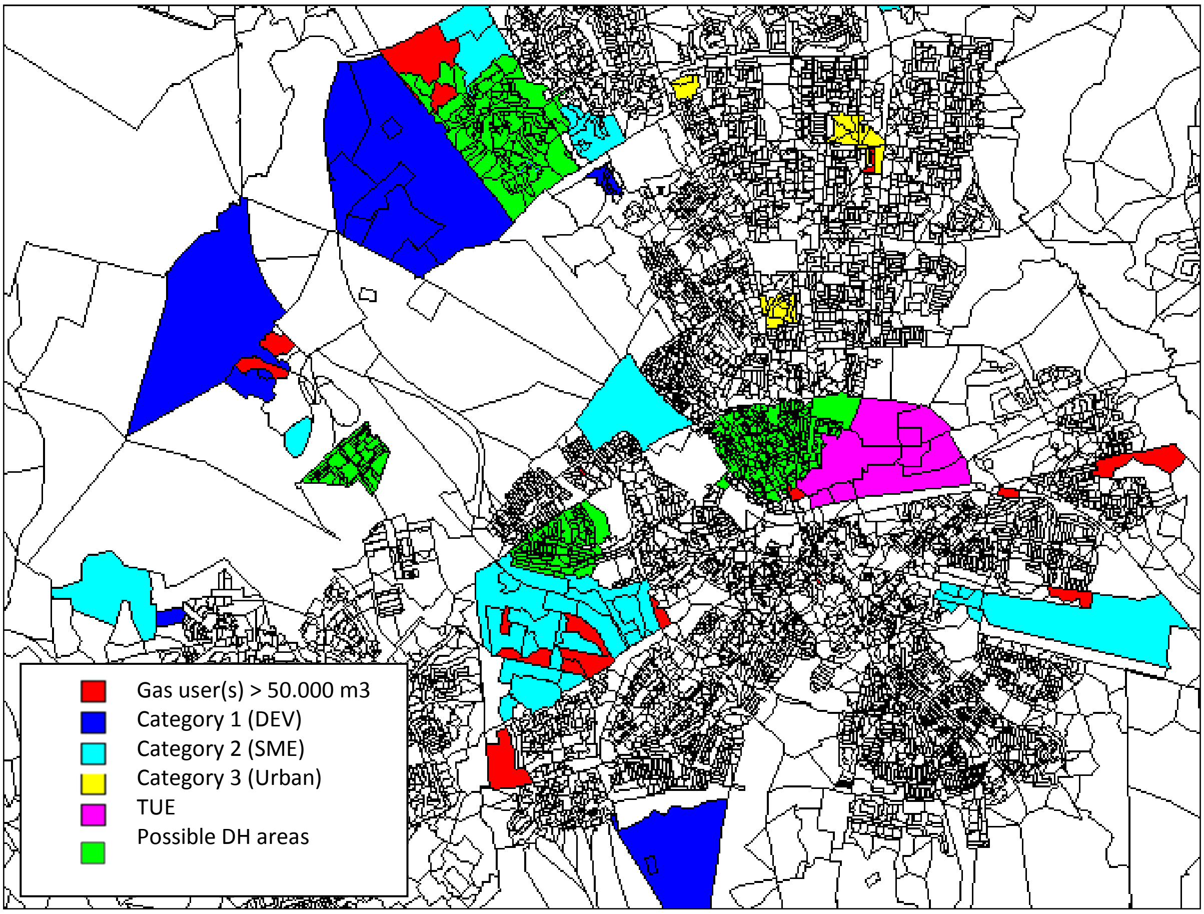

Figure 2: Industrial areas of Eindhoven, within the big spenders and the possible DH areas

Competition
The Netherlands is lagging behind in order to meet the 20% RE sources in 2020. DH can contribute in a national scale. We can see that the Netherlands is lagging not only in heat, but even in wind power and solar power. We should make a future approach up to the future.

The DTU research group of DH is continuing developing DH networks for the future, mainly the future housing concept, low energy houses. These future prospective shows results for a low energy house district, where houses use less energy, but the network can be still build with profit. During my stay at DTU, I was introduced in the DTU research group on DH. I became aware of the future in DH. The passive houses will be build more and more in the future. A strong basis can be established by a heating network before the construction phase of these houses. A triple pipe system together with a high insulated house is attractive for the future.

End consumers, governmental institutions as well the energy supply companies should put effort to generate a public heating network of the future. DH can be one of the elements for a RE approach towards 2050. For an approach towards 2050, a look into the energy supply of the countries around the Netherlands is important. Denmark profiles themselves with their export of RE technology. Nuclear power is still important for France and Germany put effort in solar technology.

For sure, the decisions in the next years should have a strong basis for the future. The decision about implementing new nuclear power is important as well the new legislation about using heat and their financial consequences. New legislation, steering policy, security of supply, safety and a strong (financial) approach are important for the future.

DISCUSSION
We can see the long history of using heat in Denmark. In the Netherlands, this is only used in a small scale basis. Within the new Dutch law, heat will be more important. A trade within heat will be important. The new law is important but maybe a bit too late. The awareness of a ‘post gas’ period is not noticeable.

Biogas is an interesting method to generate electricity, but without using the heat, this way of creating energy is not comparable with the current energy prices. Even here, heat will deserve more attention. The way of using heat in Denmark is totally different from the way of using heat in the Netherlands. I expect to see a transition in the next 10 years.

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This graduation project at the DTU and TU/e was established by KENWIB. The combination of the knowledge about processes at the TU/e and the civil engineering knowledge from the DTU was essential to gain knowledge for an implementation of DH. I will not forget the use of DH networks, and hope to work with them in the future.

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USTIFICATION FOR SETTING UP AND CONTINUING ENERGY PROJECTS

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ABSTRACT
In the past decade the average Dutch housing costs for tenants increased. This increase is almost completely attributable to the higher energy costs. The Dutch government, Aedes and the Woonbond wishes to keep the housing costs manageable. And, intend to manage the housing costs by promoting energy savings in the existing housing stock. These energy savings relate to building-related energy consumption, in particular, space heating, hot tap water and ventilation.The housing associations sector therefore faces a major investment challenge, with the objective of keeping housing costs manageable for Dutch tenants. This research aims to contribute to investments in the energy quality of existing housing stock, by:

> *Designing an instrument that provides insight into, and support in making, investment decisions. These decisions include investments to improve the energy quality of existing housing stock of housing associations. The aim is to keep housing costs manageable for Dutch tenants.*

Keywords: *Housing association, investment decision making, existing housing stock, housing costs, energetic quality of housing stock, business case.*

FULL ABSTRACT
In the past decade the average Dutch housing costs for tenants increased. This increase is almost completely attributable to the higher energy costs. The Dutch government, Aedes and the Woonbond wishes to keep the housing costs manageable. And, intend to manage the housing costs by promoting energy savings in the existing housing stock. These energy savings relate to building-related energy consumption, in particular, space heating, hot tap water and ventilation.The housing associations sector therefore faces a major investment challenge, with the objective of keeping housing costs manageable for Dutch tenants. This

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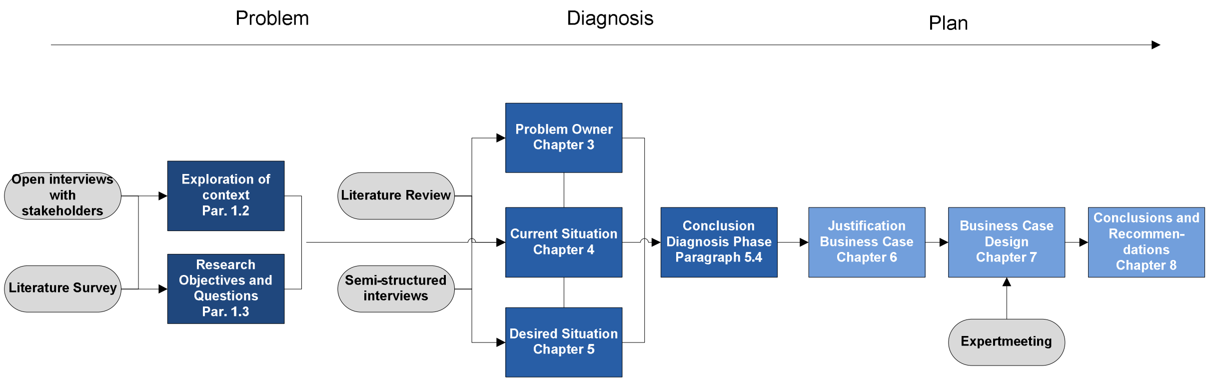

FIGURE 1: RESEARCH MODEL

Diagnosis phase

To fulfill the research objective and to analyze the problem further, a number of research questions were drawn up. These research questions relate to the problem owner, the current situation and the desired situation.

<u>The problem owner, the housing association</u>

The housing association is a government-controlled organisation that is involved with housing the lower income groups and improving poor living conditions. Since the privatisation in 1995, the policy freedom of the association has been enhanced. The legal basis for the association is described in the Dutch Housing Act (‘*Woningwet*’). The code of conduct for housing associations is described in the Decree concerning the management of the public-rented housing sector (‘*Besluit Beheer Sociale Huursector*’ (‘BBSH’)). The BBSH provides a comprehensive description of the ‘public housing sector’ in which associations may solely operate.

Housing associations have the freedom to choose a corporate strategy. Gruis (2007) distinguishes between four management styles, namely social housing provider, social housing investors, social innovator and social real estate entrepreneur. This distinction has been made by combining four characteristics: conservative people, innovators, focus on social return, and focus on financial return. The management styles enable the direction of development (and possible culture style) to be typified. Moreover, the association provides a reference framework for testing and evaluating its choices in terms of consistency with the management style. Conversely, it can be determined whether one specific management style can be adopted, based on the choices that have been made in relation to the strategic planning, the business model and property management.

By virtue of the private character and the public interest, the present association is regarded as a social enterprise or hybrid organisation operating in a quasi-market. As a result, the association constantly has to provide public justification of the effectiveness of its conduct, the results, and about what has and has not been done. The association must be accepted in society, in order to be able to perform optimally. The majority of the associations recognize the importance of the stakeholders' participation, and state that the main motives for stakeholders' participation are obtaining social acceptance, and reaching agreement about and obtaining a basis for the policy of the association (Poorter, 2006).

The current investment policy of housing associations

Housing associations have an increased interest in the development of their own professionalised (and also market-oriented) stock policy as a result of the privatisation of the Dutch public-rented housing sector and the changing requirements in the housing stock. The stock policy for associations can be subdivided into a strategic stock policy and an operational stock policy. Although it is intended as a comprehensive strategy for the organisation, the stock policy for large housing associations is often snowed under by other strategies and views. When choices have to be made between scheduled maintenance, demolition, selling or renovation, factors at district or dwelling level are often crucially important (Nieboer, 2009).

When the association intends to invest in its housing stock, it is important for it to have access to adequate capital. Investments can only be made by associations with cash surpluses and/or by securing loan capital. When associations make investments, a part of the investment is usually not profitable. This unprofitable part of the investment is referred to as the 'inevitable loss'. An investing association that wishes to replenish its stock is often dependent on "selling off rented housing as individual units" ('*uitponding*') (Van Noordenne et al., 2009).

Associations endeavour, independent of the management style, to achieve a certain financial and/or social return. The financial return can be subdivided into in a direct return and an indirect return. The direct return (also referred to as the operating return) is derived from the cash flows. The indirect return consists of the increase in value of the housing stock. The social return relates to all desired positive effects that are caused by the activities of associations. This primarily relates to the specific activities that cannot be performed in line with the market, and also to the other activities.

The desired investment policy of housing associations

Since social returns are difficult to measure objectively, housing associations are likely to be guided by financial returns. When the energetic quality of existing housing will be improved, the (financial) benefits following the improvement are for the housing associations tenants. The housing association will bear the cost of the investment, but these often do not cover the rent increase. Therefore it is important that housing associations not only consider financial returns when taken investment decisions, but make decisions based on economic considerations. This also implies social return.

Now we have a clear view of the housing associations and their investment strategies, it is possible to design an instrument, which helps to improve the justification of investment decision making, especially in energy related projects.

Plan phase

A 'business case' is used in the business world, for example in hospitals and IT companies, as a methodology and document for making decisions. The term business case is not unambiguously defined in the literature. However, authors, such as Dan and Brandon Remenyi (2009) and Marty Schmidt (2002), discuss this subject and, in addition to a definition, also provide a framework.

FIGURE 2: AN OVERVIEW OF THE BUSINESS CASE (REMENYI & REMENYI, 2009)

The definition and framework of a business case of Remenyi and Remenyi (2009) best meets the character of the housing association and its investment issues. The outcomes of the investment are emphasised in the definition of a business case by Remenyi and Remenyi (2009). Providing a transparent insight in the investment outcomes, makes it possible to get public justification. To be accountable, it is important to give an insight in the project risks related to an investment. In the definition and format of the business case of Remenyi and Remenyi (2009) risks take a central, connecting place (see figure 2).

However, this definition and framework are based on a different sector, which is why the framework is made applicable so as to reflect investment in the improvement of the energetic quality of the housing stock by housing associations.

The business case consists of five elements: business outcome, strategic alignment, stakeholder, technology assessment and project risk (figure 2). For each element an introduction, method and statement was described. The methods provided in the adapted business case are not fixed. This means other methods can be used and can lead to the same statement. However the methods which are provided in the business case are helpful and simple tools to come to a statement.

Business Outcome
A description of the intended results of an investment constitutes an important element of a business case. A description of the intended results forms the basis, on which the rest of the business case is built. By describing the intended outcomes prior to the actual investment, the effectiveness of the investment can be determined later. Besides that, providing insight in the intended outcomes is a crucial part in getting public justification.

To identify the investment outcomes an understanding of the input, output and outcome of each alternative should be provided (see figure 3). The outcomes can relate to the objectives of the housing association and should be divided into external effects (social and customer), as well as into internal effects (financial and property). To identify the effects a system dynamics model is provided.

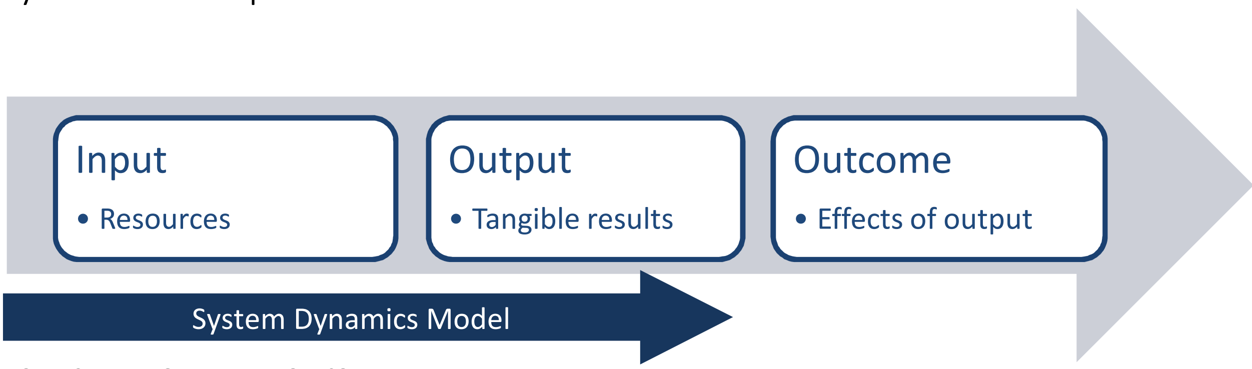

FIGURE 3: INPUT, OUTPUT AND OUTCOME

Strategic Alignment
The essence of economic act is choosing the best alternative. The investment issue is a problem of choice. The organization must choose the best alternative. This means that the chosen alternative best meets the objectives of the organization. The investment must also fit into the overall organizational strategy. When an investment contributes to organizational strategy, it is called strategic alignment. When the organizational strategy is known, it could be determined whether the business outcome is consistent with the strategy.

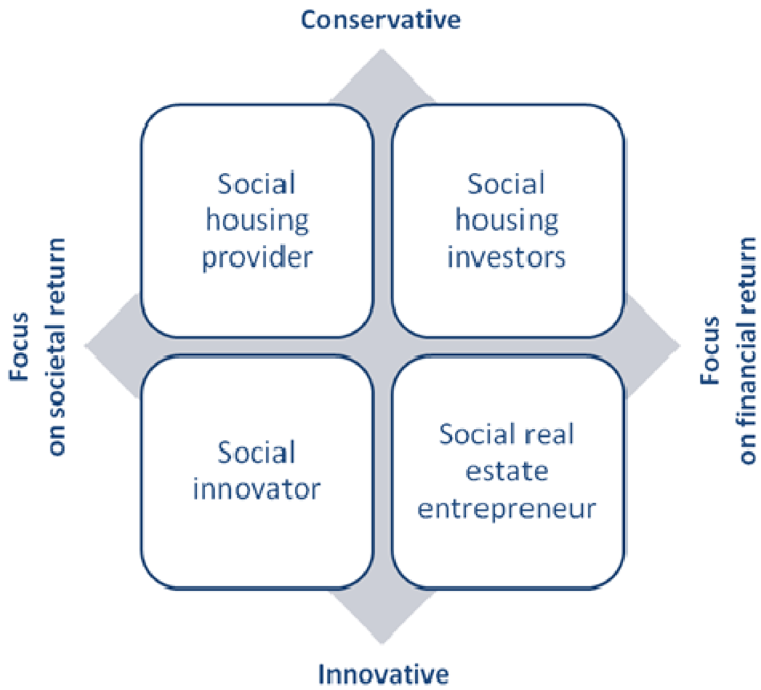

FIGURE 4: MANAGEMENT STYLES (GRUIS, 2007)

To test whether there is a strategic alignment, the organizational strategy has to be known first. Organizational strategy consists of three parts (Aedes, 2008), namely:

- Social identity;
- Strategic focus;
- Tasks and roles.

The parts of organizational strategy are expressed in the management styles, figure 4, defined by Gruis (2007).

Stakeholder

Stakeholders are individuals, groups or organizations that can place a claim on the organization's attention, resources and / or output, or is affected by that output. Stakeholder identification and positioning are important aspects of a business case, because a lack of information and concern for stakeholders leads too often and too predictable to poor performance, outright failure or even disaster (Bryson, 2004).

Social enterprises, which also include housing associations, need to be accepted by society in order to deliver good results (SER, 2005). Therefore, it is very important for the housing association to identify and position their stakeholders. The Socio-Economic Council (SER) indicates that this acceptance cannot be derived from history, but it must be earned and realized each time, in interaction with the social environment (SER, 2005).

A basic identification and analysis technique is described by Bryson (2004). It offers a quick and useful way of identifying stakeholders and their interests, clarifying stakeholders' views towards the project, identifying some key strategic issues and beginning the process of identifying coalitions of support and opposition. The technique involves several steps and exercises (figure 5).

FIGURE 5: STAKEHOLDER IDENTIFICATION, ANALYSIS AND POSITIONING

Technology Assessment

A technology asssement from a business perspective is a preliminary evaluation of technologies and their future potential in relation to the context of an organization. It helps to assess the added value of technology and its possibilities for the housing association.

FIGURE 6: TECHNOLOGY ASSESSMENT

The goal of this assessment is to find the technology for which it is most likely that a solution based on that technology provides the best solution. The best solution is a solution that meets all requirements with the least specification effort (Eijnatten, 2010).

The concepts of Bax (1993) and Vrakking (1990) could be used to assess the technology. The concept of Bax (1993) describes the technology assessment on a strategic level (figure 6). In order to ensure the applicability, the concept of Vrakking (1990) is elaborated.

Project Risk

Acquiring an understanding of the risks involved in a project is a central part of developing a comprehensive business case. The risk profile of the proposed investment needs to be clearly stated and if it is too high the business case should not be approved. Although it is not essential that a full risk analysis be performed in order to produce a business case, a review of the more important risk issues should be addressed and incorporated into the investment business case.

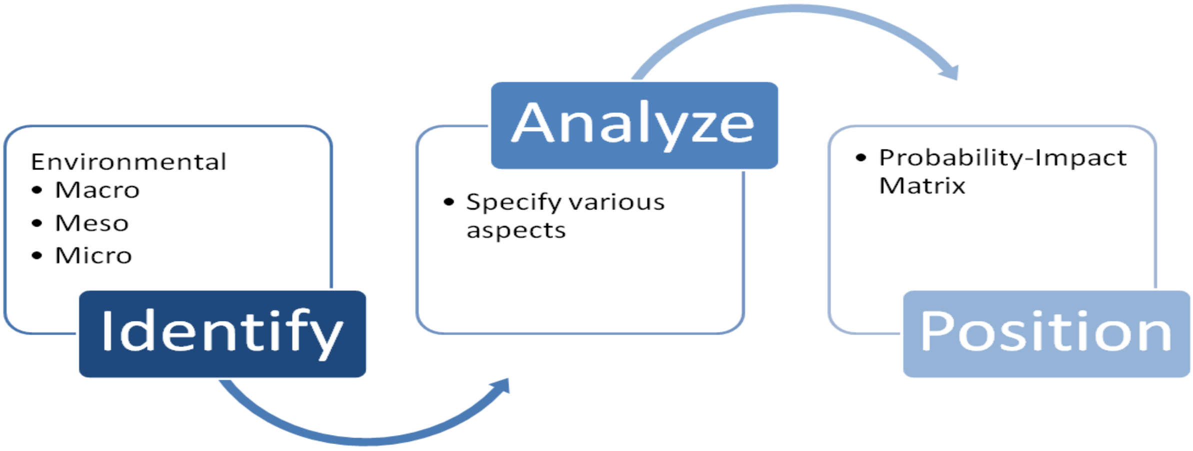

FIGURE 7: IDENTIFICATION, ANALYSIS AND POSITIONING OF PROJECT RISKS

A basic identification and analysis technique is the qualitative risk assessment. It offers a quick and useful way of identifying risks, analyzing risks and position risks (figure 7).

In order to increase the validaty of the business case, it was submitted to an expert panel on May 25th 2011. The expert panel commented that the business case is a suitable tool for making investment decisions regarding the improvement of the energetic quality of the existing housing stock. They also noted that the implementation and application of the business case requires attention, due to the corporate culture and business operations of the housing association.

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The influences of urban morphology on the average temperature of Rotterdam city

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ABSTRACT

With summers becoming warmer, we need more energy to keep the cities liveable. Isn't it more wisely to understand the effects of our current city environment, so we can protect ourselves against the unbearable city climate we have created? With GPS and temperature data of the Rotterdam city the effects of this current city environment can be visualized and analyzed to make the cities, and especially Rotterdam, more self-consciousness.

Keywords: Urban heat island, Global warming, 3D modelling, Urban morphology

INTRODUCTION

The ice ages in the distant past prove that the climate can change by itself, and radically. Adding to that is the belief that human activity can change the climate. In 1896, Swedish scientists published a new theory called the "greenhouse effect". It argued that, as humanity burned fossil fuels that released carbon dioxide (CO2) into the atmosphere, the planet's average temperature would rise. This is because the CO2 absorbs heat radiated from the sun, trapping it in the Earth's atmosphere. Despite accepting the theory, the greater scientific community believed that major climate change would take tens of thousands of years to materialise (Shell, 2007).

By the 1930s, people realised that the United States and North Atlantic region had warmed significantly during the previous half century. Scientists believed this was just a phase of some mild natural cycle, with unknown causes. Only one lone voice, G.S. Callendar (1930), insisted that greenhouse warming was on its way.

In the 1950s, Callendar's claims provoked new studies that showed that carbon dioxide could indeed build up in the atmosphere and lead to global warming. Painstaking measurements drove home the point in 1961, by showing that the level of CO2 was in fact increasing year by year. A 1967 calculation suggested that average temperatures might rise a few degrees within the next century.

Over the following decade, curiosity about climate turned into anxious concern. Study panels began to warn that future climate change might pose a severe threat and research activity accelerated. Programmes were organised on international scale and the world governments created the Intergovernmental Panel on Climate Change in 1988 (ICPP). By 2001, ICPP managed to establish a consensus, announcing that it was likely that our civilisation faced severe global warming. Since 2001, the abundance of data has strengthened the conclusion that human emissions are very likely causing serious climate change.

Depending on what steps people take to restrict emissions, the planet's average temperature might rise between 1.4-6°C by the end of the century. Although, only a small fraction of this warming has happened so far, predicted effects are already becoming visible – more deadly heat waves, rising sea levels, more frequent severe floods and droughts, the spread of tropical diseases and the decline of species sensitive to temperature changes (Kleerekoper, 2009). The Dutch meteorology institution (KNMI) (2008) also calculated the temperature and came up with four scenarios in 2006 that predicted the average summer temperature for the Netherlands. The average summer temperature is approximately 17°C and will be between 18-19°C in 2050 and 19-23°C in 2100.

A number of key characteristics of climate change in the Netherlands and surrounding areas are common across all scenarios: temperature will continue to rise. Mild winters and hot summers will become more common; on average, winters will become wetter and extreme precipitation amounts will increase; the intensity of extreme rain showers in summer will increase, however the number of rainy days in summer will decrease (KNMI, 2008). Another effect why the world, and especially cities are becoming hotter is the use of computers, television, fast cars, air-conditioning, and far holidays going by air: we will not or cannot live without it. This caused an enormous growth of energy consumption in the past decade and an increase of greenhouse gas like CO_2 in the atmosphere. So on one hand we have the rise of temperature and on the other hand we have the exploding growth of energy using and other things that cause an extra heat (Shell, 2007). On international level countries made appointments about the reduction of discharge of greenhouse gas. The Netherlands is one of them and translated the international ambitions into national ambitions. The national climate objective can only be reached if the federal government, companies, provinces, municipality welfare organizations and citizens all work together (Roorda, 2008).

In the summer of 2003 and 2006 we had an extreme summer period with extreme measured temperatures. During these summers the average death increased even more as usually. The Dutch central bureau for statistics (CBS) (2007) calculated that an increase of 1°C degree on average during the summer will lead to an extra mortality rate of 31 people each week.
The focus in this report will be on the hotter summers, because during summers cities will become ovens. Buildings and roads will absorb heat and high rise buildings block the wind. Because the heat can't easily blow away this heat will be trapped in the city, as a result, urban areas are becoming much warmer compared to rural areas (Wilby, 2007). The difference between urban and rural temperature is called the urban heat island (UHI). In this survey the UHI for the Rotterdam city will be analyzed by comparing the urban morphology

and the temperature to indicate that a specific morphology influences the temperature and enlarges or decreases the UHI.

Research question

What are the influences of urban morphology on the average temperature of Rotterdam city?

Summary

Urban heat island (UHI) is the temperature difference between urban and rural areas. Studies on the relation between these two areas exist for decades. In the Netherlands UHI has been an understanding used by scientists for several years, but society thought that UHI was an understanding which was overestimated by these scientists. In the summer of 2003 the Dutch population was caught by the heat. From that moment on we realised that our climate was changing.

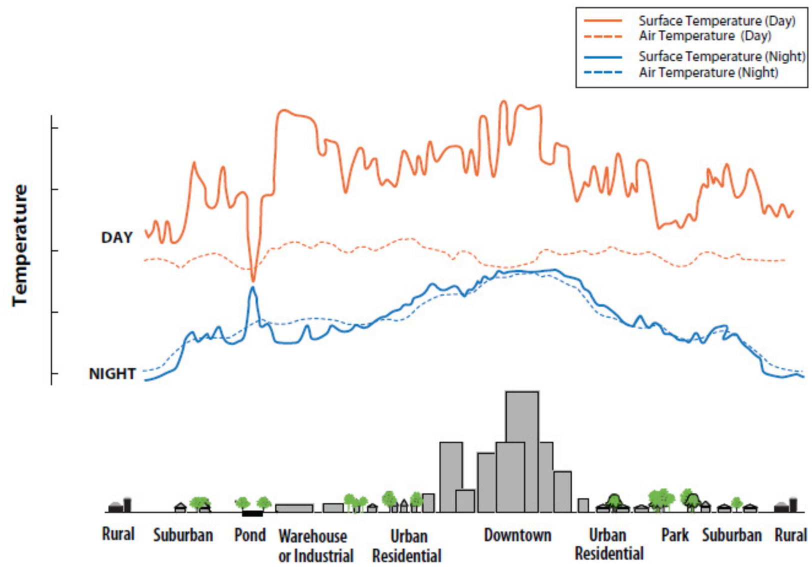

Illustration1: Variations of surface and atmospheric temperatures (Voogt J. , 2002).

The effects of the UHI can be reduced by smart planning and the use of materials that have a cooling effect. Comte, Le & Warren (1981) showed that vegetation has a cooling effect of 1-4,7°C that spreads 100m to 1km into urban areas. A study done by Upmanis, Elisasson & Lindqvist (1998) in Göteborg showed a maximum temperature difference of 5,9°C between a city park of 156 ha and the city centre. Kravcik (2007) showed that a street tree can have a cooling effect through evaporation of 20-30 kW, which stands for more than 10 air-conditioners. Water can also be helpful in reducing urban temperature. Water has an average cooling effect of 1-3°C to an extent of 30-35 meters, and can be felt even further when we have to deal with large surfaces of water. Water doesn’t heat as quickly and as a result it is able to transport the heat out of the city.

Research on the UHI was done by oke (1973) to investigate the relation between population and the UHI. Oke showed that there was a linear connection between the population and the temperature for European and for North American cities. KNMI (2011) also examined the relation between rural KNMI weather stations and urban amateur stations for 4 different cities. In this research they showed the relation between wind direction, wind speed, time of the day and the temperature. One of the main causes of the UHI was the wind speed, the UHI is the lowest when the wind speed is the highest. A third research was described by Brandsma (2010) who rode a 14 km track trough Utrecht while measuring the temperature, the wind direction and the percentage of clouds. Brandsma (2010) concluded that for a wind speed of 1 m/s or less the UHI is the biggest and especially with wind coming from the south or the east.

In foregoing research, the relations between different influences on the UCI were not combined. Therefore, the research question for current research was derived, proposing a solution to this limitation: What are the influences of urban morphology on the average temperature of Rotterdam city?

To analyze these influences, measurements from 4 tramlines (received from B. Heusinkveld and B. Van Hove from WUR-Alterra) were used that drove through the Rotterdam city centre in July and August of 2010. These tram lines measured the temperature every 20 seconds (dependent variable) on a tracked route each day. These temperatures were linked to the topographic map of Rotterdam where each part of the map has a function of the urban morphology (independent variables). These independent variables where categorized in 6 classes: dwellings (red), industry (purple), paved open space (orange and white), unpaved open space (yellow), vegetation (green) and water (blue).

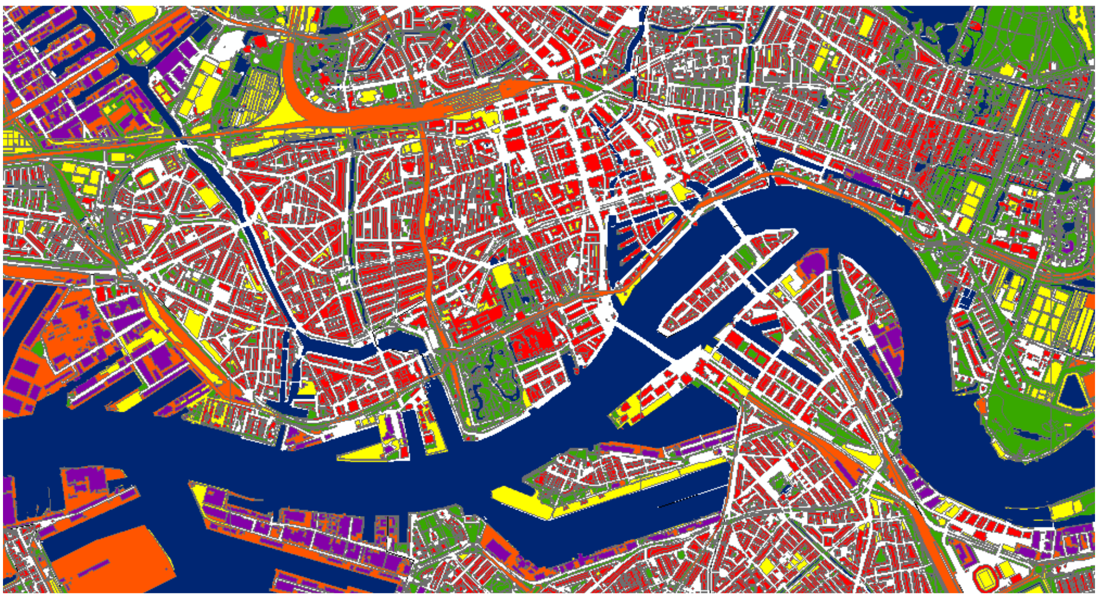

Illustration 2: Rotterdam city centre divided in the 6 colours.

For each class the percentage for one single research area (cell) which was part of the tramline, was calculated. The track of the 4 tramlines was divided in 50 equal cells (research areas) of 600 meters with a width of 200 metre to both sides. The relation between the independent and dependent variables were analyzed on quantitative (multiple regression) and qualitative descriptions and calculations for 3 periods: morning, afternoon and evening during July and August.


Illustration 3: one of the cells with the different functions in their right colours.

Software

To analyze the temperature, GPS-coordinates and the urban morphology ArcGIS has been used. With ArcGIS the temperature and GPS-coordinates can be linked to the map of Rotterdam and all morphologic functions can be reduced to the 6 described above. To analyze patterns between the urban morphology and the temperature, SPSS19 has been used. With SPSS19 the quantitative analyze has been made.

Quantitative analyze

The quantitative data analysis is based on the output of SPSS 19. For each period for both months, the relations between the dependent (temperature) and the independent values (percentage paved, unpaved etc.) were tested on their level of significance and percentage of explained variance. The test that was used to analyze the data is the (linear) multiple regression analysis.

The outcome from the analysis was that from the 14 tested models, 8 had a significant level of 0,05 or under (<0,05) which means that the 6 independent variables together influenced the variance in average temperature for that particular hour. Looking at each hour for both months only hour19 has a significant level of 0,05 or under for both months. Looking at the coefficients table from significant tests: once industry and vegetation are significant, once time unpaved open space and vegetation were significant. 6 times vegetation was the only significant independent variable and only once, industry was the significant independent variable. A remarkable fact is that the vegetation B values for the significant tests are, except from July-hour05, positive (-0,022; 0,034; 0,084; 0,036; 0,077; 0,058; 0,092) what means that for each percentage extra vegetation the temperature will rise. What we saw in the literature was that vegetation can provide a cool wind and that the temperature in parks and around trees is cooler compared to other spots in the city centre. The B value from the variable Industry, which belongs to the category heat producing functions, was negative the first time (July hour05) what means that each percentage extra of industry cools the average temperature (-0,149). For July hour17 each percentage industry warms the average temperature (0,084). Finally the unpaved open space for August hour19 showed a negative B value (-0,124) and so helps the city to lower the average temperature in August for hour19.

Looking at the further examination for July hour05, which has significant variables: industry and vegetation , the B value for Industry (-0,150) and for vegetation (-0,020). What means that the 2 independent variables together still help to cool down the average temperature for this period. Looking at August hour19 the B value changes. Unpaved open space still helps, for each extra percentage, to lower the average temperature (-0,105) and vegetation (0,104) to warm the average temperature.
Some of the tests (models) that were executed had an independent variable within the model that had a high significant level indicating a value <0.05. For July hour17 this variable was industry (0,013) and for August hour05 and 14 this was vegetation (0,036; 0,020). These tests (models) were not significant, but independent variables within the model were independently significant excluding the other independent variables .

Conclusions that can be drawn from this analysis is that for above average periods the combination of the 6 independent variables had an significant influence in variations of average temperature for that particular hour. For the test that were significant, there were only 2 that were suitable for further examination. Also, the independent variables that should rise according to diverse theories discussed in chapter 2 should lead to rising or lowering average temperature (the B values) were switched. Vegetation which seems to lower the temperature (according to the theory), helps the temperature to rise and industry, lowers the temperature where it should, according to the theory, provide extra heat. The unpaved open space helps, in line with theoretical research, to lower the temperature (ability for the wind to blow and less absorption materials that hold heat).

Qualitative analyze

The data is also analyzed in a qualitative way. What means that the relation between the independent variables and the dependent variables will be described according to diverse research. This will be done by analyzing the percentage of each cell with the average temperature for that cell.

The results are hard to define because of the wide range of cell numbers belonging to the hottest or coolest. A cell that belongs to the coolest for a specific hour could belong to the hottest the next hour. Another example is a trend for the evening can be different for July and August. For that reason it was hard to formulate an univocal result after the qualitative analysis. One of the main remarkable notices was that theory in the theoretical research doesn't have to match with this research. For example, a cell which was crossing the Meuse and therefore, following the theory, should have a cooling effect, belongs to the top 10 hottest cells (morning and evening period from July). Also a high percentage vegetation what, following the theory, should have a cooling effect, can belong to the hottest cells. Cells 26, 27, and especially 28 have a high percentage vegetation or are situated next to a large green zone, but nevertheless still belong to the hottest cells 5 or 6 times in current research

Analysing the position of the hottest and coolest cells on the geographic map, the July morning and afternoon have most of their coolest cells in and around the south side of the Meuse and (west side of) the city centre. The coolest and hottest cells for the morning and afternoon period for August were very diverse and aren't situated on specific locations. The tendency for the July evening period is mirrored for the August period. In July the most of the top 10 coolest cells are situated in the south of Rotterdam and the hottest cells in the middle. During the evening the cool zone changed from the south to the north-west and the hottest cells changed from centre and the south side of the Meuse to the south of Rotterdam. In August these top 10 coolest cells changed direction from the south side of the Meuse to the city centre and the hottest cells changed from centre to the north and south side.

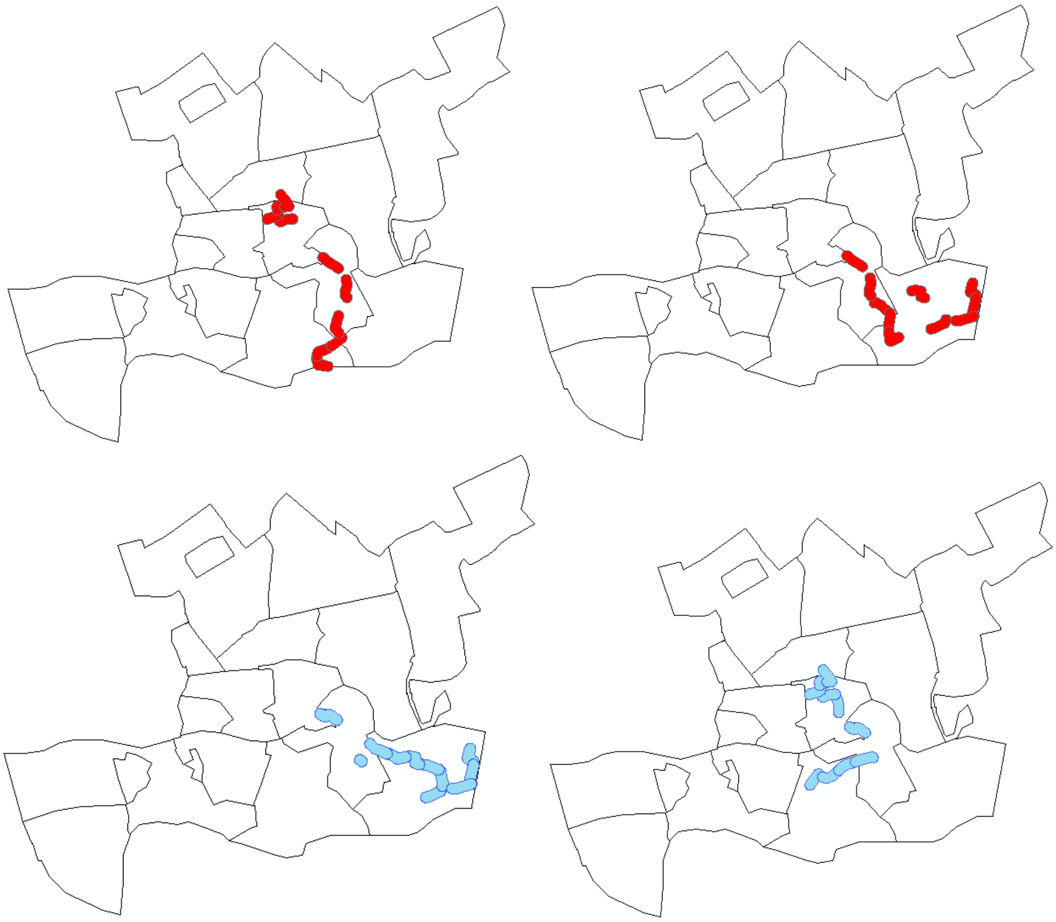

Illustration 4: The ten hottest (red) and coolest (blue) cells for the July morning period. From top left to the right bottom hour05, hour06, hour05 and hour06.

Looking at the percentage for each cell with a remarkable average temperature there is not an univocal answer. Analysing these remarkable cells by looking at the colours (functions), the influences from just outside the cell can be taken into count. For some cells around cell number 30, the percentage water is low, based on the percentage it would be strange if these cells belong to the coolest but in current research, influences from just outside the cell can be of great effect. These cells are situated near the Meuse and therefore it would be logical that these cells are relatively cooler because the theory said: water can have a cooling effect up to 30 metres (Robitu et al., 2004) and for rivers like the Meuse this effect can be felt even further.

Conclusions

In the theoretical research there are a lot of influences of the independent variables on the dependent variable. A disadvantage is the standalone where only one topic has been researched. This research tried to prove a relation between the urban morphology and the average temperature based on research from the past, a quantitative analysis and a qualitative analysis.

In the theoretical analysis the (dis)advantage of each of the 6 independent variables was described. Following Robitu et al. (2004) water can have a cooling effect of up to 3°C and vegetation can have a cooling effect of 1-5,9°C (Comte et al, (1981) and Upmanis et al. (1998). When analyzing the difference between the average urban heat from this research and the average rural heat from the KNMI we can conclude that the UHI for Rotterdam is equal compared to the research from Oke (1973). Following the results in his research the average UHI for a city with the population size of Rotterdam (+/- 600.000) should be 8°C. From the data used for this research the UHI for Rotterdam city in July was 0,93-5,78°C for the July morning, 2,41-9,79°C in the afternoon and 0,57-7,47°C in the evening. For the August period the UHI was 0,14-5,61°C in the morning, 1,25-10,43°C in the afternoon and 0-7,54°C in the evening compared to research from Brandsma (2010), who said that cities with a population of 200.000 or more can have a maximum UHI of 7°C. This statement was overruled for the months July and August 2010 in current research. Finally the average UHI should be between 0,5-1°C following Brandsma (2010). In excel table we saw values of 2,81-3,27°C for the July morning, 4,84-5,20°C for the afternoon, and 2,89-3,59°C for the evening. For August values were as followed: 1,87-2,10°C in the morning, 3,18-3,32°C in the afternoon, and 2,25-2,48°C in the evening. The average temperature is also higher than the average temperature indicated by Brandsma (2010).

For Rotterdam, a city with the river the Meuse flowing through, water can be a powerful tool to provide the city from cool air. On the south side of Rotterdam there are many pastures and greenhouses what can positively influence the airflow. On the west side of Rotterdam there is the harbour and the North sea which provide enough open space for the wind as well and the sea can even provide cool sea winds to the city. The warm air can be convected from the north where the Randstad is situated which is the part of Holland with the highest population density. In the period of July and August 2010 the most wind came from the south, south-west and south-east (KNMI, 2011) direction which should help to provide the city from cool air.

Looking at the theoretical part, it can be stated that vegetation and water provide Rotterdam from cool air and helps cooling down in the evening. Unpaved and paved open spaces help to cool down because wind can blow and mix the hot air with the cool air. The paved open space will be less effective because the paved spaces absorb heat during the day which should be released before they are able to contribute to the cooling down process of the city. Dwellings and industry (which is uncommon in the city) absorb the heat the same as paved open space, but it also blocks the wind what causes a stagnation in the mixing of cool and hot air. Especially in the centre of Rotterdam where many high rise buildings are situated.

The outcome from the analysis was looking at each hour for both months only hour19 has a significant level of 0,05 or under for both months.

The quantitative analysis showed that from the 14 tested models, 8 were significant which means that all 6 independent variables together influenced the variance in average temperature for that particular hour. The effect of each significant independent variable within these significant models with all 6 independent variables, was only possible twice what makes it difficult to form a statement about the individual effect of a independent variable on temperature changes regarding the other 5 independent variables.

The qualitative analysis was even harder to analyze because there was no clear answer. Like described in the chapter before, there was no consistency between any of the 6 independent variables on the dependent variables. Cells that following the theory should belong to the coolest cells belonged to the coolest cells in one particular hour but appear later on as one of the hottest cells in the same variable . A tendency that can be derived is the location of the coolest and hottest cells for different periods and hours. Where the cool cells are situated in the south and north, and during the day change position and move to the centre. The hottest cells are start in the centre and during the day they spread to the north and south. A reason for that can be the wind which coming mostly from the south (KNMI, 2011) and like described before, provides cool air which cools the south side of Rotterdam. It also provides the centre with cool air when it flows across the Meuse and gets mixed with the cool air from the river. So the complete temperature wave moves during the day. The warm air from the south moves to the south side of the Meuse. The cool air from the south side of the Meuse (which cools down during the night) flows past the Meuse to the centre and therefore cools the centre. The warm air from the centre flows with the southern wind to the north and so warms the north side.

The overall tendency of theoretical, qualitative and quantitative results from current research could be considered twofold. First, all research shown in the theoretical part is one sided, combining just one independent variable with the temperature, therefore the relation between variables is not made. And second, the quantitative and qualitative part where a relation between all these independent variables as pointed out in the theoretical part were combined. But looking at the overall results of the qualitative analysis, it could also be considered standing somewhere in-between because clear relations between this analysis and knowledge from the theoretical part were not found. Therefore it wasn't possible to prove relations between separate independent variables on the temperature.

A reason why it's possible that results were not significant could be the amount of data that was used. With more data a more specific average for each cell could be calculated and adding to that, outliers are of less influence when working with a large amount of data. Also the average wind for a July and August was used to help understand the results from the qualitative analysis. For future research it would be recommended to relate average temperature to the daily wind and so relate wind to the influence on the urban morphology. Also a third dimension (3D) could be added to relate the influence of the high rise buildings on the temperature, which can be added to the urban morphology. Finally the average temperature for each district could also be related to the population, in order to formulate the influence of the population density on the temperature. This can be a supplementation to the study from Brandsma (2010).

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Stijn J. Janssen

This graduation project combines the technical knowledge of my bachelor and master with the knowledge and information from the Royal Haskoning, the Wageningen university and the municipality of Rotterdam. The combination between the theoretical information about UHI and the research in real life made this project very unique and interesting. This project is also a base for further research to the combination between the UHI and the urban morphology.

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SUSTAINABILITY – DOES IT INFLUENCE INVESTORS' DECISION?

An exploration to BREEAM, as part of a multi-criteria decision analysis

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ABSTRACT

In the indistinct exploration for more sustainable investment in the build environment, this research tries to provide insight in the consideration framework of investors into the office investment decision process. In this research the Analytic Netwwork Process (ANP) is applied to determine the influence of sustainability in the investment decision of commercial office projects. The results are the preferences of influencing factors and alternatives of the investment decision. Overall conclusion of this research indicate investors confirmed sustainability as a corporate value, but the implementation of sustainability into the investment scheme on micro-level of an office by several investors is (still) not realized.

Keywords: Multi-Criteria Decision Analysis, Analytical Network Process, Sustainability, BREEAM, Investment decision analysis

INTRODUCTION

Concerning the sustainable development in the real estate industry, the Dutch government and businesses committed a covenant, called the *Lente-akkoord Energiebesparing* in April 2008. In this covenant the businesses committed to take an active role in the energy neutral development of buildings. Goal of this covenant is a reduced energy use of 25% in 2011 in new retail, residential and office development, and a reduce of 50% in 2015. This covenant is an attempt to realize the EU2020 Energy targets of a reduced energy use of 20%. Nevertheless this covenant and energy targets, still two third of the total office supply has to be preserved, as a benchmark has to have a minimum of energylabel C to be indicated as 'sustainable', which is more than 30 million m^2.

Sustainable investments in real estate are often postponed, because of a critical attitude of different earning models of sustainable investments. Real estate investors and owners are still reserved to invest in sustainable real estate development projects. Investors are still not convinced of the fact of the higher value and/or higher exit yields of 'sustainable' real estate compared to 'unsustainable' real estate. Users and owners often remark who is in fact responsible for the investment of sustainability. Most users are prepared to invest more in sustainable real estate, in case of a decrease of the exploitation costs. But if owners don't invest in sustainable real estate, the consequence is an increased risk of an unmarketable real estate (NVM, 2011).

Problem statement

Sustainability becomes more prominent in the development of offices. Private businesses are forced to take sustainability in account of the development process. Sustainability is a relative new concept in real estate development of offices. Different actors are not used to integrate sustainability and realize those sustainable ambitions. In addition, actors do have different ambitions and interests within the sustainable development process. Therewith, sustainability is a broad understanding, with many 'soft' factors and different interpretations, which makes sustainability difficult to quantify. There are different assessment methods in order to quantify and benchmark sustainability.

In the traditional real estate industry, subjects as return on investment and increasing value are stated as the most important factors in investment decision making, so it is difficult to realize those sustainable ambitions. In the indistinct exploration for more sustainable investment in the build environment, this research tries to provide insight and knowledge that could break up the traditional real industry, which operates in a 'Circle of Blame' and split-incentive in the investment decision. The goal of this research is providing insight into the consideration framework of investors into the sustainable office development.

RESEARCH METHODOLOGY ANP

The Multi Criteria Decision Analysis (MCDA) field is the study of methods and procedures which concerns about multiple conflicting criteria, the Analytic Network Process (ANP) is a specific approach within the MCDA field. The ANP was defined by (Saaty, 2001) as a general theory of relative measurement used to derive composite priority ratio from individual ratio scale reflecting relative measurement of interconnected elements within control criteria. (Azis, 2003) defined ANP as a mathematic theory that allows to deal systematically with dependence and feedback, which makes it possible to combine tangible and intangible factors by using ratio scale. ANP provides a general framework in treating decisions without making any assumption about independency of elements in higher level from elements in lower level, and about independency of elements within the same level. The main concept of ANP is influence, while the main concept of AHP is preference. Analytical Hierarchy Process (AHP) with its dependency assumptions on clusters and elements is a special case of ANP.
Within the ANP method, criteria can depend on alternatives and other criteria. Feedback improves priority which derived from judgment and makes prediction more accurate.

Therefore, the result of ANP is expected to be more stable. The intended results from the ANP method is to determine the overall influence from all elements to the decision. The influences from the elements in the feedback system with respect to each criterion is provided. Finally, the results of these influences are weighted according to the important level of the criteria, and summed them up to get overall influence from each element.
According to (Saaty, 1996), the ANP modeling comprises the following steps:

i. **Decomposition/identification –** decomposition is used to structure a complex problem into a hierarchy or network of identified clusters and sub-clusters, resulting into the ANP framework;
ii. **Comparative judgments –** comparative judgments are applied to construct pairwise comparisons. These pairwise comparisons are used to derive 'local' priorities of the elements in a cluster with respect to their parent. The pairwise comparison is based on ratio measurement, it measures proportion and judgments of each pair of factors in the network to derive ratio scale measures;
iii. **Synthesis –** synthesis is applied to multiply the local priorities of the elements in a cluster by the 'global' priority of the parent element, producing global priorities throughout the network and then adding the global priorities for the lowest level elements (usually the alternatives). Synthesis involves construction of: a) original (unweighted) supermatrix; b) weighted supermatrix; and c) calculation of the global priority weights (limited supermatrix).

Multi-Criteria Decision analysis applications in Real Estate Investment

Real estate investment is a complicated decision process, owing to the particularity and complexity of real estate investment decision-making, multiple influential factors, including economic, social, object, and environment factors, should be considered comprehensively in order to get the optimal decision. Traditional real estate investment analysis methods, such as net present value and payback period (Liu, 2000), are all single-objective decision-making methods. These methods cannot get entire and comprehensive analysis of investment project, which might result in an improper decision. Therefore, it is necessary to use multi-indices comprehensive analysis methods for real estate investment decisions.

In addition, (Wang Wu-Jun, 2004) has used the application of AHP on real estate investment decision-making. However, in actual investment decision-making projects, a variety of factors should be considered, such as the dependence and feedback relationships between different factors, like contextual and location factors.

ANP MODELLING PROCESS

This research comprises three main steps of the main ANP modeling. Phase 1 is ANP network model construction, phase 2 is model quantification or pair-wise comparison, and phase 3 is synthesis and results analysis.

1. Model construction

The ANP model is determined from literature and in-depth interviews by experts like investors, funders, and consultants. The steps needed for the construction of the network are determination of (i) factors, (ii) clusters, and (iii) influence network.

The quality of the assessment is dependent on the completeness of the variables of the research. Office investment decision-making is influenced by many factors, such as macro, medium, and micro factors. In this research the aim is to get insight in the influence on micro level of the real estate investment decision of offices. Macro (e.g. market situation) and medium factors (e.g. location) are in this research constant. Five clusters of influencing factors are derived from literature and in-depth interviews, which are used in this research (table 1).

1. Economic factors
   1.1. Revenues
      - *c1.* *Investment return* – expected exit yield to the investor
      - *c2.* *Expected lease rate* – expected vacancy rate of the property
      - *c3.* *Rental value* – expected rental income from tenants. The average rental revenue indicates the profitability of an office.
   1.2. Costs
      - *c4.* *Construction costs* – total amount of costs due to realize the office object
      - *c5.* *Exploitation costs* – total amount of maintenance and operational costs
2. Object factors
   2.1. Technical aspects
      - *c6.* *Architecture/Design* – amenity or architectural quality of a property, identity or appearance of a property
      - *c7.* *Size GFA* - size of a office to gross floor area
      - *c8.* *Parking norm* – degree of parking facilities of the office
      - *c9.* *Economic lifetime* - probability of refurbishment requirements during buildings lifecycle, indicated by the degree of maintenance condition
      - *c10.* *Finishing level materials* – high-quality finishing level of property details by the use of sustainable materials or definite materials
   2.2. Use aspects
      - *c11.* *Flexibility* – flexible arrangement of floors, expanding possibilities of property
      - *c12.* *Multipurpose* – degree of multipurpose compared to specific use
      - *c13.* *Management exploitation* – degree of experience and quality of exploitation management
   2.3. Sustainable aspects
      - *c14.* *Ecological impact* – degree of impacts to use and value due to environment
      - *c15.* *Indoor user comfort* – temperature indoor climate, acoustic disturbance, degree of direct daylight entrance, and degree of use of fresh air
      - *c16.* *Energy use* – degree of energy use (EPA)
      - *c17.* *Water use* – degree of water use
      - *c18.* *Waste management* – degree of effective waste management
      - *c19.* *Pollution* – degree of pollution caused by CO_2 emissions for example
      - *c20.* *Sustainable certification* – degree of sustainable certification like BREEAM

Table 1- *Influence relationships ANP model*

For the determination of the influences a zero-one *interfactorial dominance matrix* was used (Saaty, 2001) whose elements a_{ij} take the value 1 or 0 depending on whether there is or there is not some influence of element *i* on element *j*. The rows and columns of the matrix are formed by all the elements of the network. Resulting in the ANP network model (figure 1).

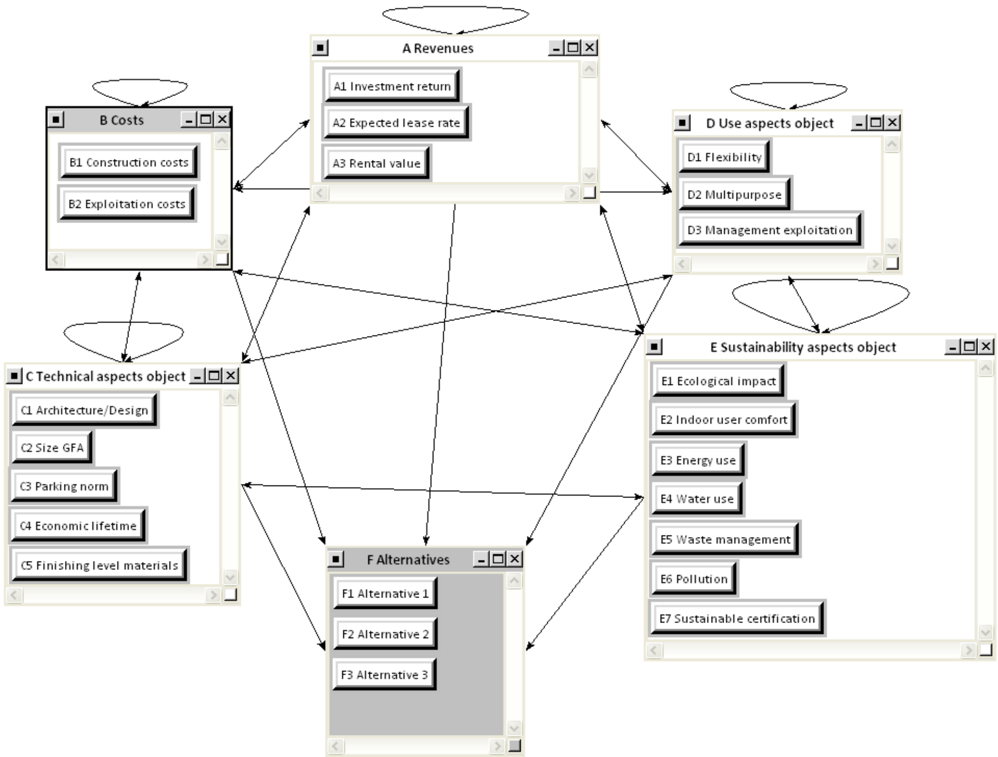

Figure 2 *- ANP network model*

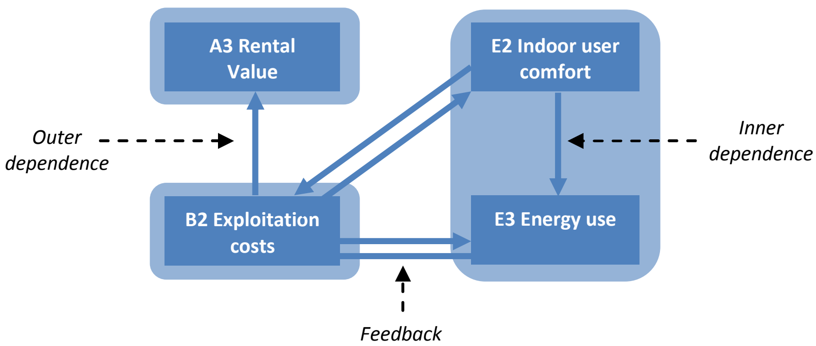

Figure 2 - *Example of inner, outer dependence, and feedback*

In an ANP network, an element in one cluster can influence other elements in the same cluster (*inner dependence*), for example Indoor User Comfort (E2) with respect to Energy Use (E3), and can also influence elements in other clusters (*outer dependence*) with respect to each criteria, for example Energy Use (E3) with respect to Rental Value (A3). *Feedback* loops of influence between elements can cause an unimportant element to become important, because an element which has low priority in its component, but a high priority of influence on elements in other components, could obtain a high overall priority in the limited supermatrix, for example Energy Use (E3) with respect to Exploitation Costs (B2).

2. Model quantification

To quantify and measure the ANP model, a pairwise questionnaire is conducted to the cluster, factor, and alternatives comparisons. The comparisons consist of assigning priorities to related elements in order to build the unweighted supermatrix. Each influencing factor is analyzed in terms of which other factors have influence upon it; generating the corresponding eigenvectors.

The questionnaire was conducted to different experts like investors, funders, and consultants. The selection of the experts was based on their expertise, function, and operating at the top 10 real estate investors in the Dutch office market. The sample size of 6 experts is considered as acceptable, compared to the ANP related researches (Gomez-Navarro, et al., 2009), (Chung, et al., 2005), (Lin, et al., 2008), and (Wu, et al., 2008).

The questionnaire was designed as a multiple-choice test into tables, that grouped the decisions relative to the pairwise comparison matrices. The relative importance values are determined with Saaty's 1-9 scale, where a score of 1 represents equal importance between the two elements and a score of 9 indicates the extreme importance of one element compared to the other (Saaty, 2001).

Experiment design

Applied to this research, a case study on the choice of the best alternative for the preferred investment of an office is tested. To rank the alternatives among the pairwise comparison from the investor point of view, comparisons are made by the respondents to three different plans.

- *Alternative 1*: *State of the Art Design* – focus on amenity, design, powerful identity;
- *Alternative 2*: *Multi-functional* – efficient, multi-purpose, and flexible possibilities;
- *Alternative 3: Sustainability* – focus on sustainability and comfort of the user.

Alternatives ANP Model			
	State of the Art Design	*Multi-functional*	*Alternative 3 - Sustainable*
A Revenues	Medium	High	Low
B Costs	Medium	Low	High
C Technical aspects	High	Medium	Low
D Use aspects	Low	High	Medium
E Sustainability aspects	Medium	Low	High

Table 2 *- Overview alternatives ANP model*

The three different plans which are used in this research, determine different plans with different scores to the clusters. In table 2 there is score indicated from the alternatives to the different clusters of the ANP model.

3. Synthesis and analysis

In phase 3, analysis of the data of the pairwise comparisons is performed. To produce consensus results, the geometric means of all respondents' responses are calculated, and synthesized to the ANP network model. The data is processed and synthesized by using ANP software SUPERDECISIONS.

The eigenvector which is derived from the pairwise comparison, is part of some column of the supermatrix. It represents the impact of a given set of elements in a component on another element in the network. The unweighted supermatrix contains the local priorities derived from the pairwise comparisons questionnaire throughout the network. The weighted supermatrix is obtained by multiplying all the elements in a component of the unweighted supermatrix by the corresponding cluster weight. With the unweighted and weighted supermatrix are raised to successive power the limit matrix is obtained. The results of the model are the limited supermatrix. The relative weightings estimated by the ANP approach were deemed acceptable, as the inconsistency-ratio was lower than 0.10, indicating a high validity.

ANP RESULTS

Concerning the output of the ANP results, the priorities of the clusters of the office real estate investment decision can be calculated. The priorities among the influencing factor clusters are illustrated in the figure 7.2. From the cluster priorities, investors prefer the revenue aspects of an office, followed by cost factors. This confirms the dominant financial/economic point of view of investors to an office investment. The sustainability aspects of an office does have a less influence of 12,4% to the investment decision.

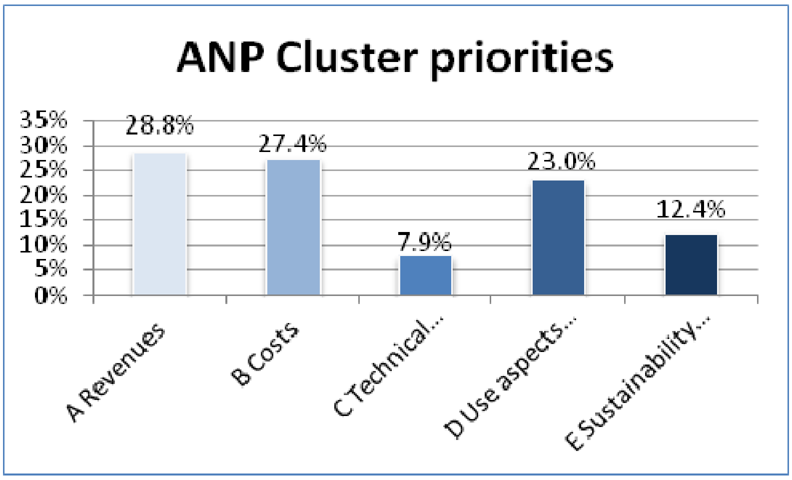

Figure 3 - *ANP cluster priorities*

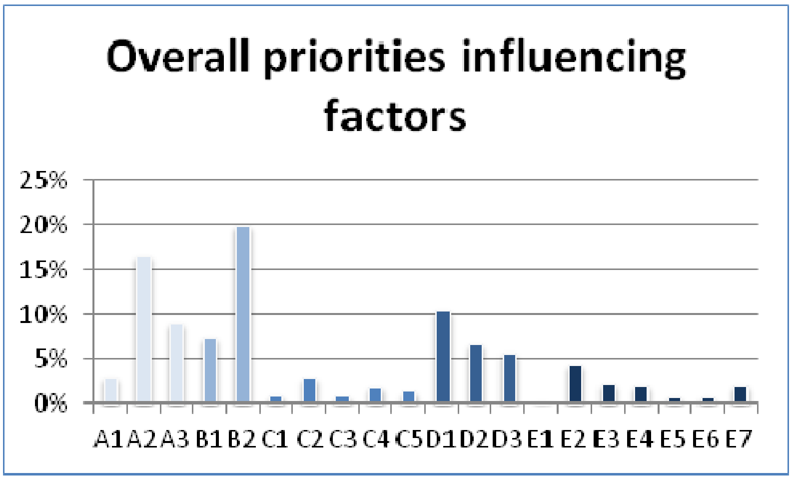

Figure 4 - *Overall ANP priorities influencing factors*

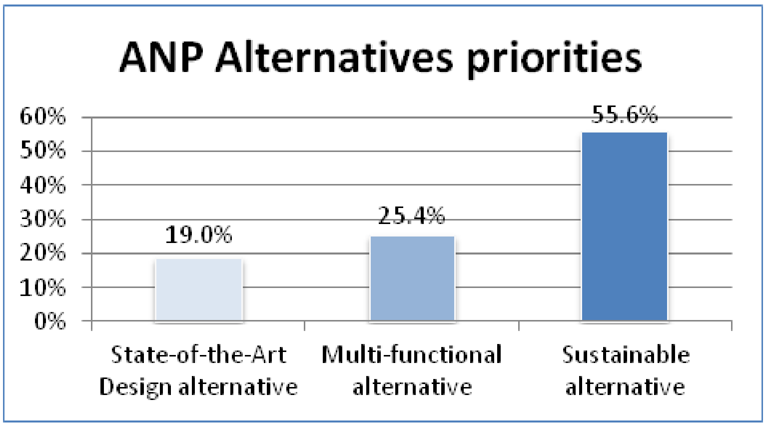

Figure 5 - *ANP alternatives priorities*

From the limited supermatrix the overall values of priorities of all the elements are obtained by normalizing each element. If we consider the relative importance of all criteria in the model, most important factors among all are the Exploitation costs criterion with a priority of 20,0%, followed by Expected lease rate with a priority of 16,7%, and Flexibility criterion with a priority of 10,6%. From the results of the overall priorities, the sustainability aspects are preferred less than 5% according to the overall office real estate investment decision.

The obtained results indicate that the 'Sustainable office' alternative is the most preferred alternative with a normalized priority of 55,6%. The 'Multi-functional' alternative is the second preferred alternative, with a score of 25,4%, followed by the 'State-of-the-Art Design' alternative with a preference of 19,0%.

CONCLUSION

This research indicates that sustainability does influence investors' decision of the commercial office development, but not directly. According to investors, a sustainable office minimizes the risk of vacancy in the future. Nevertheless investors try to maximize their return of investment, with a minimum of the perceived risk according to their investment strategy. Investors are still not convinced of the fact of higher value of sustainable real estate compared to ‘unsustainable’ real estate. Investors have a dominant financial/economic point of view, whereby the financial results of a sustainable office is (still) not sufficient, instead of a corporate social responsibility policy like a sustainable real estate portfolio.

Sustainability can be explained as a development that meets the needs of the present, whereby it tries to decrease the exploitation costs, which is the most preferred influencing factor to the investment decision. Though, the wide concept of ‘sustainability’ is preferred, indicated from the preference of the sustainable alternative. But from the criteria factors of the investment scheme on micro-level, there is no preference of the sustainability factors. Investors confirm sustainability as a corporate value, but the implementation of sustainability into the investment scheme on micro-level of an office by several investors is (still) not realized.

According to the sustainability aspects of an office object, investors don’t prefer the social sustainability like ecological impact and pollution, but prefer the sustainable quality of an office like indoor user comfort, and aspects that influence the exploitation costs, like energy use and water use.

DISCUSSION

This research focuses on the influence of sustainability on the Dutch investor’s investment decision of new development of office projects. However, the influence of sustainability is completely different from new development compared to the investment of existing offices. In fact, the most sustainable way of sustainability is no longer new development, but preserve existing offices on A-locations with a high potential of a high lease rate. Nevertheless, it is interesting to analyze the integration and influence of sustainability in new developments, because of the influence on the plan development, instead of preserving a possible restricting existing asset.

Nevertheless, the use of the ANP method as multi-criteria decision method is not free of criticism. ANP gets much more unclear and complicated as the number of alternatives and/or criteria grows, and therefore, it gets much more difficult to apply with efficiency, compared to the ‘real life’ investment decision. The ANP method illustrates the investment scheme in an ideal image and situation, without the external influences and subjectivity of the ‘real life business’.

Although the new proposal has been specifically applied to the evaluation of new office development proposals, this tool can be adapted to any type of decision-making problem, the provided criteria are correctly identified and there are some dependencies among them. This tool constitutes a very promising future research line in the field of construction management and urban development.

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Research is an interesting and complex process, but it is necessary to introduce evidence of the advantages and disadvantages of development of technology, economy, and sociology. I hope the KENWIB project stimulates the sustainable development of the society.

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IMPACT OF THE ENERGY NEUTRAL CONCEPT FOR LEISURE PARK INVESTORS

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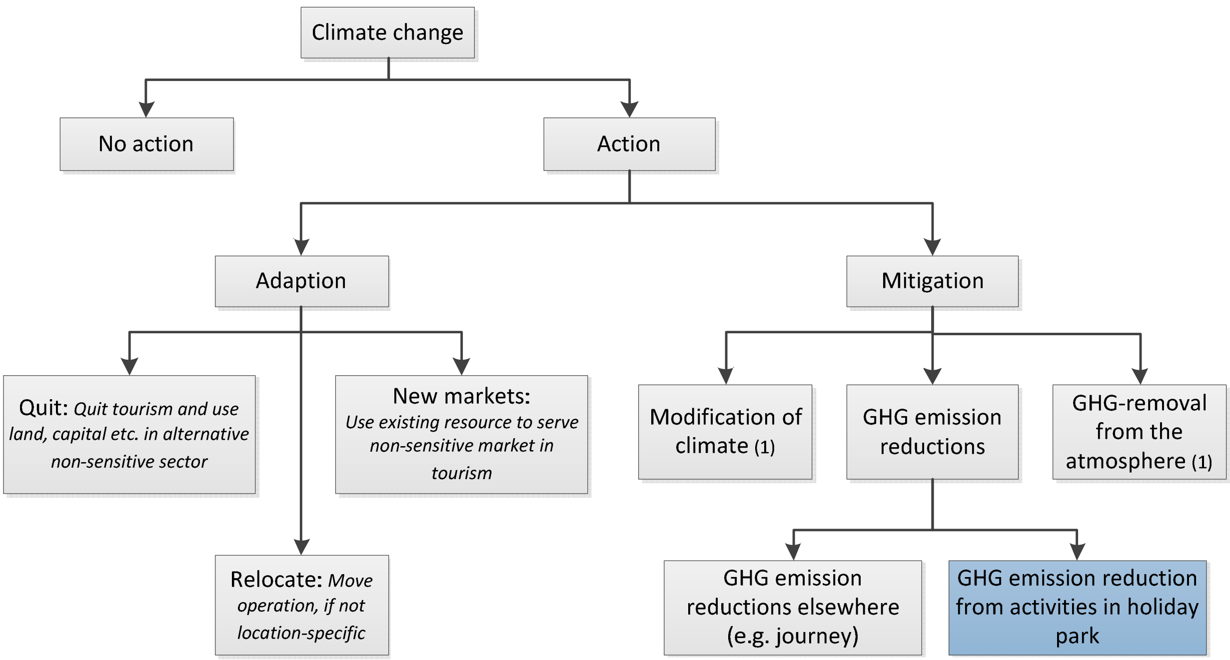
ABSTRACT
Energy neutral development is one way to coop with the current climate changes and the awareness fur sustainability in the real estate industry. In contrast to the housing and office market, the leisure market is not that far with addopting this sustainable concept.
Best feasable techniques for developing an energy neutral recreation unit is to equip it with solar panels and a sun-boiler. The central facilities can be equiped with pv-panels, sun boilers or a bio energy system to become energy neutral. When optimized the gross initial yield for the investor decreases from 8.76 to 7.86% while the net initial yield increases from 4.00% to 4.10%. This is one of the reasons why real estate brokers must advertise with the net initial yield when this concept is applied. Better results for the rate of return can be reached when only applying the energy friendly concept. This results in a gross initial yield of 8.14% while the net initial yield is 4.16%.

KEYWORDS
Leisure development, energy neutral, finance, investors

PROBLEM DESCRIPTION
There is a hard relation between the energy use within buildings and the CO2 emissions that are responsible for the climate problems worldwide (Lowe, 2005). Therefore the Kyoto protocol has been develop in 2005 by many countries worldwide. With use of this protocol these countries try to lower the total greenhouse gas production by 5.2% from 1990 levels by the year 2012. To fill in this Kyoto protocol the Dutch ministry of Housing, Spatial planning and Environment developed the policy program 'Schoon en Zuinig'. This policy wants to reduce the greenhouse gass production with 30% by the year 2020, to double the efficiency of the energy production methods from 1% to 2% and wants to generate at least 20% of the energy on a sustainable way by the year 2020. To reach this last goal lots of effort must be done the next decade because at this point only 3.8% of the electricity is generated on a sustainable way.
One of the rules to accomplish this is the increase in EPC demands from 0.8 to 0.6 for the housing sector. Badly, this demand is not been lowered for the recreation units on the leisure park because of the economic importance of this sector. But now that the leisure sector is growing in importance, also noticeability towards the environment changes in this sector. Bull & Craig-Smith (1990) claim that there are several options for tourist companies to handle this climate change (figure 1). These companies, when take action, can adapt themselves to this changing climate or can mitigate. The next scheme overviews the long-term respond options to climate change for the tourist industry.



1) More or less theoretical options

Figure 1: Long-term respond options to climate change for tourist companies

The focus of this research is to reduce the greenhouse gas emission for leisure parks (dark blue box in figure). There are more ways to reduce this greenhouse gas emission but in this research adopting the energy neutral concept has been taken to accomplish this.

RESEARCH APPROACH
As proven in the previous paragraph the leisure sector has different options to coop with the current climate problems. State of the art in durability is the use of energy-neutral and carbon-neutral concepts. In the housing sector lots of research has been done towards these concepts but in the leisure sector this research lacks in outcomes. Therefore the following research questions will be answered in this thesis:

1. What is the current state of energy neutral leisure parks in The Netherlands and what techniques are practical to accomplish this.
2. What is the financial impact for leisure park investors when applying the energy neutral concept.

These questions will be answered with use of a case study. This case study (Strandresort Nieuwvliet Bad) will be used as example for the common modern leisure park that is developed nowadays.

DEFINITION OF THE LEISURE PARK AND THE RECREATION UNIT
For recreation unit different kinds of buildings can be distinguished, for example: a villa, bungalow, terraced houses, apartments and caravans. Also the location of the unit can change between a nature environment, coastal area and recreation area. Also the usage can change, some people use it only for themselves, some for rental purposes and some use it for permanent living. Lots of sources use different definitions for both the recreation units as for the leisure park. Out of all these definitions the following definitions are created:

Definition of a recreation unit:
A recreation unit belonging to a larger group of units located on a leisure park in an officially designated recreational area which is exclusively used for rental purposes to a group of people which normally live elsewhere. This group used the recreation unit during a part of the year and hires via an exploitation company.

Definition of a leisure park:
A leisure park exists out of a group, rather similar, holiday houses or bungalows, which are only available for rental purposes by an exploitation company. This leisure park also includes central facilities like a bar, restaurant, lobby and an indoor swimming pool to provide additional service. All units on the park are owned by individual investors.

THE MARKET FOR LEISURE PARKS

Leisure can be described as ‘All activities which we perform in our spare time and let us experience something which makes us feel good.’ This can be done with use of different types of activities which vary from family and night entertainment towards retain and conference activities. The leisure park plays also an important role in the leisure market. This leisure market has changed rapidly the last decades. The total spending on leisure has increased with almost 80% between 1975 and 2000 and is going to raise the next decades (figure 2).

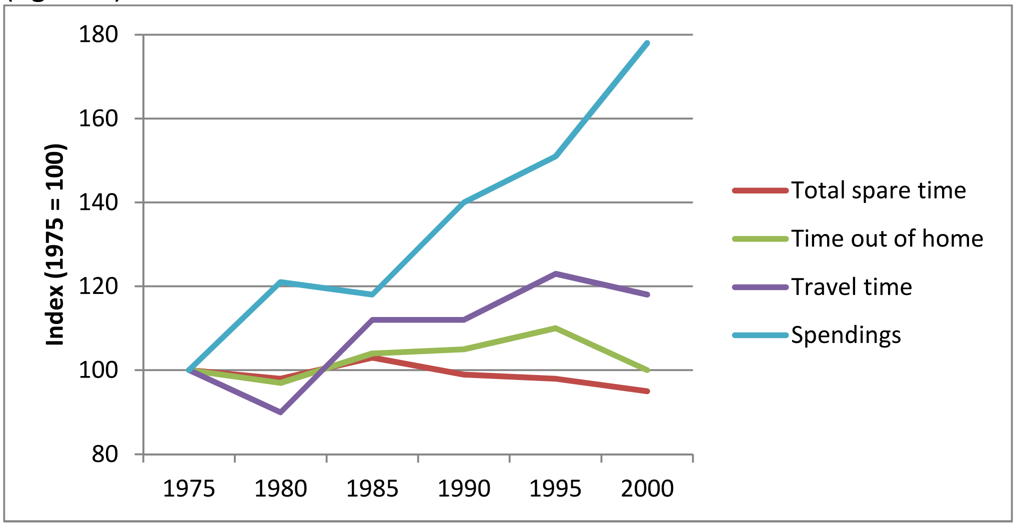


Figure 2: Spare time of Dutch citizens (Buruma, 2009).

Out of recent statistics can be concluded that the leisure market is growing faster and faster. People want to spend their spare time in quality and pay lots of money for it. Because of this trend the amount of leisure parks will increase in the next years and decades. A likely grow of 10-15 leisure parks a year with around 2-4 large scale parks (>250 beds) can be expected. These new parks will contain more luxury than the older units. Because of the large concurrency in the market individual parks must extinguish themselves. Energy neutrality can be a way to fulfil this. Especially in the German market where lots of leisure parks will be built in the next decade there are lots of chances to apply new concepts.

THE ENERGY NEUTRAL LEISURE PARK

The word ‘sustainability’ is used a lot over the couple of last decades. First only used by environmental companies and organizations but the last decades the common people are more exposed to this term (Westrik, 2000). Most times this is because companies use it for marketing purposes but the thoughts behind this word are becoming more and more important. In this research the trias energetica rules is used to coop with sustainable energy related questions (figure 3). This rule states that is it first task to limit the amount of energy that is used. To limit this amount of energy has the most significant

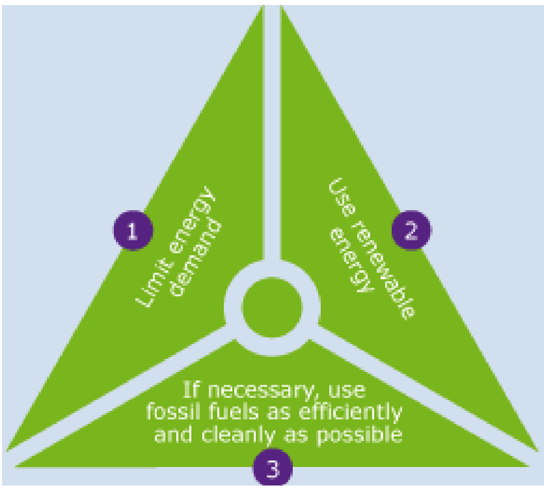


Figure 3: Trias energetica

impact on the energy sector and its pollution. After that it is task to generate the amount of energy that is absolutely necessary on a sustainable way as far as possible. This will further reduce the production of CO2 and other greenhouse gasses. The energy that cannot be generated on a sustainable way must be generated by fossil fuel. Trias energetica claims that it is task to use these fossil fuel sources as clean and efficient as possible to reduce the amount of necessary fuels and to limit pollution.
The first two steps are important for the energy neutral leisure park. But there are lots of different definitions and opinions about what is considered energy neutral. This research uses the next definition:

Definition energy neutral:
An energy neutral development means that the 'object' produces an equal or higher amount of energy than it uses in one year.

Market research shows that there is currently only limited interest in paying additional money for a sustainable holiday. Therefore I conclude that the occupancy rates stay the same for energy neutral leisure parks. Also the rental costs cannot be increased for this kind of parks. Therefore the energy neutral park must generate financial input just by implementing this concept.
When the three steps from trias energetica are used for energy neutral leisure parks the model in figure 4 can be used. As a standard leisure park the case study has been taken. The first step, reducing the demand of the recreation unit, the outcome of earlier research is used. The second step however has not been covered with research so far. Therefore this second step is the key focus for this research.

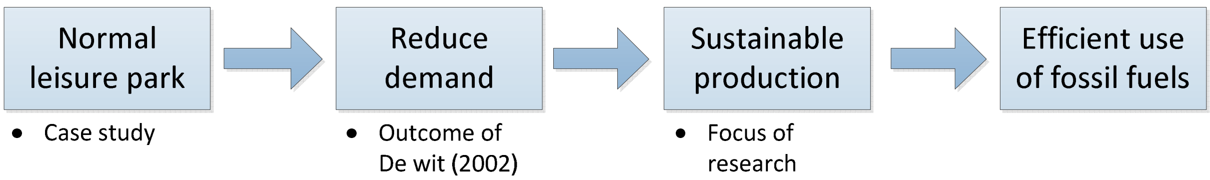


Figure 4: Stages of trias energetica for leisure park

Out of the case study the internal financial flows around energy costs can be excluded (figure 5). This proves that reducing the energy costs has a direct impact for the investors of the recreation units, but only when more owners take the same measurements. In this research the 6-person bungalow has been taken as base because this occurs the most in the park.

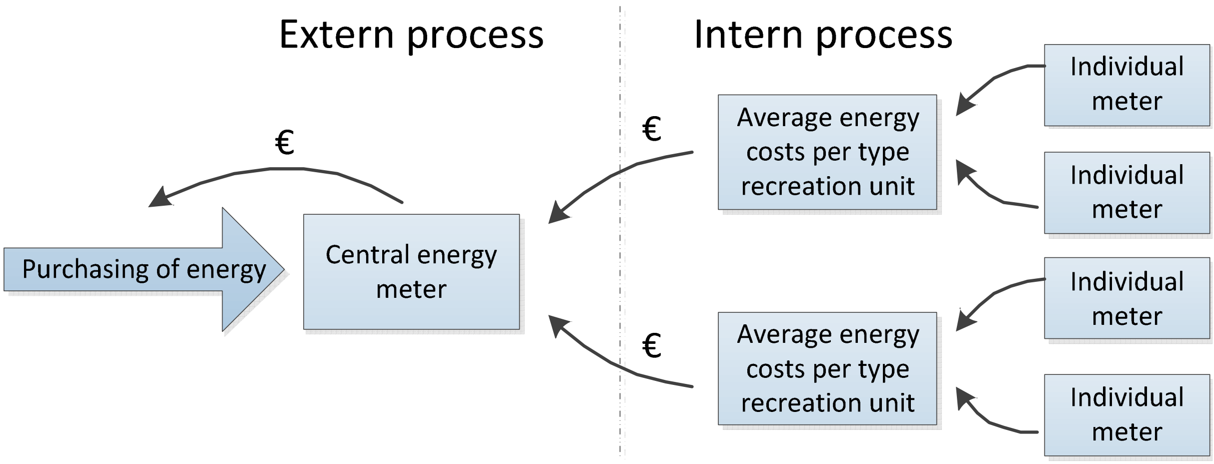


Figure 5: Payment of energy

There are lots of ways to generate sustainable energy. Lots of these methods are still in concept phase and have no proven application yet. Out of research the following methods have potential for implementation in the energy neutral leisure park.

Technique	Single recreation unit	Large scale usage
PV-cells	X	X
Sun boiler	X	X
Bio-energy		X
Waste heat		X
Wind turbines		X

Table 2: Scale of techniques

AVERAGE ESTIMATED ENERGY CONSUMPTION

De Wit (2002) calculated the energy demand of an average sustainable recreation unit for a Dutch leisure park. Because the major exploitation companies won't give their actual usage data, the data from De Wit is used in this research. The next figure includes the energy demands of an energy friendly recreation unit in The Netherlands.

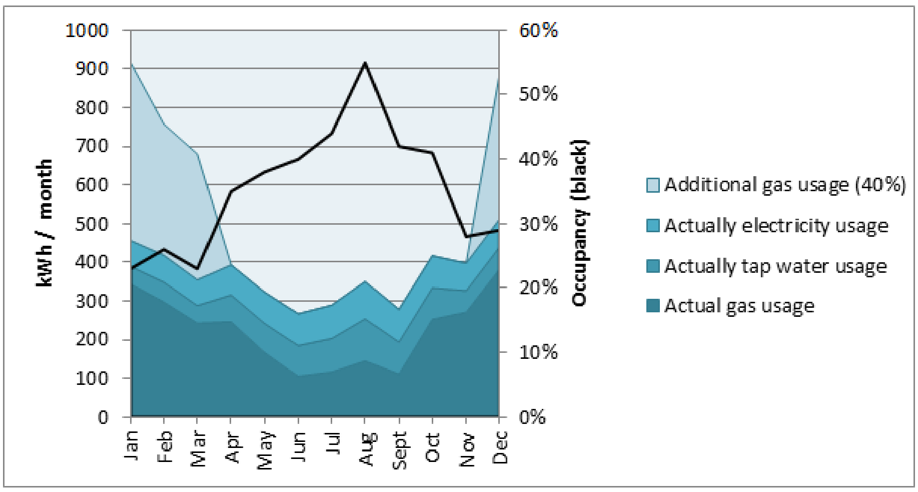


Figure 6: Energy usage with additional heating

For the central facilities the energy demand is around 352,000 kWh for heating purposes and 500,000 kWh electricity. The proven techniques all have potential to generate the desired amount of energy, although some techniques need large surface areas which makes implementation difficult. In this research waste heat energy has not been investigated due the lack of available data. The following table shows different scenarios which include different energy generation methods and different targets for them. Also the investment for these scenarios is included in the table.

#	Type	Type	Purpose	Investment	Yearly costs
1	Wind	Elec.	Park	€ 2,700,000	€ 100,000
2	Wind	Elec.	Facilities	€ 2,700,000	€ 100,000
3	PV-cells	Elec.	Park	€ 2,033,387	€ 23,989
4	PV-cells	Elec.	Facilities	€ 626,560	€ 7,392
5	PV-cells	Elec.	Single unit	€ 1,780	€ 21
6	Sun Boiler	Heat	Facilities	€ 159,999	€ 1,143
7	Sun Boiler	Heat	Single unit	€ 1,722	€ 12
9	Bio energy	Heat	Facilities	€ 46,250	€ 25,639
11	Bio energy	E & H	Facilities	€ 185,263	€ 53,976

Table 2: Investment costs for the scenarios

COST PRICE OF ENERGY

In practice the energy which is generated on the park is used for that amount which covers the demand at that time. The surplus of energy is not stored at the park but sold to the energy supplier. At the same time when an energy shortage occurs the additional energy is bought from the energy supplier due delivery contracts. Because this implicates different price variables this research used a simplified energy usage model:

> All generated energy is used, there is no surplus or shortage of energy due demand fluctuations.

Out of research follows that it is not possible to fit the wind energy scenario in this definition because wind energy can never be used for own purpose and only be sold to (specialized) energy suppliers. Therefore the wind energy scenario can be seen as a stand-alone project which has no relation with the leisure park and is therefore not included in the calculations.

For all other energy generation methods the cost price for the energy has been calculated and the possibility for subsidy (SDE+). The next table includes all costs for the different scenarios. The 'normal cost' column shows the energy costs for the energy friendly unit while the 'energy neutral costs' column includes the costs for the scenario. At last the total profit/loss for the scenario when applied are calculated.

Technique	Target	Normal costs [€/year]	Energy neutral costs [€/year]	Profit/loss [€/year]
PV-panels	Complete park electricity	€ 90,325.-	€ 149,681.-	€ -59,356.-
PV-panels	Central facilities electricity	€ 35,000.-	€ 58,000.-	€ -23,000.-
PV-panels	Single unit electricity	€ 66.-	€ 109.-	€ -43.-
Sun-boiler	Central facilities heat	€ 3,834.-	€ 6,168.-	€ -2,334.-
Sun-boiler	Single unit heat	€ 59.-	€ 131.-	€ -72.-
Bio-energy	Central facilities heat	€ 11,982.-	€ 13,146.-	€ -1,163.-
Bio-energy	Central facilities heat and electricity	€ 46,982.-	€ 91,148.-	€ -44,165.-

Table 3: Total costs for the different scenarios

THE LEISURE PARK INVESTOR

This investor can have two different targets: he can invest in real estate to use the production facilities to produce goods which deliver profit or he can see his investment only as object which has no other function than to generate rental income. Van Gool (2007) claims that for investors in real estate this second goal is the most important one. Investors in leisure objects are using their investment also for their own purposes (holidays), but because this research has its focus on investment benefits I will see the leisure investor as a real estate investor which has no other purposes for the real estate than rental income. Therefore the rate of return is determined as most important variable in the decision making process.

IMPACT FOR INVESTOR

There are two major steps in developing an energy neutral recreation unit like described earlier. The first step is to reduce the total energy demand, which can be done by reducing the EPC value of the unit. The second step is to generate the demanded energy in a sustainable way. Both steps demand a financial investment and have therefore an impact on both the gross initial yield (BAR) and the net initial yield (NAR). For both steps this impact is determined (table 4).

	Average unit	Energy friendly unit	Energy neutral unit
	Step 1 →	Step 2 →	
BAR	8.76%	8.14%	8.03%
NAR	4.00%	4.16%	4.13%

Table 4: Impact on both the BAR and NAR

Because the leisure park can only be titled energy neutral when also the central facilities contribute to this. Because energy costs of the central facilities are indirect costs for the investor, the investment impact of these measurements is also calculated. With an additional investment of 5688 euros (PV-panels for electricity and bio energy for heating) the energy costs can be lowered with 139 euros. This step has a negative impact on both the BAR and the NAR, which respectively decrease with 0.17% and 0.03%.

	Complete park energy neutral
BAR	7.86%
NAR	4.10%

Table 5: Impact on both the BAR and NAR

CONCLUSION

Out of these numbers I conclude that an energy neutral leisure park provides an almost equal rate of return (net initial yield numbers) than the case study park. On the other hand brings this kind of development more risks because this method is based upon subsidy platforms and fixed cost prices.

Also can conclude that the subsidy system for sustainable energy is still not completely developed because all production methods are not cost effective yet. When stage two of the subsidy platform can be reached this break-even point is better reachable and is sustainable energy a cost effective alternative. Different sources however claim that the SDE+ method is too popular to ever reach the second phase with this subsidy platform. When the developer has access to this second layer of financial income the leisure park will provide an additional rate of return for the investor which makes this concept more attractive.

FUTURE RESEARCH

Because the lack of research in the field of energy neutral leisure parks this was more or less a review of the current state of this sector with an overview of potential techniques which can be applied to reach the energy neutral goal. To deepen the knowledge of this interesting sector I would like to address some directions for future research. With further research it is possible to gain more accurate results which make investing in the energy neutral concept more interesting. I address two types of research questions, in the field of marketing and in the field of real estate investments:

Marketing research:

The interest of customers towards sustainable products and energy neutral concepts is growing but this research shows that only a small amount of tourists is actual willing to pay more for a sustainable holiday. How is this trend going to change in the future because of the environmental awareness of tourists? Is the tourist willing to pay more for this concept or can the occupancy ratings be raised for this kind of parks?

Investment research:

All techniques have not reached their financial break-even point at this moment. Therefore the rate of return on the investment is lowered when applying this concept. But is the investor willing to accept this lower rate of return because of the sustainable character behind his investment and towards what costs?

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TOM VAN LOO

This master thesis of Construction management and Urban Development is the result of both the study track and my personal interests, which has widened my view on area development and the related process.

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COMMUNITY INVESTMENT, AN ‘OPTION’ TO CONSIDER
A system dynamics model for a local energy community coalition

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ABSTRACT

To develop a more sustainable district; two major systems need to be changed; more renewable energy generation and increasing the efficiency of current real estate. On this moment, no real investment is made due to a split-incentive by both systems.
In this research a solution is searched by the developing the concept of a Local Energy Coalition community (LECC). A financial model is developed to determine if a LECC should invest in their own district to become energy autarky. This is done by modeling a geothermal installation in System Dynamics. The System Dynamics model calculates the profit of such investment, due to using a scenario driven planning model. The results of these methods are valued by the Net Present Value and the real option theory. The results are the financial options for a LECC to start developing a business model.

Keywords: System Dynamics, Real Option Theory, Energy Autarky, Community Coalition

INTRODUCTION

Many prominent leaders and scientists have spoken about the change of the energy system and our living patterns to save our planet. However, the ‘Green revolution’ hasn’t taken place. According to many scientists the technologies are available to produce renewable energies (Kajikawa et al, 2008). Incumbent firms use all their power to only create incremental innovations, which keep them in control. Until now there have only been green innovations. A ‘revolution’ may only occur when all facades of our energy issues have been bundled. The question is which actor will stand up and stir ‘the revolution’(Hockerts & Wüstenhagen, 2009). A renewable energy community has long been advocated, particularly by alternative technology activities, as a way to implementing renewable energy technologies, emphasising themes of self-sufficiency local determination, engagement and empowerment (Dunn, 1978)(Hoffman, High-Pippert, 2005). These communities can start redeveloping their own districts into energy neutral districts.

The path to energy neutral cities can be followed by using the pillars of energy autarky (Müller et al., 2010). The theory of energy autarky rests on three closely related principles;

- The use of endogenous potentials for renewable energy resources rather than energy imports.
- The decentralization of the energy system.
- The increase of the energy-efficiency in the supply side as well as the demand side.

Müller et al. (2010) defines energy autarky as “a situation, in which a region does not import energy resources from other regions, but rather relies on its own resources to satisfy its need for energy services”. This strong definition of energy autarky is unlikely to be fully achieved, because exchanges with other regions in reality probably always lead to a certain amount of import of energy resources. Therefore, energy autarky should be understood to be a vision to which to move to”.
In current practice creating renewable energy or sustainable houses is often separated very strictly. Furthermore, the value creation of the investment has a split-incentive.
The investor does not profit from its investment. The end-user receives value of the efficiency of the investment. This phenomenon is called a split incentive. Secondly, there is no real value received of synergy between the efficiency of the houses and the generation of renewable energy.

A system change to solve this split incentive is that the community needs to cooperate together. If they really want to change into a sustainable environment, they can make it themselves. They could be the actors to start the ‘green revolution’. In this research the problem statement is defined; “the value of a sustainable investment is not captured by current investors; this development stops them investing in sustainable district. On this moment there are no real investors who act as an energy developer on a large scale. Could a community coalition act as a new developer?” The goal of this paper is to develop a financial decision model to help a community start the redevelopment of their district into one which energy-sufficient.

LITERATURE STUDY

In the framework of energy autarky Müller et al. (2010) defines four subsystems; social, economic, energy and ecological.
The focus of this research is on the energy autarky; however the other subsystems are sometimes interconnected.
In fig 1 the model of Müller is shown. In this figure is shown how the sub-system cooperates together. In the model, primary (P) and secondary (S) energy flows are shown. These energy sources are outside the defined region. These sources need to be limited. The regional resources are used to fuel the region. The other sub-systems provide in this need. Economic factors can increase efficiency improvements, so less energy is needed.

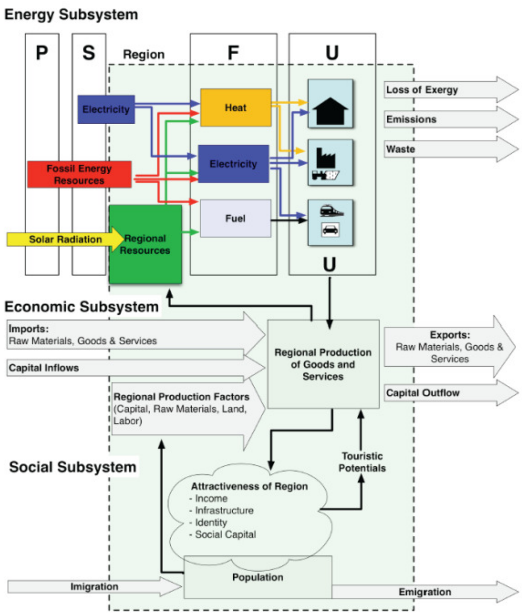

Fig 1 Energy Autarky (Muller, 2010)

Güssing is a small town in south- east Austria. It is located 130 km east of Vienna close to the Hungarian border. With a population of around 4000 people, it is totally reliable on its small- agriculture. The redevelopment of Güssing is a successful energy autarky project; the total investment generates a positive cash flow. Hence, it is the most autarkic town in Europe. So what stops us from copying this framework into our own? In the research framework is focussed on the urban area. Güssing uses his environmental resources, it generates energy with; biomass, biogas and solar panels. In the Netherlands, urban and rural areas are pretty much separated. So to fit Güssing into the framework of an urban area would have serious influence in the boundaries between cities and towns.
However, Güssing teaches us three important success factors; t every district needs to have it own resources analysis, initiator and their interest in the project is needed to start the project

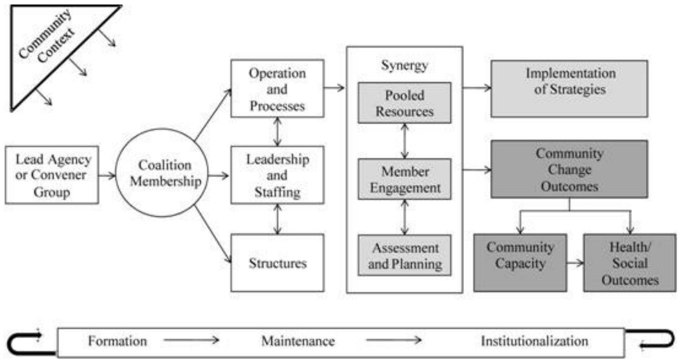

Fig 2 CCAT (Butterfuss & Keggler, 2002)

According Butterfuss & Kegler (2002) community coalitions present ripe opportunities for adopting recommended community participatory action research principles, where community members work in partnerships with researchers to collectively define local problems, identify and implement solutions to them, and evaluate their impacts. Initiating and sustaining coalitions is no simple task. However, it is a complex dynamic process that involves multiple coalition-building tasks. This can be done in many ways; the most important one is the right balance in their collaboration. In literature research to the use of community coalitions in energy autarky or energy neutral cities, no results were found. Many researches on the theory of community coalitions are done in health communities. In a recent review, the University of Chicago (2011) presented an overview of the most important community coalition's models. Community Action Theory (CCAT) fitted the most to the energy autarky concept.
CCAT is defined as a "group of individuals representing diverse organizations, actions, or constituencies within the community who agree to work together to achieve a common goal" (Butterfoss & kegler, 2002).In fig 2 the model of Butterfoss & Keggler is modelled.

To value the concept of Energy Autarky district with the LECC as developer the Net Present Value (NPV) is used. The NPV value is the sum of all discounted cash flow from the project, as can be seen in eq. 1-1. In this formula, the sum starts at, t is zero, and ends at, T, the end of the project. The, V_t, is the total cash flow of that specific year, t. The cash flow is discounted by the discount rate, r, which is raised to power time, t. A positive result means a go; a negative result means to abort the project.

$$NPV = \sum_{t=0}^{T} \frac{V_t}{(1+r)^t} \quad (1\text{-}1)$$

However, the NPV is according Dixit & Pindyck (1993) has some flaws. The option to wait with investment is not taken into account.

Trigeorgis (2001) defined the following formula (eq. 1-2) to valuate an investment option;

$$Total\ Value\ of\ Investment\ option\ =\ Static\ NPV + Value\ of\ options\ from\ managerial\ flexibility \quad (1\text{-}2)$$

In fig 3 the real option theory is modelled. The dotted line is the actually NPV of the project, V-I, as function of the cash flow of the project. To understand this picture, the value, V, of the investment is uncertain and is located on the horizontal axis. The value determines when then NPV is positive. The value where this line crossed the horizontal axis is the minimal value of acceptance for the NPV. The thick line is the value of the option of the investment according equation 1-2. Dixit & Pindyck (1994) refer to this value of the option as the cost of opportunity.

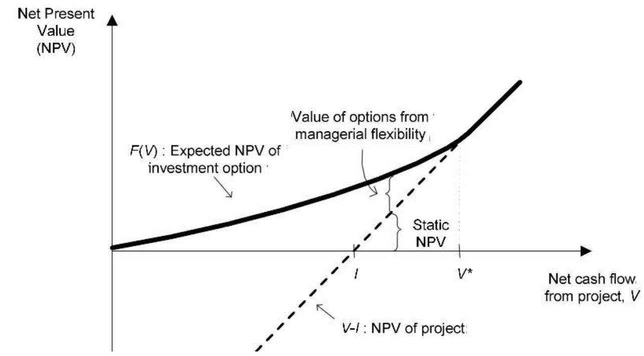

Fig 3 Real option Theory (Botterud, 2003)

RESEARCH METHOD

According Georgantzas (2010) realizing that a trade-off free strategy design requires insight about a firm's environment, both business and socio-political, to provide intelligence at all strategy levels, firms use SdP with SD to design, corporate business and process or functional strategies. Georgantzas describes three facets for SD with SdP; the business Environment, the forces behind its texture and futures requisite uncertainty, detailing the framework of SD with SdP, computing the effects on performance of changes in the environment and in strategy.

SdP with SD begins by modelling a business or social process than a business or social system. It is more productive to identify a social process first and then seek its causes than to slice a chunk of the real world and ask what dynamics it might generate (Georgantzas, 2010). Into this SD model, scenarios are implemented in the system. The scenarios are created with a scenario driven planning method. Many authors have described methods for such models. There is not really a wrong or a good model. Importantly, the scenario should have influence on the problem of system. This means the uncertainties of the key variables should be identified. When the scenarios and all other assumptions are implemented into the system, the model running can start. The result of the computed models can be analysed and strategic choices can be made. This result can then be again be implemented

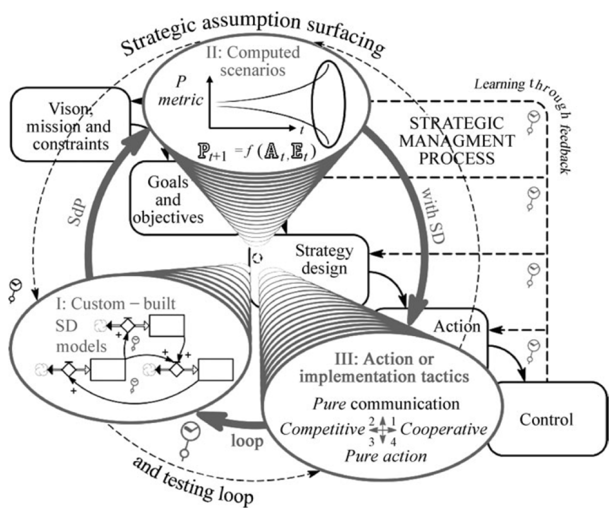

Fig 4 SD with SdP (Greorgantzas,2010)

into the SD model. By looping back into the model, the results can be checked and forecasted.
The essence of detailing the framework of SD with SdP is that you are modelling a social process. The business or social system is perhaps the end result, shown in figure 12. However, the social process of the real world should be format for this model.
This said, when modelling the model it is important to understand the state of this stage in the model. The goal of this stage in model is to implement strategies. So the implementation of the model is the goal. A random picture is not the objective. It should see if a strategy would fail or succeed. To have an ultimate model, this implementations of stage in figure 12 could be implemented in stage 1 to progress in the strategy process.

THE GENERAL MODEL OF A LECC

The general model is converted from the model of Amara & Lipinski (1983). In this model the sub-system of the LECC is not further elaborated. In the business idea the earning model of the organisation is explained. This internal process is influenced by another sub-system, the environmental scenarios. Together they form the input of the value model of the LECC. However the decision to start this organisation is not part of these two systems. So the value decision model is added to ensure the optimal investment decision is made for the organisation. The decision starts further elaboration of the LECC, into the start-up of the organisation. The model starts at the establishment of the LECC, which is in this case; the commitment of some early adopters to research the possibility to develop a company with geothermal heat and solar panels. This is constructed in a kind of business idea. Here the opportunity is developed and implemented in scenarios for the price and demand of that specific area. The value of that specific business idea is valued by using a real option theory method. This model shows some options for the LECC, they decide what to do. If they decide to continue, the business idea is further elaborated into a business model.

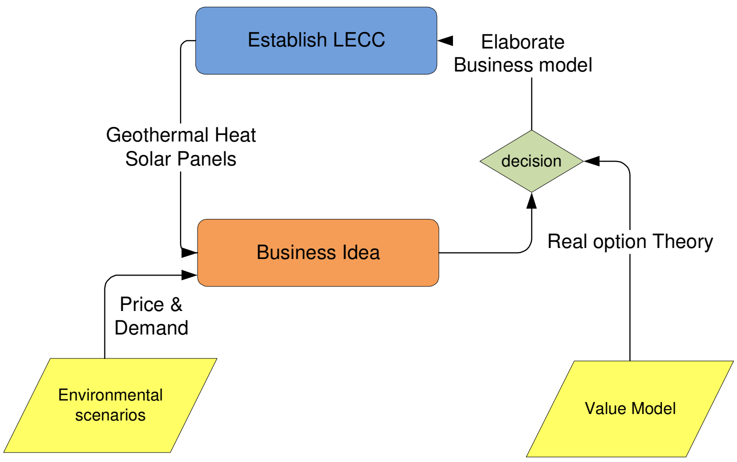

Fig 5 General model LECC (Amara & Lipinski, 1983)

Business idea: geothermal heat

Geothermal energy is heat located a few kilometres below the surface. The generation uses heat from the earth to supply us from heat. It can also use a cogeneration unit to also supply electricity. This form of generation has two forms; cold heat combination, and deep geothermal. CHP puts warmth in the ground during summer and uses this in the winter. Deep thermal generation drills in the earth tills it is so heat it can be used in district heating.
According research by the Dutch ECN research agency (2011), geothermal energy has large potential in the Netherlands. The price for thermal energy is equal or even less than the current fossil energy prices. And with the probability that prices will rise in the future, it could well be a very good technology to use in our districts.

In research by the Dutch research agency ECN (2011,) three possible functions for deep geothermal generation in the Netherlands are developed. The three functions are; horticulture, Greenfield development, and Brownfield development. The horticulture sector can use thermal heat to heat their greenhouses instead of burning gas. In Green- and Brownfield's scenarios, thermal heat is used to heat buildings. The difference is the current network, in a Greenfield there is no heating district infrastructure, in a Brownfield there is already a network available.

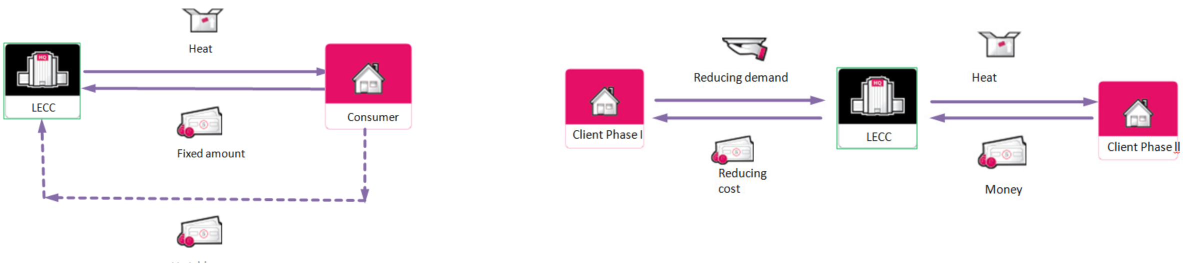

Fig 6 earning models of the business idea

In fig 6 the extension of goods is very basic; the LECC delivers heat to the consumer and the consumer pays money for it. In this research an assumption is made, which is created by trial and error.

The consumer pays a fixed amount; two/third of its current energy bill for heat, and the rest in a variable amount. The variable amount is connected to the amount of energy he uses, so this reflects on the user energy behaviour. In this matter the consumer has the incentive to reduce its energy behaviour.

The reason the LECC prefers this, is that the LECC has an extra incentive. It can sell the saved energy to a phase II district. Client phase I offers a service by reducing cost, this results in reducing cost. A geothermal installation has one only switch, on or off. So the total amount of energy stays the same. This means the LECC can again sell heat to buyers, without any extra investment. This can be invested in extra efficiency measures or dividend.

Environmental model

In this model we will use scenario-driven models to forecast the most two important variables; demand and price. This part of the research will only consist of analysing existing scenarios.

The data is used from the energy scenarios from Farla et al. (2006). These scenarios are developed on macroeconomic scenarios, namely the model of Huzinga & Smit (2004). Huizenga & Smit define the two largest uncertainties which influence the economies in Europe. The first uncertainty is the commitment to cooperate on an international level. The second uncertainty is the speed of the process of reform in the collective sector in each country. Four scenarios are developed; regional communities, Global Economy, Transatlantic market, and Strong Europe.

The regional communities' (RC) have a strong focus on national power. They block further cooperation among other EU members. Europe divides itself in different business blocks. The national organisation is growing and market processes fall. In the transatlantic markets (TM) plot the national power is still high. However collective reform is increased. This wills not from an open economy, while individual countries will keep their markets protected. Strong Europe (SE) has a high level of attention on international cooperation. European agencies are reformed; the national governments hand over some responsibilities to Europe. The focus of is also on an equal distribution of wealth among the EU. The Global Economy

(GE) focuses on extension of the EU. However the only real successes are on the economic topics. Reforms on the social and environmental issues will fail. The national government focuses on the individual responsibility.

Value Model

The corporate model with the SD and implemented scenarios show different stories of the future. For the LECC it is hard to decide which story is correct and when to invest. Dixit and Pindyck (1993) define two important characteristic of investment. First, the expenditures are at least partly irreversible; in other words, sunk costs that cannot be recovered. Second, investments can be delayed, so that the firm has the opportunity to wait for new information to arrive about prices, costs and other market conditions before it commits resources.

This model uses the continuous-time models of irreversible investment by McDonald and Siegel (1986). They had the following problem statement; at what point is it optimal to pay a sunk cost, I, in return for a project whose value is, V, given that V evolves according to the following geometric Brownian motion:

$$dV = \alpha V dt + \sigma V dz \quad (1\text{-}3)$$

In this eq. 1-3 the value, V, at time zero increases lognormal with the variance, σ, with the idea that future is always unknown. The drift parameter, α, is the proportional growth parameter. When we use the scenario-driven models, the model could be claimed as known. This is with the idea that one of the four scenarios is the truth. In simple words, α is growth implemented according the scenario data, and σ is zero.

In this 'deterministic' case with no 'uncertainty', the optimal value can be determined. The optimal value rule uses the critical value, V*.

CASE-STUDY

The model of LECC is implemented in a case-study in the city of Eindhoven. A district with 2200 units and a swimming pool was calculated to be connected to a geothermal source in their Neighbourhood. A short summary of the results are presented.

The heat demand will start in year 5 after finishing the installation. Because the scenarios for strong Europe (SE) and Regional communities (RC) are the same there is only one line for these scenarios. All scenarios are decreasing. This is under influence of the forecast of less demand and the investment in efficiency of the buildings. This results that in year 34, the second phase can be added to the LECC. This means that the demand increases.

A nice result from this model is that very high increase of price not necessary means the highest profit.

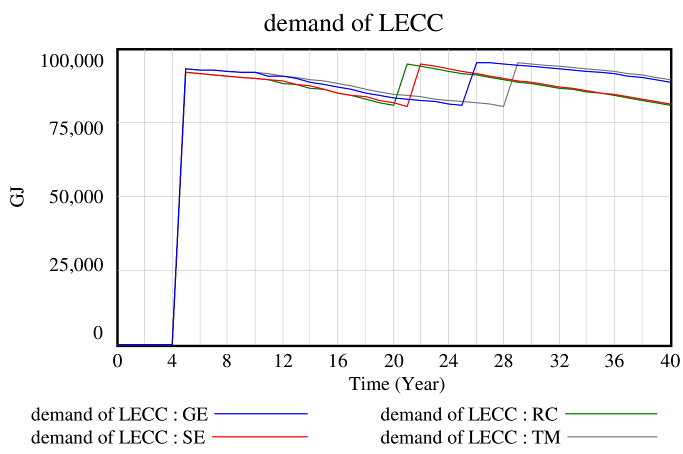

Fig 7 Energy demand of LECC, simulation with SD

Due to the high decrease of demand, phase two can quickly be added to the project which results in higher profits than the high increase of price. We can conclude that a combination of demand decrease and extension of the network offers high results.
After running the models the investment question remains, should the project be started? Four scenarios are run and the results are presented. These results should now be analysed and compared to make a decision. The standard method for such question is done with the net present value (NPV). However, as explained in the general model elaboration, after the NPV a real option analysis is made. This is done to value the cost of opportunity.

The NPV tells us to invest into the project for all four scenarios. The sum of the discounted values, V, for each scenario are larger than the investment, I.
The LECC however wants to know if this is the right time to invest. With the real option theory they try to determine the optimal investment moment.
When, V, is compared with the optimal value, V*, the conclusion can be taken that scenario GE and RC are optimal situated to invest now. The value of the model is higher than the calculated V*. However, the other two scenarios are not close to their optimal decision point. This means that the project is not optimal to invest on this moment. This optimal moment can be calculated by developing a delay in the system dynamics model.

CONCLUSION

RQ 1: What are the factors for financial feasibility of energy autarky for a community?

Environmental opportunities: Autarky can only be gained when local opportunities are exploited. These local opportunities are everywhere different. This can be; using natural capabilities, using natural waste from the own district to generate energy, or using industrial waste to produce energy.
Starting capital: Most of the times there is not enough renewable energy capacities to supply the district with energy. The energy demand is too high. So besides the investment to start a renewable energy generation plant, an investment should be made in decreasing the amount of energy. This cannot really be done in mutual phases. Both investments should be made in the same time. This causes high investment in the start-up phase of the project. An important aspect in this investment decision is the change from short-term into a long-term perspective. The strategic uncertainty of the long-term perspective is in this decision vital. To reduce the risk for the investor of the long-term, commitment of the user is needed. This commitment ensures the investor to invest for the long-term.
Spin-offs: Becoming autarkies asks a lot of commitment from all stakeholders. Social spin-off in such a project increases the success factor of the project. In the case of Güssing the town was almost dead, there were no jobs and everybody was leaving the town. Since the change in an autarkies district a 1000 jobs were created. This lifted the entire town to higher level.

RQ 2: How can a community energy coalition be organised?

For that reason the format for a community coalition was introduced. Community collations have three big advantages; they bring large group of stakeholders together, create social capital and are catalyst of change.
The best model for a community collation for this model is the community coalition action theory (CCAT) by Butterfoss & Kegler (2002), see fig2. The CCAT has proven itself in the improvement of social security in some suburbs of the USA. It is also used to increase the health care in the some district in the states.

RQ3: What are the options for the community as energy developer?

According the NPV in all four scenarios the project was positive, so feasible. The NPV only defines a go- or no go decision. With real option theory, timing of the investment is not taken into consideration. According the optimal value rule, only two of the four scenarios reached the optimal decision point on this moment. The other two, SE and TM, didn't reached the optimal value, but were feasible according NPV. Real option theory suggests to wait until the values emerge. When the future values reach the point of the optimal investment, start the project. The LECC model defines two options to consider for its stakeholders;

Firstly, invest in the project according the NPV. In the case of the Prinsejagt, all scenarios have a positive result. This means that there are financial possibilities for the district to start a process of business plan modelling. Real option Theory, tells it is not optimal to invest.

Secondly, wait with investing in the project. When all scenarios have reached their optimal value, it is time to start the project. The cost of opportunity for such a choice can be developed as a call-option. This call option can be sold to an investor or the companies in the district. When the option is not called, the forecast is not emerged and the reason to develop the option is gone. The cost of this option can be deleted with increase of the price.

Further running with SD model shows that with the current parameters. The project is calculated an optimal result in two years. This means for case of Prinsejagt option two should be followed and in two years start the project. This option is worth 37.000, - euro.

DISCUSSION

In the research some assumptions are made, these assumptions are not wrong. However, with current knowledge they could be made better.

Firstly, the generation of heat is modelled with the principles of geothermal heat. A geothermal generation plant is a high investment. The question remains if the technique is not too expensive for an organisation like LECC. Furthermore, this high investment asks for a larger area to sell to. This is not a real problem. However, the question remains if such a large area is ready to commit on a voluntary base.

If a smaller district is taken, a commitment issue is easier to tackle. This combined with a technique like the aquifer thermal energy storage could be perhaps given more practical success. Secondly, this research has the goal to help the consumer to help make an investment choice to redevelop their district into an energy autarky one. In this research the focus lays on the community development. However, the consumer perhaps wants to be convinced that the community investment is the best option. So as a tool for the consumer, an individual investment option could be an addition to the model. Thirdly, in this research the assumption was that an energy distributor, like Endinet in Eindhoven, would build an infrastructure for this district. The question is if, such companies are fund of these kinds of infrastructures. Finally, the real option part of the model is correctly constructed according theory from the authors of the theory. However, the theory of real option theory isn't a proven theory in the field of energy. Experts have cleared the result; however they were not really convinced. So, further research on real option theory in the energy sector can be helping the validation of this theory.

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Developing a sustainable concept showed me again how difficult it is to implement innovations. So many stakeholders can have an opinion in this process. I really hope that KENWIB can help support people make new steps to a more sustainable society.

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TARGET GROUP CLUSTERING FOR APPLICATIONS OF ENERGY EFFECTIVE RENOVATION CONCERNING PRIVATELY OWNED DWELLINGS

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Date of graduation:
21-03-2012

ABSTRACT

In programs for energy effective renovation of dwellings it is hard and still not clear how to select the right target group regarding the dwellings saving potential (hardware) and decision making private homeowner (software). In this research linear components of different factors and variables of dwellings and their occupants are extracted in a principal component analysis (PCA). With the components and the actual geographical coordinates of the dwellings different cluster analyses are conducted searching for new spatial contiguous energy clusters and target group clusters. The target area of the research is only one district in Eindhoven. Therefore the promising results obtained should be tested in further research.

Keywords: Energy Efficient Renovation, Target Group Clustering, Housing Submarkets, Marketing, Cluster Analysis

INTRODUCTION

Context

All the things we do in and for life on earth consumes energy. Currently fossil fuels are used for the majority of our energy production. Looking at future energy scenarios it becomes clear that fossil fuels need to be replaced by other (renewable) energy sources. The Trias Energetica is a simple and logical concept that stimulates to achieve energy savings, reduce our dependence on fossil fuels, and for the remaining part use fossil fuels as efficient as possible.

Governments in Europe decided there should be common objectives for all countries in the European Union. This leaded to European energy and sustainability objectives for the Netherlands in 2020: 1) 20 percent reduction of greenhouse gasses compared to 1990 2) 14 percent share of renewable and 3) an annual energy consumption reduction of 2 percent. The municipality of Eindhoven has even more ambitious goals, she aims to be energy neutral between 2035 and 2045 (Municipality of Eindhoven, 2008). Energy neutral in this case means that the (remaining) energy demand for the own organization, dwellings, industry and remaining connections is generated with renewables inside the borders of Eindhoven.

Campaigns of the government to reduce energy use in existing dwellings were not often successful in the past. The participation rate was in most cases not exceeding 5%, of which 3% was not attracted by the campaign but already was intrinsically motivated to compete in a program. Idea owners of such programs at municipal level are in a real need for ways to increase this participation rate. The government just finished a report with best practices for building related energy savings for private owners (Motivaction, 2011), this report has been made as part of the "more with less" program (meer met minder). In the report Do's and Don'ts are formulated. One of the Do's only raises more questions:

Choose the target group and their homes with care. There must be a potential saving in the houses and it is important to focus on a target group. A group is characterized by shared values, needs and ages. All residents of a neighborhood are rarely a target. Make sure your approach fits the target audience. Are they sensitive to comfort, money savings or unburdening? Adjust your approach to it.

Easier said than done, but how do you do such a thing if you have more than 50,000 potential dwellings in, for example, Eindhoven? Some of the questions that rose are listed below; these questions will transform into the research questions:

Problem Statement

How can we select the dwellings with the biggest saving potential bearing the characteristics of the household in mind? Is an evaluation method available which can integrate characteristics of hardware and software?

In programs for energy effective renovation of dwellings it is hard and still not clear how to select
the right target group
regarding the dwellings saving potential (hardware) and decision making private homeowner (software).

In the next paragraph research questions are formulated that will lead to the design of a study.

Research questions

- Which variables or factors of all dwellings and households in Eindhoven are available for analysis?
- Which variables or factors influence the decision for participation of private homeowners?
- Is the statistical cluster division of Eindhoven a reliable target group division?

Is an optimization of target group size and geographical distribution possible, when focusing on maximization of (1) participation and (2) reduced energy demand in a program for energy effective renovation for private owners of dwellings?

Relevance of research

In a graduation research including an internship both practical and theoretical relevance are important. In the transition towards a more sustainable Eindhoven, i.e. total energy neutrality, an important factor is upgrading the energy performance of the existing stock. Programs to achieve this are rarely successful, since too little is done to target the right dwellings and owners. The practical relevance of this research lies in its usability for BvB/e. The foundation tries to recruit up to 2,000 participants in a program for EE-renovation of privately owned dwellings. To reach this goal 20,000 potential participants and their dwellings are selected. The designed method and output will be used to select the 20,000 dwellings used by BvB/e.

Expected results

- A set of decision variables that tries to reflect the actual behavior and characteristics of private owners and their dwellings considering to participate in an energy effective renovation program;
- A cluster analysis (clustering). Resulting in a certain number of clusters (geographical constrained typological target groups) in Eindhoven;
- A dataset of all the dwellings and their owners to use in the communication strategy for BvB/e;
- A map of Eindhoven visualizing the target group clusters for energy saving.

Research design

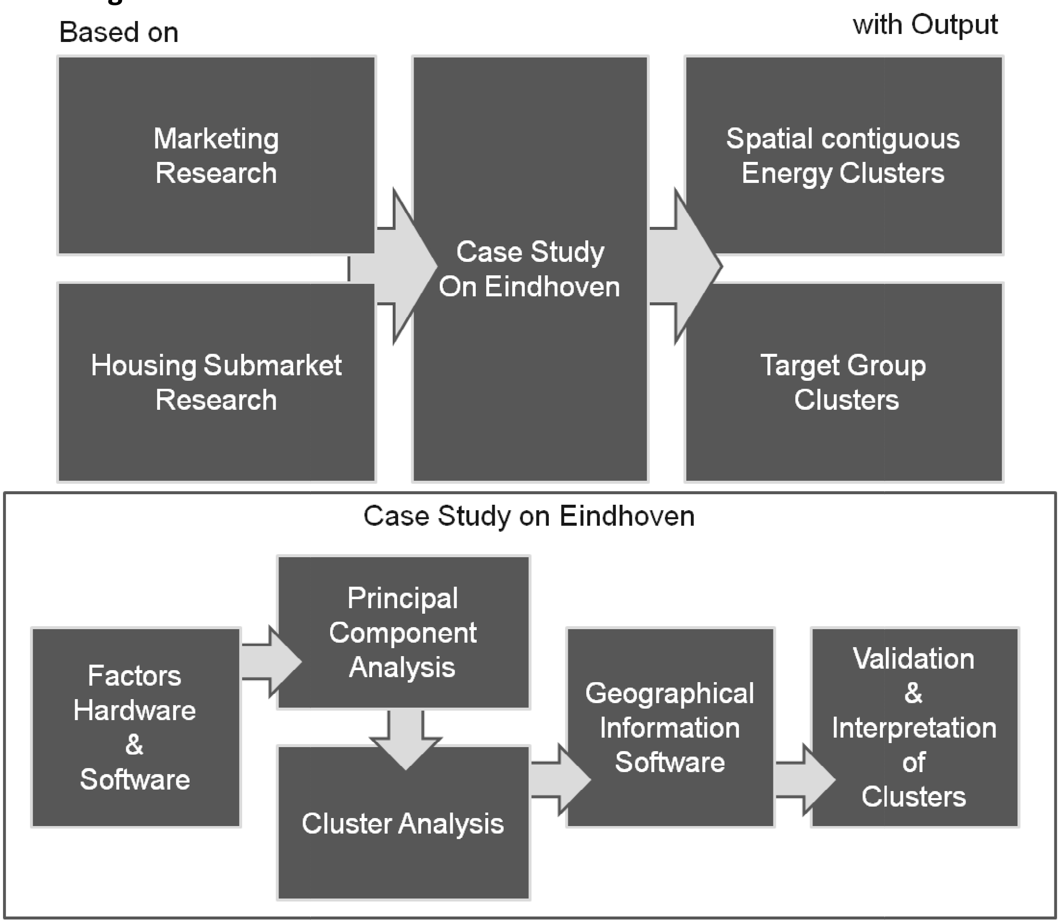

Figure 1: research model

In figure 1 the research model is visualized. With the characteristics and methods of marketing and housing submarket research in mind a case study on a district in Eindhoven is conducted. 2 studies are designed which should lead to spatial contiguous energy clusters and target group clusters. The case study consists of a study on available hardware & software factors. With these factors a PCA and CA is conducted the results are presented with maps using GIS. With the last step the found clusters are validated and an interpretation is given.

THEORETICAL ORIENTATION

Housing submarket research

Neighborhoods are a historically grown, physical presentation of groups of buildings. In which neighborhood a property is located is influenced by administrative decisions of planners and therefore historically determined. In the 1960's research on housing markets started, it was based on a belief that the prices of property are not only defined by its physical location but also structural, demographic and socio-economic characteristics have influence. The most often used definition is given by Bourassa et al. (1999) were a submarket is defined as a set of dwellings that are reasonably close substitutes of one another, but relatively poor substitutes for dwellings in other submarkets. Transferring this towards the challenge for target group clustering in Eindhoven this research indicates we should look further then an "a priori" division of the municipality of Eindhoven for neighborhoods and small clusters.

It is disputable that with the use of housing submarkets, factors related to energy usage are left out of the response variables. In this research it could be wise to use a statistical submarket housing model, where technical, structural and energetic characteristics of a dwelling are taken in account too. Wu & Rashi Sharma (2011) deals with the topic of housing submarket classification and the role of spatial contiguity, sometimes called nearness or proximity. A spatially constrained data-driven classification methodology is used to deduce spatially integrated housing market segments. This research is extremely useful because it links geographical constrained data into a model where different variables are statistically considered in their coherence. Submarkets are formed with houses more similar to each other based on location and their physical, typological and demographic properties.

It is concluded that the method advocates the utility of spatial submarkets where public and private organizations can identify specific geographic zones of potential growth or with special needs. Is it possible to identify these regions and use them as target groups for energetic effective renovation programs?

Marketing research

In a program for energy effective renovation there is a need for a division of target groups. People are attracted to different aspects of the results of a renovation program and therefore have different grounds for participation. Cluster analysis is used in market research for selection of possible or preferred consumers, the so called market segmentation. With market segmentation the market is divided into target groups or sub-markets. An older overview for possible application is given by Punj & Steward (1983) and an implementation is conducted by Kuo et al. (2002).

CASE STUDY ON EINDHOVEN
Eindhoven is divided into 7 quarters, i.e. Centrum, Tongelre, Gestel, Stratum, Strijp, Woensel and Gestel. These 7 quarters are split further into 20 districts and 116 neighborhoods. Based on composition of the dwelling stock a neighborhood is further divided into clusters. The city of Eindhoven has more than 1,100 a priori clusters. In figure 2 the target area is visualized, district "De Laak" consists of 2 neighborhoods and 34 a priori cluster representing 2187 occupied dwellings.

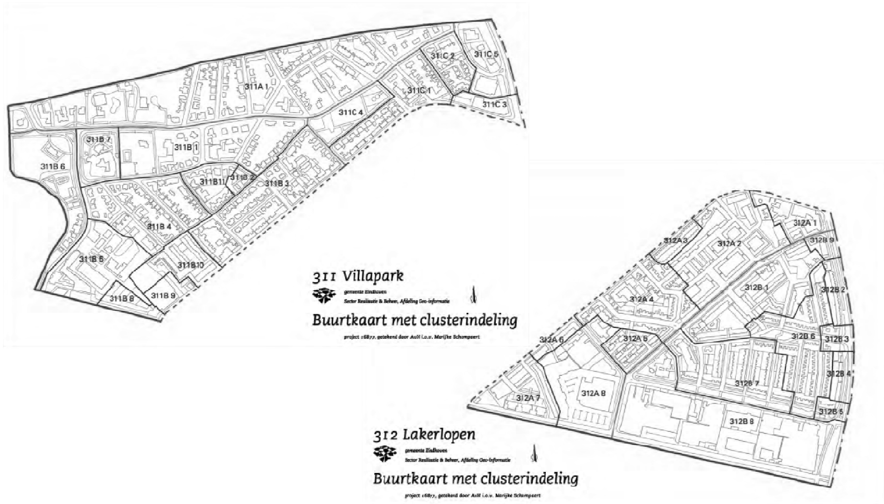

Figure 2: Target Area district "De Laak" Eindhoven, a priori division

In figure 3 the following available and useful factors of hard & software are enlisted. The municipality delivers information about hardware and software. The hardware factor "typology" is converted to a interval level using the example dwelling saving potential of Agentschap NL. Endinet delivers standard year usage figures of electricity and gas connections of every dwelling in the area under study.

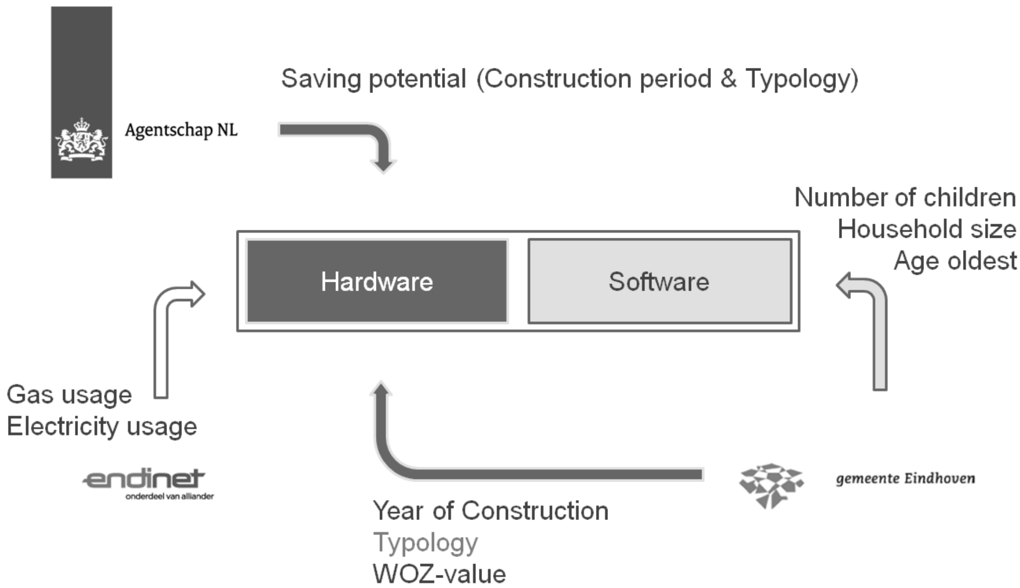

Figure 3: Factors of hardware & software available for analysis

On the dataset of 2187 dwelling a principal component analysis (PCA) was conducted on the 9 variables with oblique rotation (Direct Oblimin). The KMO verified the sampling adequacy for the analysis, KMO - .726 ('Good" according to Hutcheson & Sofronniou (1999)), and all KMO values for individual items were > .618 which is well above the acceptable limit of .5 (Field, 2009). An initial analysis was run to obtain eigenvalues for each component in the data. Three components had eigenvalues over Kaiser's Criterion of 1 and in combination explained 78.40 percent of the variance. The screeplot was slightly ambigious and showed an inflexion that would justify retaining 2 or 3 components. Given the large dataset, and the convergence of the screeplot and Kaiser's criterion on three components , this is the number of components that were retained in the final analysis. The items that cluster on the same components suggest that component 1 represents the "dwelling saving potential", component 2 the "Household characteristics" and component 3 that "Wealth comes with age".

The two studies are validated using the weighted average standard deviation (WASD) (Wu & Rashi Sharma, 2011).

$$\mathrm{WASD}_{\text{per characteristic}} = \frac{\sum_{i=1}^{i=n}(N_i * SD_i)}{N} = \frac{\sum_{i=1}^{i=n}\left(N_i * \sqrt{\frac{\sum_{j=1}^{j=N_i}\left(x_j - \bar{x}\right)^2}{N_i}}\right)}{N}$$

In most cases there is need for spatial contiguous boundaries of a cluster, this is inspected visually too (Wu & Rashi Sharma, 2011). The third measure used is the shape of the distribution in the "variwide" plot. This plot is shown in de lower left corner of figure 4. The results of a CA are better when it is shaped as much as possible like the plot of the individual saving potential of dwellings. Two different studies are executed, both are discussed in the next subparagraphs.

New spatial contiguous energy clusters

At first a new spatial contiguous cluster division for district "De Laak" is made. Whether the a priori classification is a well performing division regarding saving potential and homogeneity of clusters should be based on judgments for all different levels in the classification is answered next. For the most specific level (neighborhood clusters) the statistical cluster division of Eindhoven is quite a good representation. Moreover the homogeneity of the formed 34 clusters is significantly higher using the data-driven classification methodology, this conclusion is based on the found weighted average standard deviation for the characteristic saving potential which is 28 percent lower. Using the a priori division on any higher level of aggregation is risky, for the homogeneity is much lower in these divisions than in the division used in this study. There may be districts with highly coherent dwelling types and building periods but this may not be presumed.

The results of the first study support the belief that a data-driven classification method, such as cluster analysis, can lead to a better clustering of dwellings for energy effective renovation up to a certain level. The statistical a priori division of the municipality performed quite well at the lowest level. But a better spatial contiguous division is possible by using the

3 components deduced out of 8 variables and the geographical coordinates weighted by multiplying them with 10^2.

Target group clusters

The second study conducted focused on target groups in which the location of a dwelling was not used as a validation criterion upfront. To come up with a target group division for the district different amounts of clusters were generated as output. The cluster analysis where 6 distinct clusters were found was evaluated and an interpretation was formulated. Three levels of saving potential were split into two categories of household size, i.e. large and small. The insight that 6 target groups do characterize the district can be of use in the marketing campaign for BvB/e. 4 of the 6 clusters represent saving potential and a division into large and small households is made.

It does not come as a surprise that the output of the cluster analysis where target groups are distinguished seems to act upon the first two components characterizing the data set. Because the target groups are not spatially contiguous the homogeneity is much higher than the a priori division in 5 clusters.

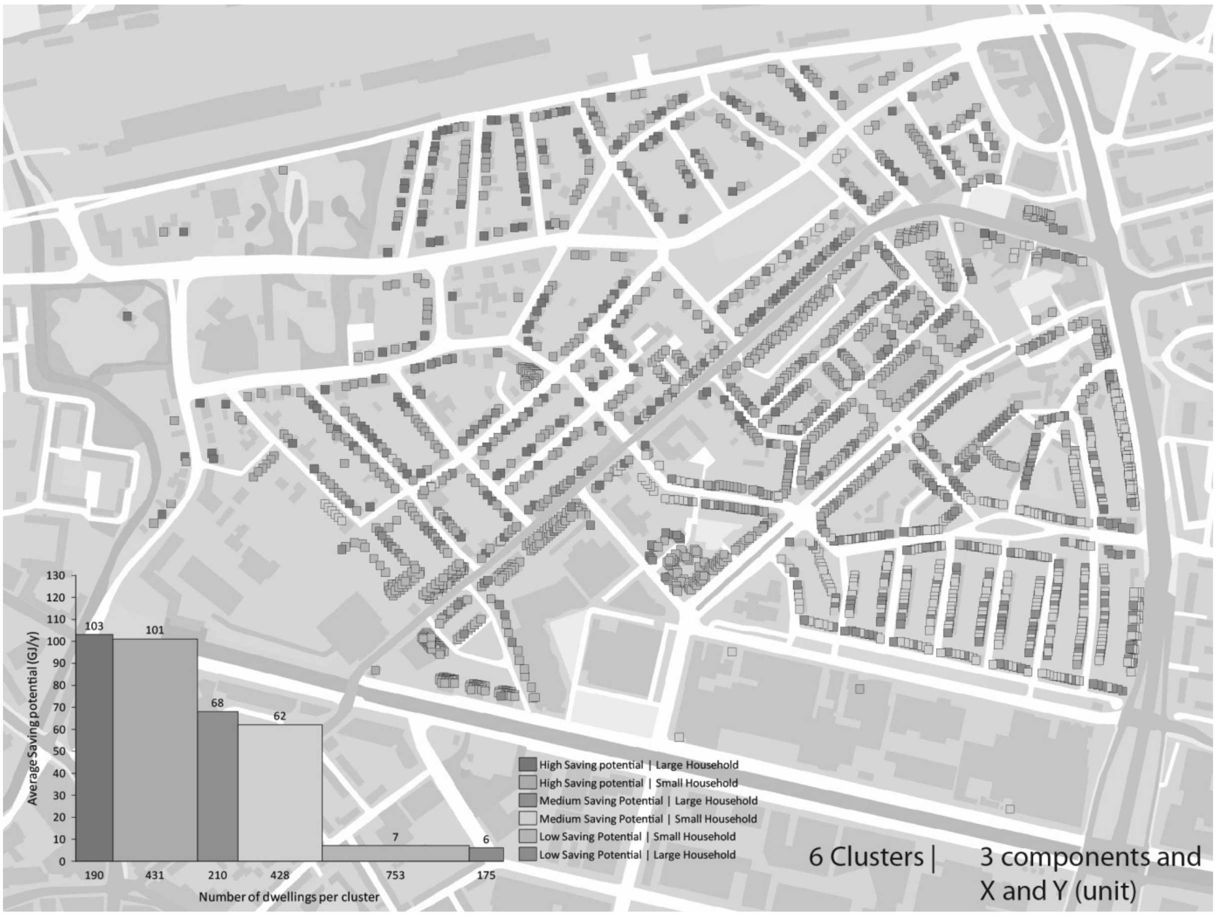

Figure 4: Visualisation of "De Laak" divided into 6 target group clusters

CONCLUSION AND DISCUSSION

In the conclusion and discussion section the implications of this study for the research on energy performance in housing submarkets and the usability of target group clustering for the energy effective renovation program for private homeowners are discussed. KENWIB is in the early stages of exploring the field of cluster analysis for use in energy related submarket research. In this section the research questions are answered.

Conclusion

Available factors and variables

With the problem statement and research design in mind the goals of this study are evaluated and conclusions are formulated. It is important to realize that the data used for cluster analysis determines the quality of the output. Therefore it is investigated which variables or factors of all dwellings and households in Eindhoven are available for analysis.

For this study the Standard Year Usage (SYU) for gas and electricity of a connection in a dwelling were used. Those figures are statistically compared with the figures used in the research of Brouwers et al. (2010). The current SYU's (figures of the last quarter of 2011) are available and they should represent the current electricity and gas use of a dwelling as accurately as possible. The introduction of smart meters in all dwellings will introduce a new interesting variable in dwelling related energy usage studies.

In the registers of the municipality a lot of information is availabe concerning the composition of the household and the age of the occupants, this information is deduced from the GBA. In the WOZ-database of the municipality the typology and year of constuction of each dwelling are stated. The information on variables describing the size of a dwelling, like surface or volume is not availabe for all dwellings. This is a real setback because the volume of surface combined with the known year of constuction and gas usage forms a reliable measure for energy performance of a dwelling.

Now the energy performance of a dwelling, and therefore the saving potential is determined based on dwelling typology and year of construction using the example dwellings of Agentschap NL. This method is presumed to be less accurate than using empirical data representing actual energy performance for analysis.

Decisions for participation

The goal to explore decisions for participation was not achieved to full satisfaction. Which variables or factors influence the decision for participation of private homeowners cannot be concluded based on this research. Of course the 8 variables used, characterize the dwelling and their occupants but it is not tested whether these variables determine the decision for participation in the EE-renovation program.

Interpretation of extracted components out of the data set

In the principal component analysis three components are extracted. These three components account for 78% of the variance in the data set used for this district. These components are interpreted as 1) dwelling saving potential, 2) household characteristics and 3) "wealth comes with age".

Discussion

Limitations

The source of the data of the different variables which are available really determines the quality and possibility to come up with a new target group division for neighborhoods. Most of the variables included consist of empirical data, i.e. data collected by (semi) direct observations. Only one variable cannot be described as empirical, this is the saving potential of a dwelling. To assess the saving potential of a dwelling the typology and building period are used. The adopted value is therefore an average value to sort identical dwellings build in a specific period of time. It was attempted to come up with a more empirical measure for potential energy savings. But actual figures for all dwellings, e.g. the energy label, or volume or surface are not available.

Because the data collection for this experiment was a time consuming process, only one district is analyzed up until now. Even though the results are promising, no guarantees can be given that this approach will work for all other districts in Eindhoven. The conclusion that the maximum of 6 target group clusters will be enough to characterize all districts in Eindhoven should be seen as a hypothesis and should therefore be tested in further research.

Not all demographic data available is used for analysis. Culture and ethnicity are not included as factors. Real research on buying behavior and sensitivity for marketing approaches is not included in the study, so the deduced target groups are only a further exploration of districts and characterize them regarding saving potential and household size. The communication agency could use this to adapt their strategy on district level.

Recommendations

Due to time constraints and the necessary practical output that had to be obtained, some research steps were executed rapidly. It is advisable to rerun the analysis with another measure for saving potential or at least leave it out of the analysis for once to see how clusters are formed then. It is known this does undermine the results. However it would be disputable to take the results of this study as a proof that the used factors are optimal. This may not be concluded before more experience is gained by actual using PCA and CA to divide object into target groups. As said this can be done analyzing different combinations of variables of the same district.

Another recommendation is that an even stronger belief in and further validation of the method can be gained by executing it on several other districts in Eindhoven. All districts have another division of dwelling typologies and construction periods. This will lead to further insights on the usability of housing submarket research for target group clustering. It is expected that conducting the study on other districts will take one-tenth of the time needed than when it was done for the first time. The hypothesis is that all districts can be divided into at most 6 target group clusters.

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After finishing a broad bachelor ABP, with extensive extracurricular activities at the student boat club with the associated development of social and management skills, he started his master CME at the TU/e. In his graduation thesis on the topic of target group clustering for energy effective renovation many stakeholders participated believing in his enthusiastic and inspiring attitude. Basically on his own he managed to set project boundaries and implemented research methods such as cluster analysis for implementation on housing submarket and marketing research.

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ENERGY CONTROL IN THE DWELLING MARKET

A case-study on energy consumption and generation in the dwelling market of Eindhoven

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ABSTRACT
This research consists of two different case-studies. The first case-study investigates the effects of a maximal improvement of the dwelling bounded energy label, and the second case-study investigates the effects of the implementation of PV systems on the complete suitable roof area of the dwelling stock of Eindhoven.

Keywords: Energy Efficient Renovation, Case study, Housing Submarkets, Marketing

This research consists of two different case-studies. The first case-study investigates the effects of a maximal improvement of the dwelling bounded energy label, and the second case-study investigates the effects of the implementation of PV systems on the complete suitable roof area of the dwelling stock of Eindhoven. Both case-studies are stand-alone investigations, with the similarity that both studies explore the improvements of dwellings.
Both case-studies can be put together in one conceptual model (Figure 3). The conceptual model consists of four different phases:

- The target area phase: This phase is for both case-studies the same and represents the starting point of the case-studies. The complete housing stock of Eindhoven is converted into standardized dwellings. The standardization process is performed for each individual dwelling and is based on the construction period of the dwelling and the type of dwelling. Consequently average numbers of the standardized dwelling are used in the next phase (e.g. gas and electricity consumption, roof area, etc.)
- The contextual orientation phase: This phase is unique for each case-study and it calculates the total energetic savings and investment costs of the different interventions. The two improvement packages together represent the dwelling bounded energy label improvements and are calculated by the first case-study, the PV system implementation intervention is calculated by the second case-study. The phase ends with the potential energetic savings and corresponding investment costs on a city level.
- Simulation phase: This phase of for both case-studies the same. The simulation phase simulates two situations and compares both situations with each other. The first situation consists of different scenarios of intervention strategies, and the second

situation consists of a benchmark, which represents an unchanging current situation. Both situations are simulated during a simulation period of 34 year, starting in 2011 and ending in 2045.

- Conclusion phase: The conclusion phase discusses the different findings of the case-studies and tries to find answers on the different research questions.

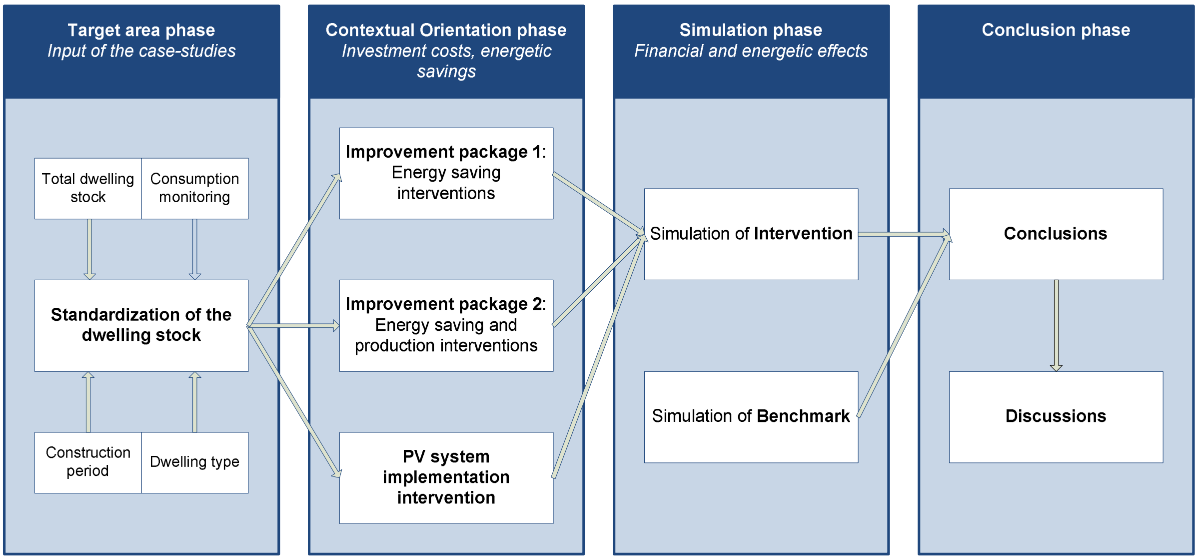

Figure 3: Conceptual model of the study

<u>Case-study on dwelling bounded energy labels</u>

The case-study on dwelling bounded energy labels consists of two parts. The first part calculates the energetic effects of two improvement packages on the current dwelling stock and it calculates the corresponding investment costs of these improvements. The second part simulates the effects of the first part during a simulation period, starting in 2011 and ending in 2045, and compares the result with a benchmark. Both parts will be calculated using the simulation tool MS Excel. All calculations of the first part will be executed according to the calculation tool of AgentschapNL.

The goal of the case-study on dwelling bounded energy labels is to study the energetic and financial effects of a maximal improvement of all the dwelling bounded energy labels within the city boundaries of Eindhoven. The case-study therefore seeks an answer to the next research questions:

RQ1: What are, theoretical, the potential annual energetic savings in case all the dwelling within the city boundaries of Eindhoven were improved to a maximal energy label?

RQ2: What are, theoretical, the potential annual financial savings in case all the dwelling within the city boundaries of Eindhoven were improved to a maximal energy label?

RQ3: Is the investment financial feasible, and if so, under what conditions?

The first case-study investigates the total possible energetic improvements of the dwelling stock of Eindhoven as a result of a maximal improvement of the dwelling bounded energy labels. It uses a calculation model of AgentschapNL which is based on example dwellings and it uses a simulation tool which is designed in MS Excel. The AgentschapNL method is called ‘voorbeeldwoningen 2011, bestaande bouw’.

The first step of the case-study investigated the total effects of two improvement packages on the total dwellings stock of Eindhoven. The first package describes an implementation of isolation and installation improvement, the second package describes an implementation of all improvements of the first improvement package and above that the implementation of a small roof-mounted PV system and a small solar boiler. The isolation of all dwellings was optimized to an Rc value of 2,53m^2K/W and all installations were optimized by replacing heating systems and water heating systems by a HR 107 combination boiler. The small roof-mounted PV system consists, for single-family dwellings, of a 15 square meter module system and for multi-family dwellings of a 10 square meter module system. The solar boiler consists, for single-family dwellings, of a 2,7 square meter system and for multi-family dwellings of a 2,0 square meter system.

As stated before, all calculations were done with example dwellings. The calculation tool and the example dwellings were designed by AgentschapNL. All the example dwellings were selected on type and construction period and were assessed on equality of physical and energetic consumption properties. The tool presents average gas consumption of all example dwellings and electricity consumption of the installations of all example dwellings. A dataset by ENDINET and by the municipality of Eindhoven made it possible to implement Eindhoven as target area. All dwellings were fitted on the calculation tool of AgentschapNL which in turn made it possible to calculate the effects of both improvement packages on the total dwellings stock on Eindhoven.

Unfortunately the average gas consumption per example dwelling presented by the tool (in case of its current state) did not perfectly match the average actual gas consumption per example dwelling presented by ENDINET. As a result the first step of the case-study described two possible applications of the tool. The first application applied the total housing stock of Eindhoven and calculated all energetic improvements of both improvement packages with the average gas consumption (per example dwelling) of the tool. The second application applied the total housing stock of Eindhoven and calculated all energetic improvements of both improvement packages with the actual gas consumption (of ENDINET) and calculated the improvements in terms of percentage of the first improvement.

Despite the application of the tool (the effects are not visible in absolute numbers) implementation of the first improvement package on the target area results in a reduction of the total gas consumption of 52,18% and an increase of the total electricity consumption of 0,23%. Furthermore, the implementation of the first improvement package requires a total investment of €877.774.326,-, which is about €8.952,- per dwelling. In case the second improvement package was implemented on the target area the total gas consumption could even be further reduced to total reduction of 60,17% and the electricity consumption could be reduced by a total reduction of 7,49%. The second improvement package requires a total investment of €1.892.255.123,-, which is about €19.297,- per dwelling.

In case of an application of the tool with absolute numbers (which is based on current state consumption numbers presented by the tool) the gas consumption could be reduced from a total consumption of 197.692.101 m^3 to a total consumption of 94.540.329 m^3 as an effect of the first improvement package, and it could be reduced to a total consumption of 78.731.427 m^3 as an effect of the second improvement package. In case of an application of the tool with relative numbers (which is based on the actual gas consumption presented by

ENDINET and calculates with the relative effects of the application with absolute numbers) the gas consumption could be reduced from a total consumption of 145.746.347 m^3 to a total consumption of 69.698.827 m^3 as an effect of the first improvement package, and it could be reduced to a total consumption of 58.043.886 m^3 as an effect of the second improvement package.

The second part calculated the financial effects of the intervention measures (calculated in the first step) during a simulation period of 34 year and compared the results with a benchmark. All calculations were performed with the simulation tool MS Excel and were performed on the same example dwellings as were used in step 1.

Unfortunately the tool did not fit perfectly on the target area, and therefore the tool calculated, for each improvement package, two different scenarios. The first scenario executed its calculations with, 'the current state' of the tool as the starting point, the second scenario executed its calculation with the relative effects of the first scenario and used as starting point the actual average gas consumption of ENDINET. Combining the two different starting points with the two different improvement packages leads to 4 scenarios.

The first two scenarios calculated the effects of the improvement packages on energetic consumption numbers of the tool, which were based on average numbers of the Netherlands. The advantage of using these numbers is that the financial and energetic calculations are correct, meaning that the investment costs correspond with the energetic improvements. The disadvantage of using these numbers is that the numbers do not (completely) fit the application of the target area, because the actual average consumption of the target area is much lower than the average consumption of the tool. In case the (absolute) savings of the improvement packages were applied on the actual average consumption (based on ENDINET), in certain cases, the new consumption (in case the improvement packages were installed) would turn up to be negative, which of course is not possible. A possible solution to fix the problem is to work with relative savings. In this case the energetic savings, in terms of percentage, of the calculations based on numbers of the calculation tool were applied on actual energy consumption of the target area. The advantage of using these relative improvements is that they fit better on the target area, meaning that the energetic effects can be measures more precisely. The disadvantage is that the relative costs are higher, because both methods use the same investment costs, except the energetic savings, in case the relative improvements were applied on actual numbers, are smaller.

Applying all four scenarios in the two different parts of the case-study leads to the following results:
Scenario 1: This scenario describes a 100% percent implementation of the first improvement package in 2010, with as starting point of the calculations the 'current state' average energy consumption of the tool, and with absolute improvement calculations. Implementation of the first scenario leads to major advantages. This means that in case energy demand and energy price develops according to historical date and an interest rate of 3,34% is used, no additional monthly payments are required on top of the benchmark situation and the total investments are repaid during the simulation period. The implementation of the first improvement package leads to a reduction of 52,14% of the total gas demand and a minor

increase of the electricity demand of 0,23%, furthermore the implementation leads to an average cost reduction of €48,- per month during the simulation period. The implementation of the first scenario leads, compared with the benchmark, during the simulation period to a total profit of about 1.9 billion euro.

Scenario 2: This scenario describes a 100% implementation of the second improvement package in 2010, with as starting point of the calculations, the 'current state' average energy consumption of the tool, and with absolute improvement calculations. Implementation of the second scenario leads, as the first scenario, to advantages, only on a different level. Energetically spoken the results exceed the results of the first case-scenario, since gas consumption is reduced with an extra 10% and electricity consumption is reduced with almost 40%. However financially spoken the extra savings come with a price. Although the second scenario shows that during the simulation period the intervention shows a better financial result than the benchmark, the second scenario achieves only half of the monthly savings the first scenario achieved. But still this means that in case energy demand and energy price develops according to historical data, and an interest rate of 3,34% is used, no additional monthly payments are required on top of the benchmark situation. Furthermore the total investments are repaid during the simulation period, which makes the second scenario also financially healthy.

Scenario 3: This scenario describes a 100% implementation of the first improvement package in 2010, with as starting point of the calculations, the actual average energy consumption of ENDINET, and with relative improvement calculations. The implementation of the first improvement package, under these conditions, also leads to a financial healthy situation. This means that in case energy demand and energy price develops according to historical data and an interest rate of 3,34% is used, no additional monthly payments are required on top of the benchmark situation and the investment costs are repaid during the simulation period. The implementation of the third scenario leads, relatively, to the same reduction of the total gas demand (52,14%) and the same minor increase of the electricity demand (0,23%) as scenario 1. However because scenario 3 has to deal with similar investment costs as scenario 1, but with less absolute energetic improvements, the implementation leads to a negligible average cost reduction of only €1,- per month during the simulation period. Therefore, financially spoken, the benchmark has the same performance as the intervention. However, energetically spoken, the intervention performs better than the benchmark.

Scenario 4: This scenario describes a 100% implementation of the second improvement package in 2010, with as starting point of the calculations, the actual average energy consumption of ENDINET, and with relative improvement calculations. The implementation of the second improvement package, under these conditions, leads to a financial unhealthy situation. This means that in case energy demand and energy price develops according to historical data and an interest rate of 3,34% is used, additional monthly payments are required on top of the benchmark situation, otherwise it is not possible to repay the investment costs during the simulation period. Only an extra monthly repayment of €22,50 per dwelling leads to financial healthy situation, meaning that at the end of the simulation period the investment costs are repaid and financially the intervention has equally total costs as the benchmark. The implementation of the fourth scenario leads, relatively, to the same reduction of the total gas demand (60,17%) and the same reduction of the total electricity *demand (37%) as scenario 2. However because scenario 4 has to deal with similar investment costs as scenario 2, but with less absolute energetic improvements, the intervention leads, during the simulation period, in case of no extra repayments to equally average cost per month as the benchmark and to a total long-term loan which is bigger than the initially investment costs. In case of an extra monthly repayment of €22,50 per dwelling , during the simulation period, the average monthly costs of the intervention is equal to the average monthly costs of the benchmark. The extra monthly repayment leads eventually, at the end of the simulation period, to equally total costs between the intervention and the benchmark and it leads to a fully repayment of the investment costs.*

As was discussed before, the total monthly costs depend, for the main part, on the applied interest rate. The starting point of the study was to investigate the macro-economic effects of improving the current dwelling stock of Eindhoven. In case this improvement would be handled centrally, for instance by the city, province or government, the total investment would be much higher and as a consequence the applied interest rate would be lower. In that case an interest rate comparable of an interest rate the government has to pay over national depth could be applied, which is, at the moment, about 3,34%. However, in case a centrally policy turns out to be infeasible, the only alternative is a decentralized policy. In this case the total investment per improvement would be much lower, since all dwelling owners are responsible for their own improvements, and as a consequence the interest rate would be much higher. In that case probably an interest rate of about 8 percent would be applied, which results in higher monthly costs of the benchmark than of the intervention, which makes it impossible to repay the investment costs. And as a consequence the long-term loan will grow exponentially because of the interest rate.

This means that the interest rate determines for an important part the successfulness of the investment. In case it's too high the costs will grow exponentially, in case it's too low, the costs will be repaid easily. It is therefore also possible to determine the breakpoint of the interest rate. The breakpoint can be defined as the interest rate that results, at the end of the simulation period, in equally costs between the benchmark and the intervention and is calculated with no additional monthly repayment fee. In case of scenario 1, the breakpoint interest rate is 4,65%, in case of scenario 2, it is 3,55%, in case of scenario 3, it is 3,35%, and, finally, in case of scenario 4, it is 2,8%.

Case-study on PV

The second case-study elaborates the results of a case-study on photovoltaic (PV) systems in the dwelling market of Eindhoven. In total eight different scenarios are simulated. The scenarios differed from each other in penetration time of the market, efficiency development of the PV system and price development of the PV system. The simulation is executed in MS Excel with a time interval of one year starting in the year 2011 and ending in the year 2045.

The case study only discussed on-grid systems and thus excluded stand-alone systems. A PV system which is connected to the local electricity network is referred to as being 'on-grid'. Any excess power that is generated can be fed back into the electricity grid. Under a FiT regime, the owner of the PV system is paid according the law for the power generated by the local electricity provider.

The case study ignored the effects and investments necessary for high penetration of PV in the grids. A recent case-study (European Distributed Energy Partnership, 2011) has evaluated how much PV can be integrated into the distribution network without causing network failures. The study found that Germany, which by end of 2010 had more than 16000 MW of PV electricity integrated into its network, is still a long way from exceeding grid limitations. The study recommends that PV could account for up to 20% of supply without affecting the grid, under some technical developments.

Different technologies have different appearances and therefore different aesthetic values. Since taste is very personal and the differences between the systems are only small, the aesthetic values of different systems is excluded in this study

The goal of the PV case-study is to study the opportunities of PV systems for the existing dwelling market in Eindhoven. The study attempted to find an answer on the following research questions:

RQ1: What are the most important energetic and financial variables as it comes to a large-scale implementation of PV systems in Eindhoven?

RQ2: Which scenarios can be distinguished and what are the effects of the scenarios?

RQ3: What will be the total financial and energetic effects in case the technology will be large-scale implemented in the city?

In total eight different scenarios are elaborated and simulated. Each scenario is assessed on financial and energetic results and is compared with a benchmark. The benchmark is a future situation in which no PV system will be installed (in other words with a continuing of the current situation). The scenarios are chosen by the manipulation of three variables, namely time of installation, PV system cost development and the efficiency development:

- *Time of installation*; the ultimate goal is a 100% market penetration of small roof-mounted PV systems in the dwelling market in the year 2040. This means that by 2040 all the available and suitable roof area will be used to generate electricity. There are, however, two different scenarios to pull this off. The first scenario simulates a 100% PV system installation in 2011 and the second scenario has a wider spread and simulates an equal distribution of the PV system installation, with an installation of 14.29% every five years. Although the first scenario might not seem achievable it is very interesting to compare it with the second scenario in order to investigate the financial and energetic effects of a situation in which the market is penetrated in an early stadium versus a situation in which the total market it penetrated in a later stadium.
- *PV system cost development*; there are two different basic scenarios that will be simulated as it comes to the development of the PV system costs, namely: The Paradigm Shift Scenario and the Accelerated Scenario. The scenarios differ in political support. In case of the Paradigm Shift Scenario the implementation of PV gets more political support and as a results the total PV costs decrease must faster in time.
- *PV system efficiency development*; three different scenarios will be presented as it comes to the future development of the efficiency of the PV systems, namely: The pessimistic scenario with a current efficiency of 140 Wp/m^2 and a future efficiency of 200 Wp/m^2 in

2040, an expected scenario with a current efficiency of 140 Wp/m^2 and a future efficiency of 250 Wp/m^2, and finally an optimistic Scenario with a current efficiency of 140 Wp/m^2 and a future efficiency of 400 Wp/m^2.

Although the case study dealt with eight different case-study scenarios, the existences of most of these scenarios depend on time rather than choice. Only time can tell how direct variables like module efficiency and PV system cost, and indirect variables like conventional electricity prices, the globally installed capacity of PV systems, and the interest costs of investments, will develop. The only variable one can manipulate as it comes to implementation is the decision and the moment to invest in PV systems. Therefore one can argue that the case-study only simulated two different scenarios, all the other scenarios are alternatives of these two basic variables and have as main purpose to develop a range of possible energetic and financial effects of these concerning 'basic' scenarios. For this reason this summary will only focus on the two basic scenarios.

Additional also the status of the long-term loan at the end of the simulation period is included. The first basic scenario simulates a direct 100% installed capacity of the complete suitable roof area of all dwellings in Eindhoven. This basic scenario is only simulated with the expected system efficiency development, it is simulated with two different system costs development scenarios (accelerated and Paradigm shift scenario) and it is simulated with three different interest scenario rates (0%, 3,34% and 8%). This leads to a financial performance, an energetic performance and a status of the long-term loan:

- ***Financial performance*** is the difference between the cumulative costs in case of the benchmark and the cumulative costs in case PV was installed according to the scenario and measured in the year 2045 (according to cumulative costs during the period between 2011 and 2045).
- ***Energetic performance*** is the difference between the total cumulative electricity demand of all dwellings and the total cumulative electricity generated by means of the installed PV systems according to the scenario (measured in the period between 2011 and 2045).
- ***Unpaid balance long-term loan*** is the status of the long-term loan at the end of the simulation period. A positive amount represents an unpaid amount meaning that the investment is not yet repaid.

Table 3: Total performance of basic scenario 1

System cost development	System efficiency development	Interest rates	Financial performance	Energetic performance	Unpaid balance long-term loan
Accelerated	Expected	0%	€3.213.172.922,-	-1.673.188.042 kWh	€0,-
Accelerated	Expected	3,34%	€387.044.126,-	-1.673.188.042 kWh	€0,-
Accelerated	Expected	8%	€-16.052.682.411 ,-	-1.673.188.042 kWh	€24.490.531.772,-
Paradigm Shift	Expected	0%	€3.339838.243 ,-	-1.673.188.042 kWh	€0,-
Paradigm Shift	Expected	3,34%	€576.084.711,-	-1.673.188.042 kWh	€0,-
Paradigm Shift	Expected	8%	€-15.988.320.139,-	-1.673.188.042 kWh	€24.193.121.683,-

Table 3 shows the interest rate is, as it comes to the financial performances, the most important variable. The applied interest rate depends in most cases on the organizational form of the implementation. In case the total implementation of PV takes place individually and all the different dwelling owners are themselves responsible for the investment of the PV systems, probably a high interest rate would be applied and the total financial performance would be enormous negative. The enormous negative result is a consequence of the fact that due to the high annual interest fee of the enormous investment the initial annual costs are higher, than the initial annual costs in case no PV systems were installed. Therefore in this situation no repayment of the investment costs is possible and as a result the long-term loan increases exponential as a result of the high interest rate. The total electricity costs in case of the benchmark during the period is about 6,5 billion euro. The total costs in case PV systems are installed according to the scenario and in case of an interest rate of 8% are about 22.6 billion euro. Almost 21.9 billion euro of the 22.6 billion euro exists of interest costs, and only about 0,7 billion euro exists of electricity costs in case not enough electricity could be generated by the PV modules. Furthermore at the end of the simulation period the long-term loan accounts for almost 24.5 billion euro. For this reason a decentralist organization form scenario with a corresponding interest rate of 8% is not viable.

A better scenario would be a central organized implementation plan of all PV systems. Not only does this implementation method ensure a lot of financial benefits as a result of economies of scale, it also ensures the total investment would probably have to deal with a much lower interest rate. As a comparison the government has to pay about 3,34 % interest over its public debt. In case this 3,34% would be applied on the total investment that has to be made to install all the PV systems according to the first scenario. The financial performance would be a lot better than the situation with an interest rate of 8%. Depending on the system cost development the financial performance would be in the range between 387 million euro and 576 million euro.

The financial performances of the first basic scenario (in case of an interest rate of 3,34 percent) can also be expressed in monthly costs per dwelling. In case of the benchmark, the average electricity costs per dwelling will be €72,- per month in 2011. Due to the increase electricity demand and the increase electricity price the average electricity costs per dwellings increases to €261,- per month in 2045. During the simulation period the average electricity costs per month and per dwelling will be €159,- In case PV systems were installed according to the first basic scenario the monthly average electricity costs during the simulation period will be €150,- in case of the accelerated scenario and €145,- in case of the paradigm shift scenario. This results in an average monthly electricity cost reduction of €9,- to €14,- euro per dwelling.

Since for the system efficiency only the expected scenario is simulated, the energetic effects are the same, irrespective of the different financial scenarios. So in case the complete suitable roof area was provided with PV systems in 2011, in total about 340 million kWh electricity is generated while only about 317 million kWh electricity is demanded. This means that in potential, roof and dwelling mounted PV systems, can provide enough energy to meet its own demand. However, because of the minor yearly power loss of the systems and next to that, a yearly increasing electricity demand, this is only a small period the case (only the first three years). After that demand exceeds production. In case, the total amount of generated electricity is compared with the cumulative electricity demand (during the simulation period), than in total there is deficit of almost 1.7 billion kWh electricity. That is about 12 percent of the total demand during the period, meaning that during the simulation period 88% of the total electricity demand was generated with PV systems.

All in all the first basic scenario is, in case of an interest rate of 3,34% and in case of the expected PV system efficiency development, feasible. During the simulation period of 34 years an average minor reduction of €9,- to €14,- per month per dwelling could be achieved and in total about 88% of the total electricity demand could be generated by dwelling and roof mounted PV systems. Furthermore it is at the moment theoretical possible to generate enough electricity to cover the complete demand of the housing market of Eindhoven. However due to the increase in demand and the decrease in electricity generation (due to the efficiency loss of the system), this is only in short term possible.

The second basic scenario simulates a gradually implementation over time. One can argue that a 100% implementation of PV system, even in the range of the upcoming couple of years, is simply not possible. Therefore an alternative, perhaps easier to achieve, scenario is simulated as well. This second basic scenario simulated a situation in which every five year another portion of the total available and suitable roof area is provided with PV systems. Meaning that every five year about 14,29% of these roofs will be implemented with PV systems. Like the first basic scenario, the most important variables were simulated with different values, leaving a range of possible financial and energetic effects. The second basic scenario is simulated with two different system cost development scenarios (the accelerated scenario and the paradigm scenario), with three system efficiency developments (the pessimistic scenario, the expected scenario and the optimistic scenario) and with three different interest rates (0%, 3,34% and 8%).

Table 4: Total performance of basic scenario 2

System cost development	System efficiency development	Interest rates	Financial performance (EURO)	Energetic performance (kWh)	Unpaid balance Long-term loan
Accelerated	Pessimistic	0%	€2.828.856.397,-	-6.518.586.411 kWh	€0,-
Accelerated	Pessimistic	3,34%	€2.394.149.960,-	-6.518.586.411 kWh	€0,-
Accelerated	Pessimistic	8%	€-2.116.548.783,-	-6.518.586.411 kWh	€6.914.116.866,-
Paradigm Shift	Pessimistic	0%	€2.948.279.709,-	-6.518.586.411 kWh	€0,-
Paradigm Shift	Pessimistic	3,34%	€2.577.645.331,-	-6.518.586.411 kWh	€0,-
Paradigm Shift	Pessimistic	8%	€-1.667.636.403,-	-6.518.586.411 kWh	€6.344.738.730,-
Accelerated	Expected	0%	€3.021.641.778,-	-6.083.737.646 kWh	€0,-
Accelerated	Expected	3,34%	€2.581.585.187,-	-6.083.737.646 kWh	€0,-
Accelerated	Expected	8%	€-1.931.387.744,-	-6.083.737.646 kWh	€7.059.358.599,-
Paradigm Shift	Expected	0%	€3.151.079.856,-	-6.083.737.646 kWh	€0,-
Paradigm Shift	Expected	3,34%	€2.776.060.561,-	-6.083.737.646 kWh	€0,-
Paradigm Shift	Expected	8%	€-1.470.710.358,-	-6.083.737.646 kWh	€6.467.570.391,-
Accelerated	Optimistic	0%	€4.175.148.204,-	-3.371.694.280 kWh	€0,-
Accelerated	Optimistic	3,34%	€3.686.128.536,-	-3.371.694.280 kWh	€0,-
Accelerated	Optimistic	8%	€-1.372.435.850,-	-3.371.694.280 kWh	€8.369.301.606,-
Paradigm Shift	Optimistic	0%	€4.360.650.685,-	-3.371.694.280 kWh	€0,-
Paradigm Shift	Optimistic	3,34%	€3.950.715.185,-	-3.371.694.280 kWh	€0,-
Paradigm Shift	Optimistic	8%	€-735.307.012,-	-3.371.694.280 kWh	€7.496.643.637,-

Again the interest rate is the most important variable as it comes to the total financial effects and as it comes to the status of the long-term loan. Although the financial implications are less than for the first basic scenario, a high interest rate still has an enormous negative financial effect and an exponential increase of the long-term loan. Depending on the system cost development and the system efficiency development, the financial performance in case an interest rate of eight percent is used will be between -0,7 billion euro and -2,1 billion euro and the unpaid balance of the long-term loan will be between 8.4 billion euro and the 6.3 billion euro. So also in this case, a high interest rate must be avoided as much as possible. Therefore this scenario only has a chance of success in case of a central organized implementation of the scenario or another organization form which guarantees a low interest rate.

In case of a gradually implementation of the PV systems and the application of a low interest rate, the financial performance looks promising. Still the financial effects depend for an important part on the system costs development and the system efficiency development. But independently of these developments, and in case an interest rate of 3,34% would be applied, the financial performance would be somewhere between the €2.4 billion euro and the 4.0 billion euro.

The financial performances of the second basic scenario (in case of an interest rate of 3,34%) can also be expressed in monthly costs per dwelling. In case of the benchmark, the average electricity costs per dwelling will be €72,- per month in 2011. Due to the increase electricity demand and the increase electricity price the average electricity costs per dwellings increases to €261,- per month in 2045. During the simulation period the average electricity costs per month and per dwelling will be €159,- In case PV systems were installed according to the first basic scenario the monthly average electricity costs during the simulation period will be, depending on the system cost and system efficiency development, somewhere between €63,- and €101,-. This results in an average monthly electricity cost reduction of €58,- to €96,- euro per dwelling, which is a monthly average reduction of 52% of the total electricity costs.

In case the changeable variables of the case-study develop according to the most expected scenario, meaning that the system cost develops according to the accelerated scenario, which implicates a continuation of the current globally political support, the system efficiency develops according to the expected scenario, which implicates systems efficiency from 140 Wp in 2011 to 250 Wp in 2040, and an interest rate of 3.34% would be applied, the model simulates a financial performance of about 2,581 billion euro. This means that in case PV systems were gradually installed (according to the second basic scenario) according to the most expected scenario, an average monthly reduction of 65,11% could be achieved (compared with a situation in which conventional energy demand continued and no PV systems were installed).

The energetic effects of the different scenarios only depend on the systems efficiency development. The differences are quite large. In case the efficiency develops according to the pessimistic scenario and all suitable dwelling roofs were gradually provided with PV systems, in total about 7.3 billion kWh electricity could be generated. In case of an expected efficiency development about 7.7 billion kWh electricity could be generated and in case of an optimistic efficiency development about 10.4 billion kWh could be generated. During the simulation period the total electricity demand (in case of a linear growth of the current and historical demand) will probably be about 13.8 billion kWh. This means that a gradually implementation strategy has as result that during the simulation period in case of a pessimistic efficiency development about 52,72% of the total electricity demand is generated with PV systems, in case of an expected efficiency development about 55,87% of the total electricity demand is generated with PV systems and in case of the optimistic efficiency development about 75,54% of the total electricity demand is generated with PV.
Gradually implementing PV systems also has as effect that during the simulation period at best at the end of the period electricity generation meets electricity demand. In case of the pessimistic efficiency development, this is not the case, and electricity generation will never meet electricity demand. In case of the expected scenario only during the year 2041 enough electricity is generated to meet demand. But due to decreasing system power and increasing electricity demand, this is only for one year the case. In case of the optimistic scenario electricity generation will largely meet energy demand from 2036 on.

All in all the second basic scenario is, in case of an interest rate of 3,34% and irrespective of the systems cost and efficiency development, like the first basic scenario, feasible. During the simulation period of 34 years a monthly average reduction of €58,- to €96,- euro per dwelling could be achieved and in total, depending on the efficiency development 52,72% to 75,54% of the total demand could be generated by PV systems.

As already concluded the average interest rate is, as it comes to the financial performance and the status of the long-term loan, the key variable. Where, for both the basic scenarios, an interest rate of 3,34% leads to a positive financial performance, an interest rate of 8 % leads to an extreme negative financial performance. This means that a breakpoint exists between both scenarios. This breakpoint depends on the costs and efficiency development and is therefore unique for each scenario. It is interesting to determine the breakpoint, because it determines the border between a financial healthy investment and a financial unhealthy investment. Table 5 presents, for each scenario, the interest breakpoints.

- ***Interest breakpoint*** is the minimum interest rate in which it is possible to repay the long-term loan. In other words; it is the minimum interest rate in which it is possible to decreases the long-term loan in absolute way, during the simulation period.

Table 5: Interest breakpoints of the eight different PV scenarios

Cost developm.	Efficiency developm.	Basic Scenario	Breakpoint interest rate	Cost developm.	Efficiency developm.	Basic Scenario	Breakpoint interest rate
Accelatered	Expected	1	4,1%	Paradigm	Expected	1	4,1%
Accelatered	Expected	2	6,2%	Paradigm	Expected	2	6,6%
Accelatered	Pessimistic	2	6,1%	Paradigm	Pessimistic	2	6,5%
Accelatered	Optimistic	2	6,7%	Paradigm	Optimistic	2	7,1%

Now both basic scenarios are elaborated and discussed, it is interesting to know what the main differences are between both scenarios. Although the scenarios are, in a way, very explicit, the conclusions between the differences can be placed in a larger perspective. In this perspective the first scenario disputes a situation in which as soon as possible PV systems are at large scale implemented and the second scenario disputes a situation in which implementation is more spread over the simulation period. Both situations are only compared with a situation that simulates the most expected variable development. This means that the system cost development follows the accelerated scenario, the PV system efficiency development follows the expected scenario and all financial calculations are calculated with an interest rate of 3.34%. All calculations are collected in Table 6.

Table 6: Differences between basic scenario 1 and basic scenario 2

Variable	Basic scenario 1	Basic scenario 2
General properties		
PV system implementation	Direct 100% implementation in 2011; system replacement in 2040	Gradually implementation of 14,29% in 2011, 2015, 2020, 2025, 2030, 2035, 2040; system replacement of 2011 in 2040
PV system cost development	Accelerated (3,41 €/Wp – 0,83 €/Wp)	Accelerated (3,41 €/Wp – 0,83 €/Wp)
PV system efficiency development	Expected (140 Wp/m^2 – 250 Wp/m^2)	Expected (140 Wp/m^2 – 250 Wp/m^2)
Interest rate over annual costs	3,34%	3,34%
Simulation Period (SP)	2011 – 2045	2011 – 2045
Energetic Results		
Cumulative electricity demand without PV systems	13.786.631.027 kWh	13.786.631.027 kWh
Total electricity generated during SP	12.113.442.985 kWh	7.702.893.381 kWh

Percentage electricity generated of total demand	87,86%	55,87%
Financial results		
Total investment and maintenance costs PV systems during SP	€2.612.338.220,-	€1.056.755.367,-
Total interest costs during SP	€1.413.064.398,-	€220.028.296,-
Total extra electricity costs during SP	€1.213.915.127,-	€2.479.469.940,-
Total electricity revenues during SP	€493.105.289,-	€4.364.448,-
Total repayments during SP with PV	€4.025.402.618,-	€1.269.602.005,-
Total costs during SP with PV	€6.159.276.854,-	€3.964.735.793,-
Total electricity costs during SP without PV	€6.546.574.151,-	€6.546.574.151,-
Financial performance during SP (total)	€387.044.126	€2.581.585.187,-
Financial performance during SP (per month / per dwelling)	€10,-	€64,50

Basically the table shows that is it is not possible to select the best scenario. Both scenarios have their own strengths and weaknesses. It really depends on the goal and on what is thought to be important.

If the main goal is to optimize the total amount of generated electricity than the first basic scenario is better. Implementing this scenario leads to a situation in which about 88% of all future electricity demand, originating from the dwelling market, can be provided with PV electricity. In case an equal implementation spread is chosen only about 56% of all future electricity demand originating from the dwelling market can be provided with PV electricity. This is understandable since the first basic scenario uses all suitable and potential roof area from the beginning of the simulation period and the second scenario only uses half of the suitable and potential roof area, because it takes the whole simulation period to provide the complete suitable roof area. The difference in electricity generation is slightly reduced because of the fact that future systems have an increased efficiency.

If the goal is to optimize the financial results, then the second basic scenario is preferable over the first basic scenario, which in turn is preferable over the benchmark situation. But if one looks at the individual items one could notice the investment costs of the first basic scenario are more than twice as high as the investment costs of the second basic scenario. As a result the interest costs of the first scenario are higher (almost 7 times!!) than those of the second scenario and this in turn leads. In case of basic scenario 1 the repayment costs are almost four times as high as the repayment costs of the second basic scenario. Logically the possible extra electricity costs of the first basic scenario are lower than those of the second basic scenario (about twice as high) and the revenues of electricity that is sold back into the grid is higher in case of implementing the first scenario (almost exceed by a factor of 100). All the different items together causes the second basic scenario to have a financial performance which is about twice as high as the first one.

The results show, regardless of the first or second basic scenario, that it's theoretical possible and financial feasible to invest in PV systems. The financial feasibility however strongly depends on the interest costs. The basic principle must be to reduce the interest costs as much as possible. If the rate exceeds the so-called interest breakpoint, it is financial better to stick with the current situation without PV. One of the ways to reduce the interest rate is to implement PV systems on a large-scale base. In case of individually implementation, the interest costs will probably exceeds the interest breakpoint and as a result the long-term loan will explode, because interest costs over minor investments are much higher than interest costs over major investments.

Furthermore one must accept the fact that the transition process from conventional energy production methods to more sustainable energy production methods takes time and money. In case the interest breakpoint is not a feasible case, the model shows that, despite the rising electricity demand and rising electricity prices it's still cheaper to embrace conventional ways of electricity production. However in case of an interest rate of 3,34% it is, depending on the implementation strategy, theoretical possible to both generate between the 56% and the 88% of the total electricity demand of all dwellings in Eindhoven with PV systems and to make a profit between €10,- and €64,50 per month per dwelling.
Despite the positive outcome of practically all the different scenarios, at the moment, especially in the Netherlands, the implementation of PV systems is restricted to only little and small initiative. It seems that the market as well as the government has some dominating barriers that prevent large scale initiatives of implementation.

Although at the moment research on these barriers is missing, especially the determination of the most important barriers of public authorities is not really that hard. The most important barriers can be found in the type of organization and its possibilities. In case of the municipality currently manpower and knowledge is lacking to organize these kinds of large-scale projects.

The missing manpower and knowledge is mainly an effect of all kinds of cuts. The type of organization questions the necessity from a public agency point of view to implement PV systems. The Western capitalistic countries are characterized by their free markets. It fits the culture of those countries that most pioneering initiatives are market driven. The last couple of decades the influence of governments has only been reduced due to large scale privatization of all kind of organizations and therefore a public interference, does not fit the current Western philosophy anymore.

Furthermore a possible barrier could be the uncertainty of the development of key variables. The case study describes a development of the key variables according to the most expected scenario. For example the study assumes an increase in energy demand and a linear increase of energy prices and the study assumes an absence of any restricted production limits. Most important variables are simulated with different values; however the total future development of the energy market depends on a tremendous amount of variables and as a result it seems almost impossible to be certain about its development. Most of the scenarios that are simulated in this study have a payback period of about 20 years. But, given the uncertainty of the future development, this means that doing these investments leads, irrevocable, to risks. One can imagine that public agencies (or other big agencies) consider these risks as too high. Apparently, at the moment, the disadvantages of the consumption of fossil fuels, does not balance the risks of a large scale PV investment.

Another barrier could be the effect of other sustainable energy techniques in case of a large scale implementation. The case study only assumes the implementation of PV systems. Large scale implementation of other sustainable techniques could lead to a competition between these techniques. This is especially plausible in case the conventional energy prizes increase in an equal way as they did the last couple of decades and the total energy consumption decreases.

Finally an important barrier is the lack of knowledge. Despite the simplicity of calculating the results of the implementation of PV systems, up to now, this information was missing. At the moment most municipalities are searching for ways to get a more sustainable city. They are searching for reliable information in order to find out which technique or techniques to bet on. This study provides that information for PV systems, however there are more techniques which can, and have to, be examined in a similar way.

At the moment one must realize, that from this study's view of point, it seems like the European Union backs the wrong horse. Conventional electricity prices do not reflect actual production costs. The European Union invests more in nuclear energy research (€540 million yearly in average over five years through the EURATOM treaty) than in research for all renewable energy sources, smart grids and energy efficiency measures combined (€335 million yearly in average of seven years through the Seventh framework program). Actually today in Europe fossil fuels and nuclear power are still receiving four times the level of subsidies than all types of renewable energies do (IEA, World Energy Outlook, 2011). If governments reduce the financial aids on conventional methods and instead invest those aids in sustainable methods like for instance PV systems then perhaps the transition process could even be cheaper and be feasible with a reduction of the interest breakpoints. After the transition process energy prices will probably rise to current conventional energy prizes, since most of the current energy prices consist of all kinds of taxations.

SUSTAINABLE DEVELOPMENT OF INDUSTRIAL AREAS
A practical research towards the importance of land allocation within the sustainable development process of industrial areas

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ABSTRACT
This paper is about the research that has been done towards the importance of land allocation policy within the sustainable development of industrial areas. In the theoretical framework industrial areas are explored and factors that contribute towards sustainable development described. Argued is that the policy and governance plays an important role in realizing a sustainable area. Specifically the influence of land allocation is proposed in this context as instrument for achieving a sustainable industrial area. Three aspects of land allocation are discussed: type of ownership, housing conditions and pricing policy. A case study is done to investigate the implementation of land allocation on its support, feasibility, effectiveness and risks. The results of the case study and theory show that special land allocation policy could be a useful tool for achieving a sustainable industrial area.

Keywords: industrial areas, sustainability, development process, land allocation

INTRODUCTION

Nowadays, industrial areas have to deal with a lot of problems related to finance, quality, demand and life span. The main focus in relation to sustainable development is in this research on the optimization of the life span of industrial areas, so that obsolescence and depreciation of these specific urban areas could be avoided. The organisation and planning of an industrial area seems to be crucial for further development. Problems with the quality on industrial areas and preserving industrial areas on long-term could often be derived from decisions made in the preliminary phases of the development process (Blokhuis, 2010; THB, 2008).

When looking at sustainable implementations for industrial areas, two different types of designing an industrial area could be indicated. First, a sustainable industrial area could exist of sustainably built individual properties. Every building is in this case sustainable or energy neutral. Second, an industrial area could be sustainable over the entire area. Sustainability is provided by collective facilities and the area is managed by a park management organization or the owner of the industrial area. This kind of industrial areas focuses on urban scaled solutions and is developed as a sustainable area in the preliminary phases. In this research, the focus will be on this second type of sustainable industrial area.

THEORETICAL UNDERPINNINGS

Current situation industrial areas

More than one third of all industrial areas in the Netherlands are considered as obsolete (figure 1.1). Obsolete areas often have to deal with vacancy, which can result in unsafe areas, impoverishment and value decrease of the property and the land. A downward trend arises and settled companies will look for other places. This strengthens the vacancy within an area and the attractiveness of the area will further decline. A reinforcing loop is the result. Through this trend the used space for industrial areas increases (Tweede Kamer der Staten-Generaal, 2006). To avoid the obsolescence of new areas, these areas need to be built in a more sustainable way while taking into account the life span of the area.

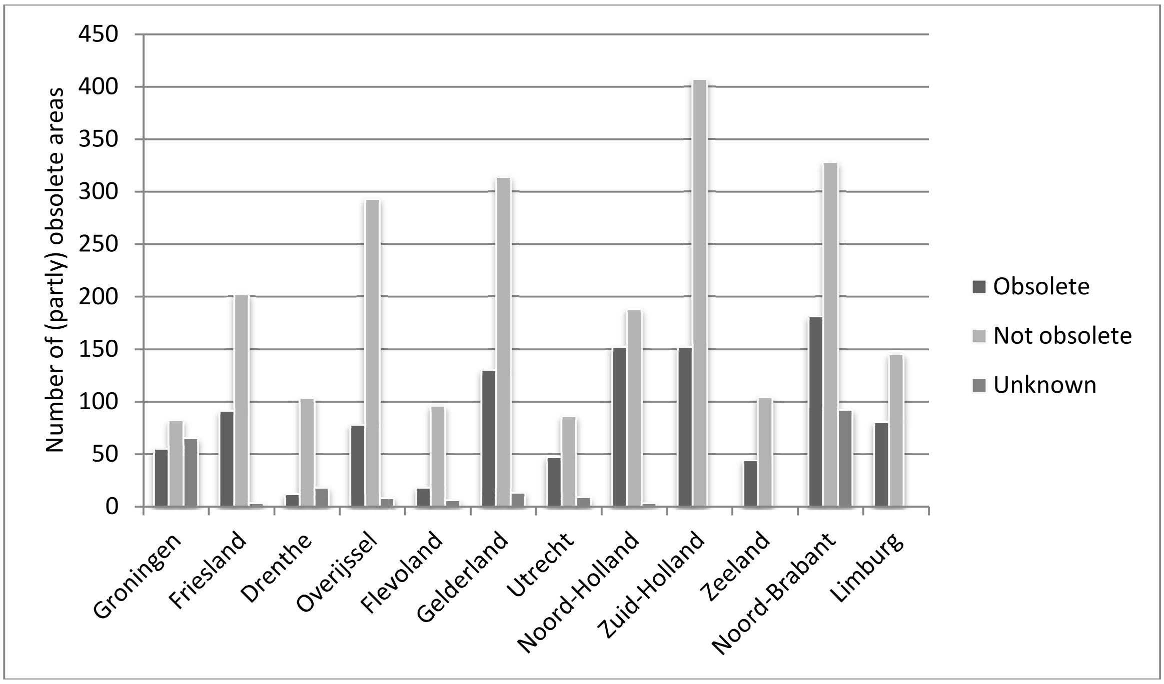

Figure 1: Obsolescence industrial areas in the Netherlands per January 1st 2011 (Based on IBIS, 2011)

Another problem is that the obsolete areas cause cluttering of the built environment. To avoid this cluttering while still answering the demand for industrial areas, the redevelopment of existing areas is important. Considered is however, that this redevelopment stagnates, despite the attention it has gained last years by the government (Blokhuis, 2010).

To change the current situation on industrial areas several causes have to be taken into account. The causes are clustered in 'planning and organisation' and 'architecture and urban design'.

Trends could be discovered on field of sustainability, changing demand, quality requirements and commercializing the market of industrial areas. Especially the trend sustainability is taken into account. The mentioned problems have to be tackled and the trends taken into account to achieve the proposed goal.

Factors that influence sustainable development

Already in 1998 the Dutch government investigated possibilities to create sustainable industrial areas. The physical possibilities for the development of a sustainable industrial area could be distinguished into two groups (Stuurgroep Boegbeeld Duurzame Bedrijventerreinen, 1998): the application of sustainable business processes and the application of a sustainable design of the area. During the years this division remained relevant, although through innovation some measures became easier to implement, like the use of renewable energy sources in area development, or more accepted by the stakeholders, like park management. However, the attention on the influence of policy and governance on the development of sustainable and high quality areas is increasing in the last years. Several researches are done towards the functioning of the current policy and stimulation of sustainable development by the public parties. A relation is observed between the current policy and physical possibilities. In figure 2 an overview of the implementations for the development of a sustainable industrial area is given. The physical factors mentioned by Stuurgroep Boegbeeld Duurzame Bedrijventerrein are included in the aspects 'Energy& material use' and 'Spatial layout'. The figure is completed with the aspect 'Policy and governance'. Interesting for this research is the factor policy and governance, and especially in this the land allocation.

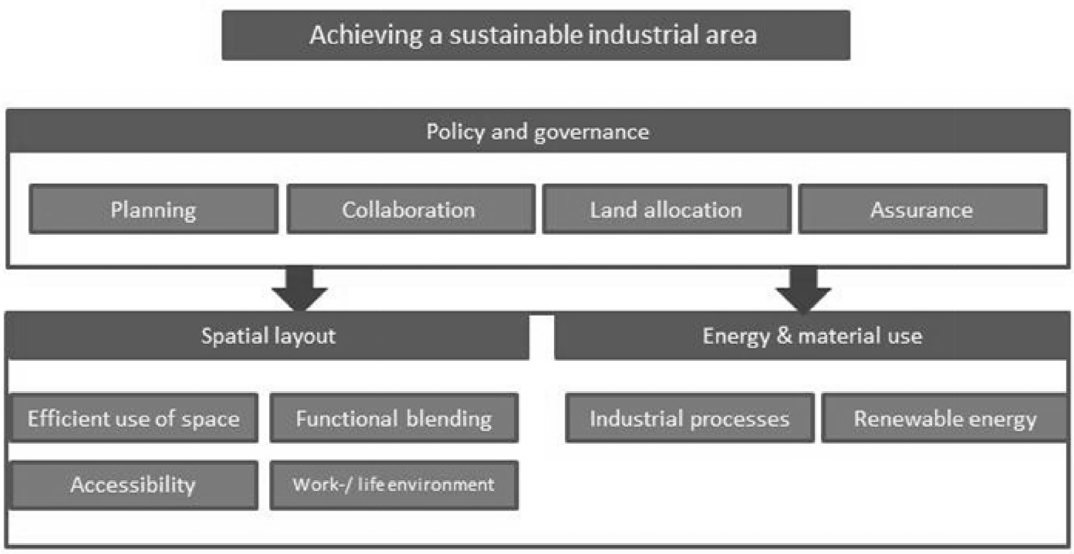

Figure 2: Overview factors sustainable industrial area development

The stakeholder analysis also shows that the public parties are involved in several different forms; the municipality is strongly involved on local scale, but also owns a lot of land so that it often functions as the land acquisition party. About 83% of the available land for industrial areas is owned by the municipalities (VROM, 2010).

Land allocation policy as tool

By implementing a land allocation plan, the land owner is able to control the established ambition level for an area in the allocation phase of the development process after these ambitions are set in a master plan and additions are made in the zoning plan. Currently most industrial areas are developed in the traditional way. This means that the municipality acquires the necessary land for development and facilitates the plan development, site preparation and land allocation. After the land is purchased, the user usually built its property. Other ways of allocation could be interesting for sustainable development.

In figure 3 the proposed relation between the land allocation policy and the goals set for the exploitation phase is shown. With the land allocation policy, mainly improvements in the exploitation phase are pursued. Therefore, the land allocation plan and the maintenance are highlighted.

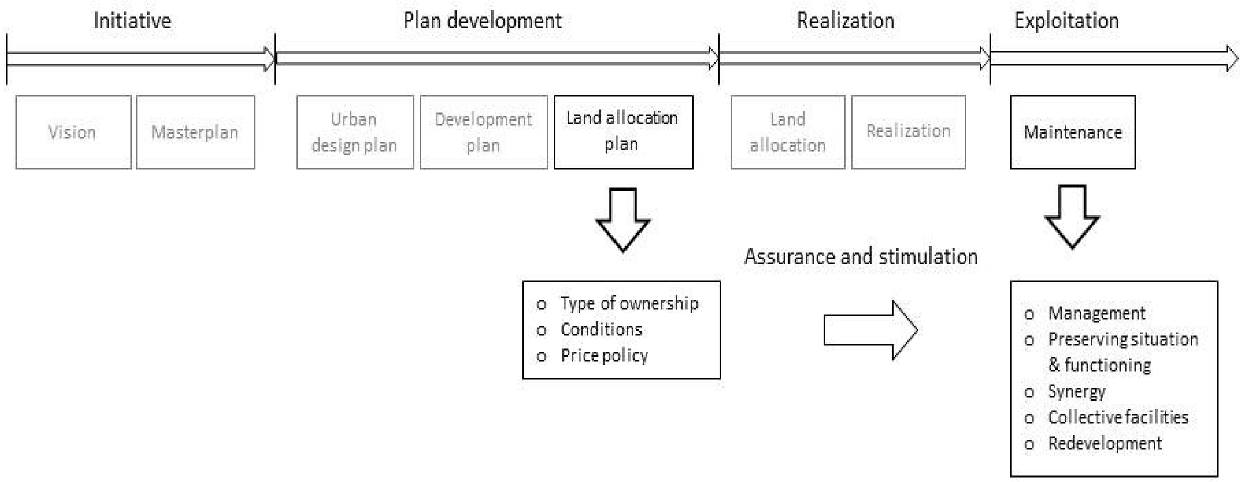

Figure 3: Land allocation within the development process

Looking at the land allocation there are three interesting aspects to investigate in relation to developing a sustainable industrial area:

1. Type of ownership

Different types of ownership are known. The most common one is the sale of land, followed by leasehold of land. In case of sale the buyer of the land has all the control, meanwhile by leasehold the land owner, this is often the municipality, keeps certain control over the land (RIGO, 2009). The choice between sale and leasehold has influence on the financial status of the stakeholders. In case of sale, the future owner pays the total price of the land plot in one time. However, in case of leasehold, the lessee pays an annual price for the land; this price is often called a canon. Therefore leasehold causes a continuous cash flow of revenues instead of one impulse at a certain time. Advantage for the land owner is the control option related to the land exploitation. The land owner is allowed to end the leasehold during the contracting period when the user doesn't meet the minimum requirements. For a successful implementation of leasehold, support of both land owner and users has to be created. Currently several (sustainable) industrial areas are planned wherein a leasehold construction is investigated and some industrial areas are already realized with leasehold. However, some doubts are made about the support of this type of ownership under both entrepreneurs and municipalities. Mentioned is that leasehold has to lose its negative image before it will be used on larger scale.

2. (Housing) conditions

Chances are seen in setting conditions by the land owner towards the housing of businesses in a certain area. With this tool requirements could be set that increase the successful realization of a sustainable area. Which kind of juridical instruments are used, is dependable of the chosen type of allocation (sale or leasehold). The support of the future user for the housing conditions has to be taken into account so that the demand for the industrial area remains sufficient: the conditions should be financially feasible for the entrepreneur.

3. Pricing policy

The land price could be a tool for stimulating developers or entrepreneurs to create a sustainable area or building. This is a pull option to involve entrepreneurs in the development. A used method is giving discount on the land price or the annual contribution for park management when the company takes into account certain measures for sustainability. Another possibility is the realization of quality zones. The land prices in these zonings could vary depending on the urban requirements.

METHODOLOGY CASE STUDY

To test the theoretical statements about land allocation as tool, the development process of four cases is explored. Data about the cases is collected by keeping interviews with involved parties and studying literature. The data will be qualitative.

The two most relevant stakeholders are investigated and interviewed per case. These stakeholders are the landowner and the user. The interviews will show the incentives of the landowner for implementing special land allocation and how this is organized. Users of the projects are interviewed about their motivation for a certain location and their experience with the industrial area.

The interviews are structured according to nine management factors: ambition, organisation, planning, motivation, support, feasibility, risks, effectiveness and attitude future. After the interviews are done, the input gained from the interviews will be analyzed and compared with the theory. This will result in recommendations towards the landowner about the application of special land allocation policy.

The selection for the four cases is done on several criteria. First, the cases needed to have a sustainable character. This could be measured with the aspects of the BREEAM certification. Second, special forms of land allocation have to be implemented in the cases. And third, a mixture of types of industrial areas is pursued.

According to these criteria, the following cases are selected:

1. Ecofactorij, Apeldoorn
2. Haven VII, Waalwijk
3. Haven van Moerdijk, Moerdijk
4. A4 Zone West, Haarlemmermeer

The first three cases are realized industrial areas, the last case is still in the plan development phase.

RESULTS CASE STUDY

Implemented land allocation policy

The cases show different implementations of land allocation policy. When looking at the three main instruments of this research, namely type of ownership, conditions and pricing policy, the cases all implemented at least one of these aspects or will be implementing one of these instruments. Not every case implemented the instruments on the same way, a difference is notable in the extent of the implementation of each instrument and the used combination of instruments. In table 1 and 2 the implemented land allocation tools are described per case. Pricing policy is less known and only fully implemented by Ecofactorij.

Project	Type of ownership
Ecofactorij	Leasehold
Haven VII	Sale and leasehold
Haven van Moerdijk	Leasehold
A4 Zone West	Probably leasehold, followed by an area fund

Table 1: Type of ownership per case

Project	Housing conditions
Ecofactorij	"Quality plan": required and voluntary conditions
Haven VII	Required conditions: park management, layout aspects
Haven van Moerdijk	Checklist "Chances for sustainability": voluntary requirements. Required conditions: park management, environmental test, housing advice by Havenschap
A4 Zone West	Required conditions: park management, BREEAM certification, requirements set by ACT "Guidance sustainability" as guide for the industrial area

Table 2: Housing conditions per case

Differences land owner and user

Regard to the support for the performed land allocation policy, the land owners and users show a different attitude. Overall the support of the land owners for implementing leasehold and setting conditions towards the land allocation is higher than the support of the users. Their attitude towards the future is more positive than the users have, especially for leasehold. However, the municipalities often have a twofold view on the performed land allocation policy. On the one hand they have ambitions about sustainable development; on the other hand the financial feasibility is very important.

The users mainly see financial advantages of the leasehold. In some cases the economic situation has resulted in more support of the users for leasehold, while they normally would prefer sale of the land above leasehold. A growing involvement of the users in their surrounding area and in sustainable thinking is noticed by the municipalities after they've housed on the sustainable industrial area.

Lessons learned

Type of ownership:

- The relation between ambition and the implemented type of ownership seems to be weak, but indirectly this relation is visible. The underlying thought of the municipalities is often preservation of the area on the long-term.
- A relation could be noticed between the economic situation and the preferred type of ownership, especially from the view of the users. The ambitions from the land owners could fluctuate according to the economic situation.
- For the users the location is more important for housing than the type of ownership. In all three developed cases this is mentioned as decisive housing incentive.
- Feasibility of leasehold could be insufficient on financial field because a new development requires some bigger start investments. On the other hand, the municipality defines that the investments will be financed externally, so that this is not a mayor problem. By implementing a leasehold construction with payment in once at the start, the start investments are assured.
  Another point of discussion is the feasibility of implementing leasehold in smaller municipalities. The municipal device should be able to handle the extra administration and necessary governance. Expected is that this is not the case in every municipality.

(Housing) Conditions:

- Not all set conditions appeared to be realistic and feasible. The set conditions have to be physically underpinned for a high juridical feasibility. For gaining sufficient support by the entrepreneurs the housing conditions should preferably be financial feasible. In case of a good location of the industrial area, the entrepreneurs are more tolerant towards the conditions. This seems to be similar to the support of the type of ownership.
- The economy is considered as main risk for the proposed housing conditions. It could influence the support for the housing conditions.

General:

- The feasibility of the development of a sustainable industrial area in general is in different cases (Ecofactorij, Haven VII) dependable on the economic situation.

CONCLUSIONS

Importance

Looking at the results of the theory and case study, the statement could be made that land allocation policy could be a useful tool for achieving a sustainable industrial area. However, it has to be mentioned that this functionality is closely related to the ambitions that are set by the land owner for the industrial area and its sustainability.

Support

For a successful implementation of the land allocation tools by developing a sustainable industrial area the support of the main stakeholders should be sufficient. The research shows the incentives of the land owner to choose for the proposed land allocation policy. The ambitions of the land owner are relevant for the chosen land allocation policy. However, the financial feasibility stays in most cases the decisive factor for the land owner because of the importance of the (short-term) financial result. The economic situation is also a highly influencing factor. This is nowadays seen by the interviewed persons as a risk for especially the set conditions for the land allocation. The support for these conditions fluctuates according to the economic situation.

For the user the sustainable character of the area and the implemented type of ownership seem to be secondary to the location of the industrial area. Regarding the support for specifically leasehold, the negative image of it and the unfamiliarity with this type of ownership was supposed to be leading in theory. In practice, entrepreneurs do prefer sale above leasehold.

Concerning the housing conditions, on the one hand the implemented stringent housing conditions influence in some cases the housing choice of the users. On the other hand, it is noticed that on the investigated industrial areas participation in park management (a required condition) has a positive effect on the involvement of the entrepreneurs in the area and their support towards sustainable implementations during the years.

Conditions

The following conditions for developing a sustainable industrial area are proposed to implement based on the theory and practical test:

- Requirements clustering of businesses: e.g. clustering same quality requirements, exchange of energy
- Requirements park management and maintenance
- Requirements preserving situation: tackling vacancy, ensuring specific function of land
- Requirements layout : zoning plan related conditions, e.g. parking, land use

Recommendations

Recommendations could be made for the implementation of the proposed land allocation policy by the land owner. These recommendations include:

Ambitions: Set ambitions on long-term for both the realization and the financial feasibility.
Financial value**:** Investigate whether or not a less traditional cash flow is desired. Include a fee for maintenance of the area in the land allocation.

Support: Give a clear description of the proposed land allocation and its incentives to the (future) users. Focus on the financial advantages for the user.
Feasibility: Ensure that the ambitions meet the capabilities of the stakeholder, sufficient knowledge increases the feasibility.

Risks**:** Link the economic situation to the financial aspects for the user. The economy may increase the support for leasehold, while it could diminish the support for certain housing criteria.

DISCUSSION

By doing this research, boundaries are set to limit the research context. Nevertheless, there are some subjects that are interesting for future research**.** A growing demand for involvement of the private sector in development of industrial areas is visible. The roadmap ‘verzakelijking van de bedrijventerreinenmarkt’ from the Ministry of VROM (2010) mentions this aspect. This research could be seen as a first step towards this new focus. However, more research has to be done on the involvement of the private parties in the development process of sustainable industrial areas.

The SER ladder is a planning tool to avoid unstructured development. This research has shown that implementing the SER ladder is difficult and not yet generally applied by new developments. Further research towards the SER ladder should be done to improve this instrument.

The proposed land allocation tools may be interesting to implement by redevelopment. The pros and cons of this implementation have to be further analysed to come to conclusions.

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This graduation research has increased my knowledge about process management and urban development. It was a very interesting period; the graduation internship at ARCADIS has provided a lot of new insights and experiences.

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PRIVATE HOUSING WITHIN REACH
Making private housing attainable for medium income households

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ABSTRACT

Due to several different developments in the housing market it has become more difficult for medium income households to find an attainable private dwelling with corresponding mortgage. This has a negative influence on the number of transactions and deteriorates the flow through in the private housing sector. Since a first analysis showed that the mortgage lending restriction is the main restraining element, the emphasis of this thesis is on minimizing system risks by involving suitable stakeholders and thereby providing competitive mortgage loans. The result is a new business model that provides a structural improvement of the financial accessibility of private housing, which above all enables the medium income households to purchase private dwellings with an attainable mortgage. Furthermore, this Housing Investment Plan provides a good platform for the implementation of a standardized but diverse process and product and thus the ability to develop competing housing prices and energy efficient dwellings.

Keywords: Private housing, Investment plan, Housing price, Mortgage loan, Additional housing costs

INTRODUCTION

The housing market is a big and very diverse market with its own rules and target sectors. There are two main sectors in the housing market, which can be referred to as the private housing sector and the social housing sector. Both sectors have the same two submarkets. The first is the rental housing market where a monthly amount is charged for renting the dwelling. The second market is that of the owner-occupied housing where the owner has a mortgage loan with which the dwelling is financed on a monthly basis. This brings the total to four forms of housing.

The current problems in the housing market are complex and take place in all of the above submarkets. The real problem group are the households with an annual gross income between €34,000 and €43,000 (11-12% of all households (Statline, 2011a)). These households have an income that is too high for the social housing sector and too low to get a decent mortgage loan. Therefore, these are the households that is focused on during the research. Restricted rental rules in the social housing sector imposed by the European

Committee in 2011 and restricted mortgage regulations in the same year, in combination with the increased housing prices of the past two decades, are at the bottom of this problem and define the target group of this research.

There are three main problem areas concerning the problem, namely *housing prices*, *mortgage lending* and *additional housing costs*. These are the starting point of the research and the triptych in which this research is executed to answer the main research question: *What financial measures contribute to an improved financial accessibility of owner-occupied private housing for households with an income between €34,000 and €43,000?* The main research objective is to make this housing attainable for the target group by providing possible solutions in the three subareas and in addition by developing a financial measure in the event that existing measures are not sufficiently contributing to the objective.

EXPLORATION OF THE THREE PROBLEM AREAS

In the exploration below a theoretical orientation is made on the three problem areas of the research.

Housing prices

The housing price is composed of seven elements and are listed in figure 1.

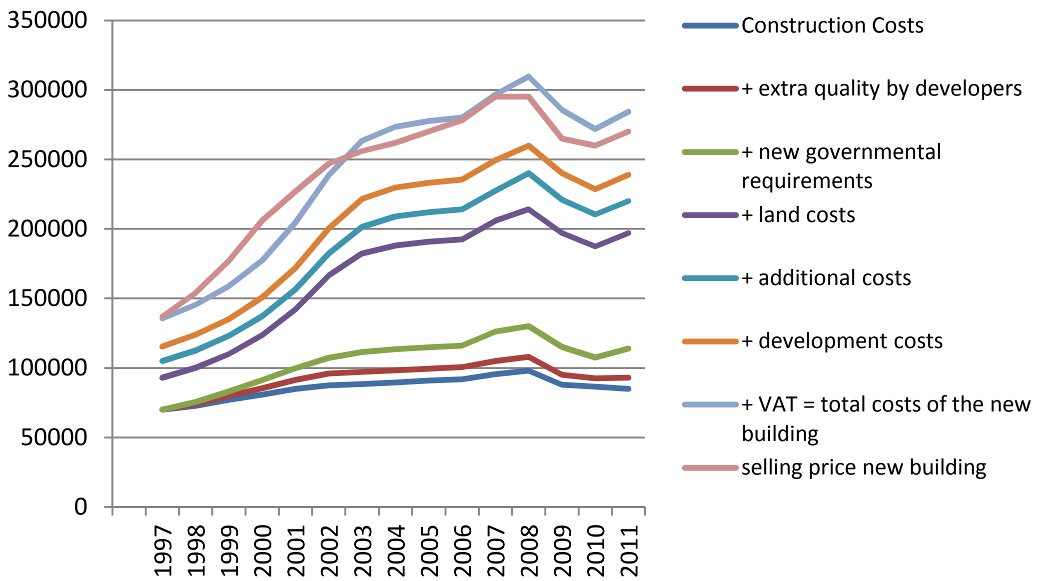

Figure 1, Price and cost development of the average new home (NVB, 2011)

From the figure above it can be concluded that the construction costs, *new governmental requirements* and *land costs* have changed significantly over the past ten years. The construction costs have decreased since all other costs increased and this element has been constant over the past decade. The costs of *governmental requirements* have increased mainly because of the tightening EPC standards. The land prices have increased dramatically (260%, 1997, 2011) due to planning policies in the '80s to effectuate new dwellings near urban locations (Vinex) which encouraged the scarcity we face now. (NVB, 2011)

To improve the financial accessibility of the target group on the short term, it is necessary to lower the land prices by depreciation to proceed developing new projects with market-oriented prices. On the long term the most structural measure is to use one consistent and up-to-date land valuation method and to include developers incentives in the calculations. Finally, various optimisations are possible in providing affordable dwellings and the introduction of an initial-costs-fund can save up to 30% of the additional costs.

Mortgage lending

The maximum height of the mortgage loan is depending on numerous factors. Therefore, only the direct influences are listed below.

- Housing ratio
- AFM directive
- Mortgage interest rate
- Competition
- NHG
- Single- and double-income household

The financial accessibility can be improved in two ways here. First, the loan capacity can be maximized by excluding up to €8,000 from the calculation if a dwelling is purchased with an EPC-report with a maximum of 0.6. An interest discount on NHG guaranteed mortgages is another way of maximizing the loan capacity. Second, there are also measures to maximize the range of feasible housing without having to maximize the loan capacity. These are stated in table 6 and the discounts can go up to 50% of the market value and can thus be good solutions in providing medium-low incomes a private dwelling.

Additional housing costs

Additional housing costs are 43% of the total housing costs and 12% of the average disposable income of households. In the pie chart of figure 2 the elements of the additional housing costs are illustrated and it is clear that energy costs is the main component, covering 48% of the total additional housing costs.

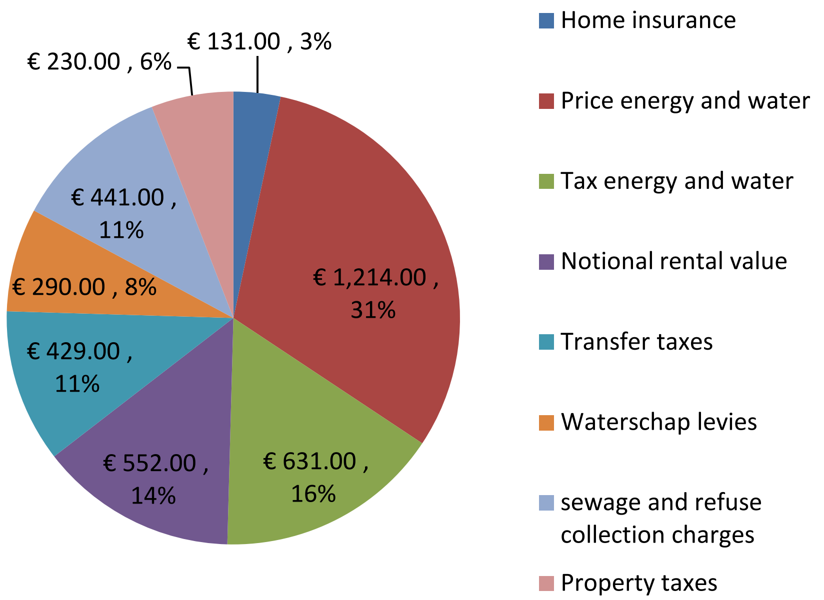

Figure 2, Components of additional housing costs (annual costs) (COELO, 2011)

Since energy costs cover a big share of the total costs and will increase exponentially in the future, the emphasis is on these energy costs and how these can be controlled and confined. The measures can take place in the three subareas of the *Trias Energetica*: preventing energy utilisation, maximizing the amount of sustainable energy and efficient use of finite resources. By comparing the EPC reduction and the investment costs (effectiveness) to the annual savings of the investments, a realistic long-term advantage can be established. (Earth energie advies, 2010) Finally, over time the investment costs will decrease and energy costs will increase, which means that energy saving measures will become more and more effective.

CONFLICTING AREAS
From an analysis of the above three problem areas and the conflicts between these areas it is concluded that there is a lack of integral vision on the current problems of the housing market. There are no real umbrella measures that significantly reduce the gap between housing prices and mortgage lending and that incorporate the additional housing costs in the mortgage lending process. One of the examples is the limited existing extra loan capacity for energy saving measures of €8,500, while potential savings are much higher and additional costs for the A^{++} and energy neutral dwellings are higher. In essence, this is an umbrella measure with high potential, except for the limitation of €8,500 (see figure 3).

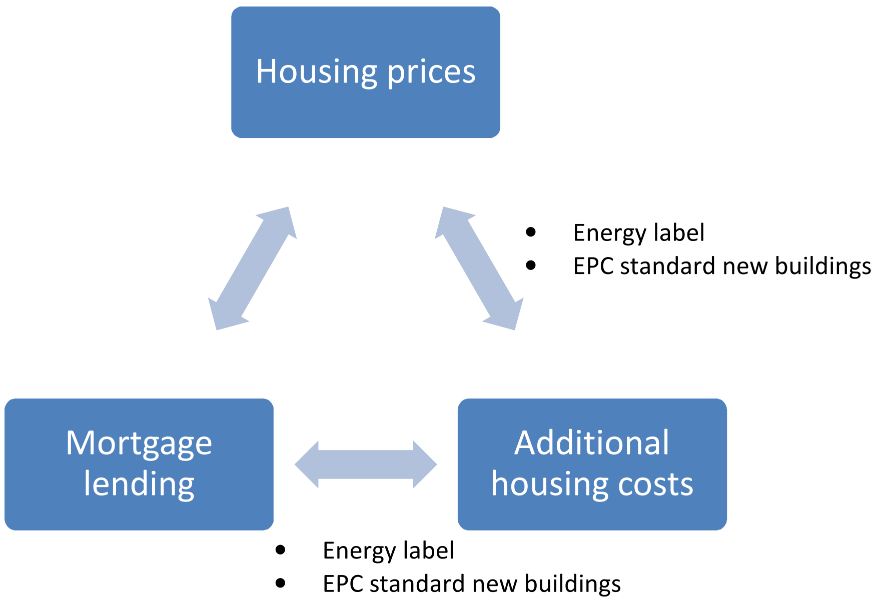

Figure 3, True integral measures

The lack of integral vision can partially be ascribed to the well-defined but restricted roles of the actors that operate in the three different areas. These actors all have their own interests, intentions and contributions which might not always be on the same wavelength. From this it is clear that there is a need for connecting measures and cooperating stakeholders, to satisfy the customer and to adapt to changing economies and the changing housing market.

DEVELOPING MEASURES
In the housing market numerous measures can be defined and drawn up for the different stakeholders in the housing sector, to accomplish a higher feasibility for the target group. In this research the focus is on measures that can be initiated and facilitated by a project

developer or in close cooperation with relevant stakeholders. This enables specific and tangible measures for project developing companies.

Standardization

On the side of the construction costs and developers' margins a lot has been done already (NEPROM, 2012), but the building process and product can be more efficient and failure costs can be reduced by standardization. In a sector where failure costs cover 11% of the total turnover, and in the context of the current tendency of the market it is essential to force back the avoidable failure. According to a research among different stakeholders in the construction sector the highest reduction is possible by a better focus on the workability during the projects' design phase, which can further reduce the technical adjustments. Standardization in process and product at an early stage can result in lower failure costs. (BouwKennis BV, 2011)

Financial situation customer

For both the project developer and the customer it is important to have a clear view of the financial situation of the customer and its loan capacity according to the up-to-date regulations. In combination with the customers' requirements/wishes this gives a good insight in the range for the product: the lower bound is shaped by the wishes, the upper bound by the loan capacity. To both parties it is important to be aware of this range in an early stage, where there is still enough room for manoeuvre and the requirements can be translated into a suitable product. Therefore, the communication with potential customers about the product and location has to be initiated by the project developer in an early stage. In line with this, mortgage advice can be facilitated by the project developer: in the form of a mortgage advisor joining a meeting, or (in a preliminary phase) by explaining the different mortgage types and additional measures to finance the dwelling. This gives insight in the opportunities and helps the customer to make choices.

Reduction packages

The share of additional housing costs in the total housing costs is increasing and thereby the monthly housing costs increase, independent of the tightened regulations on the primary mortgage costs. These total housing costs are leading in the monthly costs and it is therefore important for the project developer to make this clear to the customer in an early phase. In line with the aforementioned standardization it is possible to offer product-based EPC reduction packages. Since sustainability is becoming more and more important and customers start to realize that sustainable housing is better and saves money, it is important to meet this demand. Different packages can be proposed with corresponding additional investment, possible additional loan capacity and monthly savings.

Conclusion

It is clear that aforementioned measures are important to keep developing private housing for medium-income households. For the project developer it is necessary to be active and facilitating in all three areas, to provide accurate information to the customer and to develop good value for money, in both the purchase (housing price) and use (housing costs). These are measures that are more or less in line with the existing conduct of business. For the future it will be important to work together with other stakeholders to develop and optimize an integrated system. This teamwork also demands role adjustments to synchronize objectives and a solid platform to do so.

A first analysis showed that the tightened financial standards are currently the most limiting influences. This, in combination with the aforementioned solid platform, provides the idea to initiate a new concept for funding the housing market where the construction industry has more influence on and insight into pre-financing projects and mortgage loan conditions. In this case, mortgage loans are financed by the *Housing Investment Plan (HIP)* which is founded by the stakeholders involved in private housing. Since this research is performed in cooperation with a project developing company, the funding concept is elaborated from this point of view.

THE HOUSING INVESTMENT PLAN

From a base model, some modeling options, expanding options, stakeholder analysis, exploratory interviews and two best practices (*German Bausparen* and the *Danish Mortgage model*), a final model is composed and illustrated in figure 4, according to the *Board of Innovation* imaging technique. (Board of Innovation, 2012) This model gives way to a new financing approach in private housing.

The model consists of five *players*: the project developer, pension fund, customer, government and NHG. In addition to their traditional role and participation level, some *players* add *objects* to their activities to improve the functioning of the HIP, which will eventually benefit their individual goals (see table 1).

Table 1, Goals, objects and added objects per player

	Goal(s)	Object(s)	Added object(s)
Housing Investment plan	Providing fundable private owner-occupied housing for households with incomes between €34,000 and €43,000	NA	Transparent mortgage loans, mortgage bonds, saving accounts, NHG dossier
Project developer	Business continuity by developing profitable market-oriented dwellings	Market-oriented dwellings	One-time investment
Pension fund	Long-term investments of pension contributions with an optimal profit and minimal risk	Long-term investment	NA
Customer	Building capital and maximum enjoyment and independency for minimal costs and risks	Interest and repayment	Savings, Data
Government	Safe financial products for its citizens' assets	Political support	Tax-free savings, premium

From this table it can be concluded that the goals of all *players* are in line with and supportive to the goal of the Housing Investment Plan: Providing fundable private owner-occupied housing for households with incomes between €34,000 and €43,000.

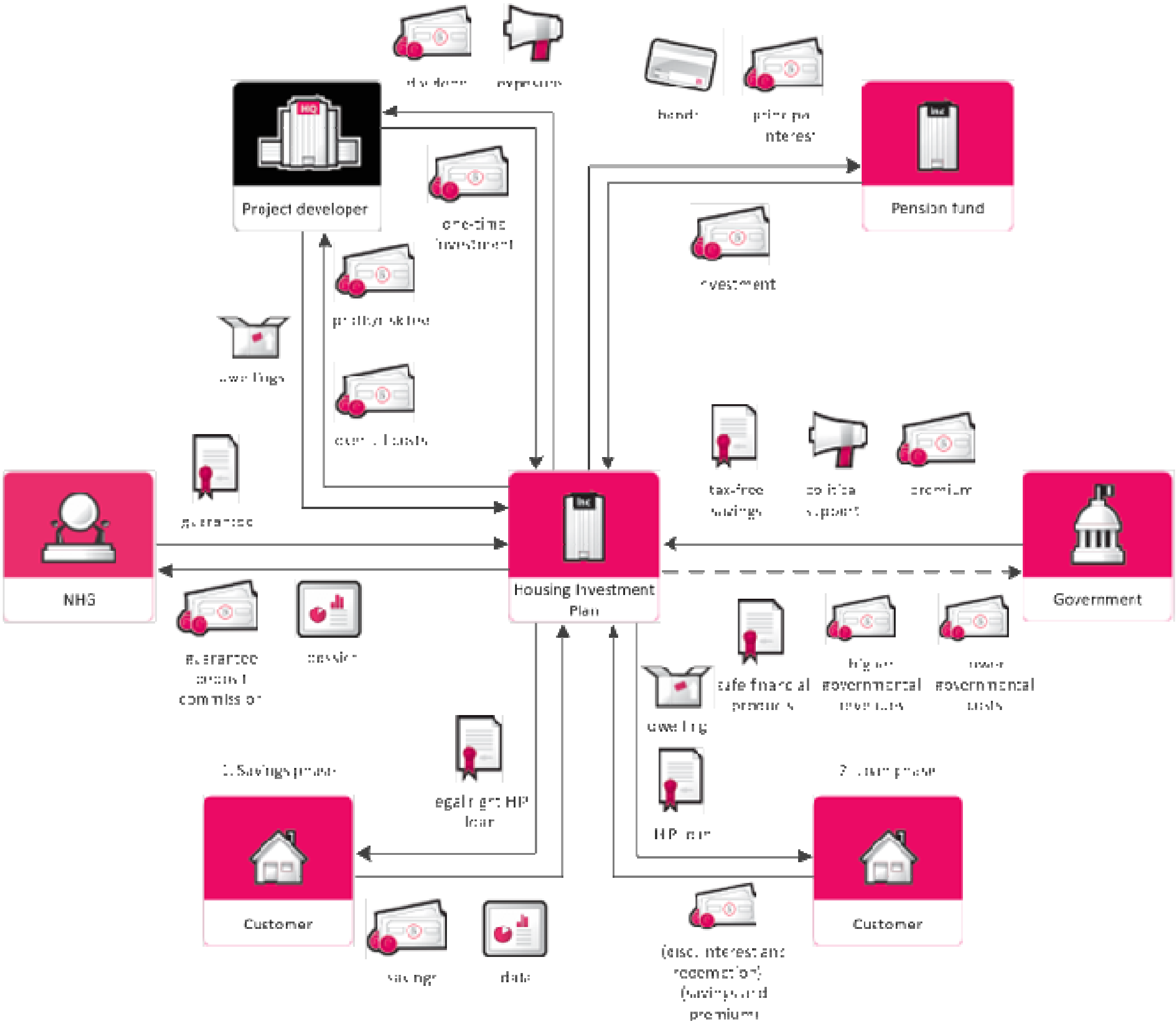

Figure 4, Final model of the Housing Investment Plan

The bank in its traditional and capital providing role is no longer involved in the model and will have a mediating role at most. Pension fund capital is used to finance the mortgage loans and market risk and credit risk are borne by respectively the HIP and the pension fund. These lower risks allow for competitive interest rates and in combination with HIP savings, housing costs can be significantly lower than the traditional costs and hence loan capacities increase.

The savings account and the mirrored bonds based on *match funding* in combination with the constant payment mortgage loan provides a safe and transparent system and is therefore customer friendly. In a time with failing difficult financial constructions, a stagnant housing market and major economic uncertainties, these models are very important to inspire customer confidence.

One of the main disadvantages of the implementation of the Danish mortgage model is the fact that a lower LTV-ratio is implemented, which means that customers need to bring in capital to get a mortgage loan: something that is not generally accepted any more in the Netherlands. This is intercepted by means of the savings phase, which is incorporated in the model to take care of structural savings long before a dwelling is obtained and which provides additional benefits for both the customer and the project developer and pension fund. Furthermore, this lower LTV-ratio creates a more solid financial system with less credit risk and a higher resistance to devaluation.

It can be concluded that with a slight change of roles through *added objects* of just a few *players* an innovative model can be composed in which goals and benefits of all players are represented. It is important to tune the supply to the demand, also and especially when it comes to financial products. In the *Housing Investment Plan* this is established by linking the demand for long term mortgage loans to the supply of long term bonds with the same interest rate, repayment and period structure. For the customer this investment plan does not change anything significant, the difference is in the efficient way in which the funding is engaged.

Below, a shortlist of the most important advantages of the HIP is stated.

- Attainable housing for households with incomes between €34,000 and €43,000.
- Safe and transparent mortgage loans with reduced LTV-ratios.
- Insight into maximum monthly housing costs.
- Safe and stable products for investors.
- Reduced system risk.
- Business continuity for project developer and availability of data collection of future customers.
- Better government finances.
- System is not dependant on financial market.

CONCLUSION AND DISCUSSION

In the main research question the measures that contribute to an improved financial accessibility of owner-occupied private housing for the target group are asked for. In this research measures are distinguished on different levels.

Existing measures

From the existing measures in the different problem areas it is concluded that these measures do not provide a structural improvement of the financial accessibility. Measures are too limited to provide a solid basis: limited budget, limited target group, limited duration of the measures etc. Furthermore some measures weaken and limit other measures, which indicates the lack of integration between the three problem areas. Besides this, there are even measures introduced by one organization and undone by another.

Conflicting areas

From the three conflicting areas it can be concluded that there is a lack of integral vision on the current problems of the housing market. There are no real umbrella measures that significantly reduce the gap between housing prices and mortgage lending and that incorporate the additional housing costs in the mortgage lending process. There is a need for connecting measures and cooperating stakeholders, to satisfy the customer and to adapt to changing economies and the changing housing market.

Measures project developer
Measures that have high potential to improve the financial accessibility of housing for the target group are standardization and the initial-costs-fund method, excluding energy saving measures from loan calculations, NHG mortgages with interest rate discounts and finally the *Housing Investment Plan* that is introduced in this research.

Housing Investment Plan
The tightened financial standards and the low customer confidence, in combination with the need for a solid platform, resulted in a new funding concept for private housing: the *Housing Investment Plan*. Together with some of the stated modeling options and expanding model options and with two best practices in mind, a final model is composed. This plan consists of multiple stakeholders working together to get a transparent and safe model that contributes to an improved financial accessibility by offering competing mortgage loans including a fiscally attractive savings account in a pre-mortgage phase, lowering the LTV value and increasing the loan capacity. The plan makes a good platform for the implementation of a standardized but diverse process and product and thus provides the ability to develop competing housing prices and energy efficient dwellings.

Discussion
The research objective is achieved by stating existing financial measures and furthermore providing measures a project developer can take to enhance the existing role and contribute to a better financial situation in the three areas. A new and innovative measure is stated, explained and constructed and this *Housing Investment Plan (HIP)* is primarily equipped to improve and renew the mortgage lending process. This however, does not mean that the *Housing Investment Plan* does not contribute to the housing prices and additional housing costs.

It was during the research that it became clear that the mortgage lending process is the most problematic and therefore most relevant area of the three, and that this aspect is the foundation for attainable owner-occupied private housing for the target group. It can be concluded that the research objective is achieved by providing a solid and transparent platform with competitive products and future expansion and add-on possibilities.

Future research
During the research some interesting new questions come up which cannot be answered within the scope of the research or because there is no time for it. These recommendations for future research are listed below.

- Elaborating the fiscal and legal possibilities of the *Housing Investment Plan*.
- Elaborating a real case with use of the HIP model and proposing this to the stakeholders involved.
- Elaborating different entities and organisational structures for the *Housing Investment Plan*.
- Research on the possibility of expanding the model to other submarkets/with additional stakeholders like for example the private rental market/value capturing.

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This summary before you is the result of a research on the financial measures contributing to an improved financial accessibility of owner-occupied private housing for medium-income households.
The research is done in cooperation with *Hurks vastgoedontwikkeling* in Eindhoven and with this thesis I will finish the master Construction Management and Engineering at the Eindhoven University of Technology. This thesis is also the end of my study career at the TU/e, that started in the autumn of 2006 with the Bachelor Architecture, Building and Planning.

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COMPLEX MIXED COMPLEX
An exploratory study of the difficulties for housing associations regarding the implementation of energy-saving measures in mixed building complexes

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ABSTRACT
This research provides insight into difficulties encountered by housing associations if they decide to implement energy-saving measures in building complexes inhabited by tenants as well as owner-occupiers. The urgency of this topic is high considering the effects on the environment, the rising energy prices and the increasing number of these so-called mixed complexes.

The difficulties are scrutinized in a literary study and through interviews with several housing associations. The research shows that difficulties may occur on three different areas: juridical, financial and technical. Most of the complications can be mitigated by preventive or curative measures. Preventive measures can be used in homogeneous complexes to avoid future problems. The curative measures to reduce current problems are translated into two models. One model focuses on solutions in juridical field, the other one on those in financial field. Using these models could improve the efficiency of the procedures and the measures taken by housing associations.

Keywords: Dutch social housing market, mixed complexes, housing associations, sustainability, difficulties.

INTRODUCTION
The present use of energy has a hazardous effect on the environment. Floods and extreme dryness are clear signals. The excessive use of fossil fuels has certainly influenced these events. Therefore, it is important to reduce the use of fossil fuels.
Reducing fuel consumption is not only important for the environment, for households it is also important in a financial respect. Daily costs of living are, to a large degree, determined by energy costs. Furthermore, energy prices raised sharply last decennia. Compared to the mid 1990s energy prices are three times higher now (CBS, 2008). The expectation is that they will increase even more.

According to the research report *Wonen en Energie* (RIGO, 2005) it is to be expected that in 2026 households, living in unsustainable dwellings, will spend most of their living costs on energy. Most of these dwellings are older, poorly insulated and inhabit by low-income households. A significant part of these dwellings are owned by housing associations. A housing association is a public organization intended to offer suitable and affordable housing for low-income households. Especially for this group energy costs are important and rising energy prices may have a major impact on their daily living costs. Therefore, it is important for housing associations to offer low-energy houses.

Housing associations are trying to improve the energy efficiency of their portfolio. About 55 percent of their property consists of apartments. These apartments can be part of a rental complex or a mixed complex. A mixed complex is a complex with both dwellings for rent and for sale. Recently mixed complexes are more common. This is due to the fact that associations sell more dwellings. This trend is the result of modifications in the policy of housing associations and the government.

The management of mixed complexes differs from that of rental complexes. The association does not only have to deal with tenants, homeowners also get involved. In this case the management is also in the hands of an ´Association of Owners´ (VvE Belang, 2010). This new management system can cause problems if an association decides to implement energy-saving measures in dwellings in a mixed complex. The increasing number of mixed complexes in the portfolio of associations on the one hand and the increasing importance of sustainable housing for low-income households on the other leads to more pressure on these problems.

The type of problem may differ between building complexes. Problems can be juridical, financial or technical in nature.

RESEARCH METHODOLOGY

Goal – To generate insight into possible difficulties encountered by housing associations when implementing energy-saving measures in mixed complexes in order to formulate procedures to reduce these difficulties.

Research questions

1. What is the significance of sustainability in the existing housing stock for the society, the environment and the economy?
2. Which juridical aspects are involved in implementing energy-saving measures in mixed complexes and which difficulties may be encountered?
3. Which financial aspects are involved in implementing energy-saving measures in mixed complexes and which difficulties may be encountered?
4. Which technical aspects are involved in implementing energy-saving measures in mixed complexes and which difficulties may be encountered?
5. How can these difficulties be dealt with?

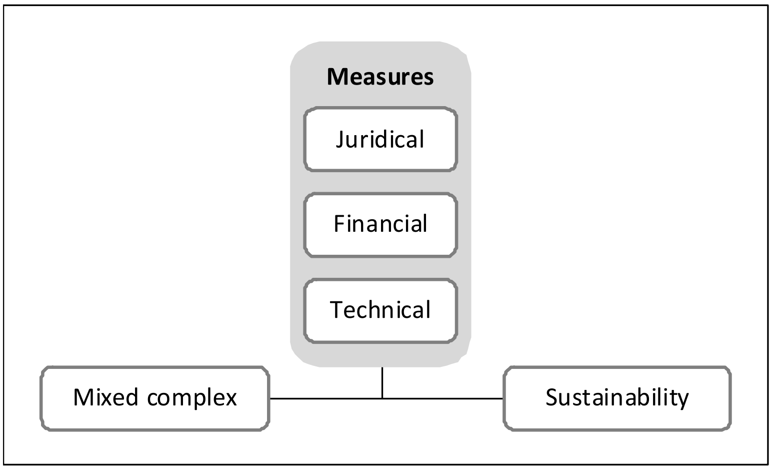

Figure 1: Model

Figure 1 illustrates the research questions in a simplified way.

Research design

The necessary data for this study will be gathered from a literary study and interviews with seven housing associations. In the sample the portfolio of the associations is taken into account. This research focuses on difficulties in mixed complexes with apartments. Because associations in larger cities have more apartments in their portfolio, these associations have more experience in this field. This is why housing associations in the cities Amsterdam, Rotterdam and Utrecht are selected.

RESULTS

Juridical difficulties

A housing association has to deal with several parties when implementing energy-saving measures in mixed complexes: tenants, owners and the Association of Owners. Among these parties juridical difficulties can be encountered.

One juridical difficulty between a housing association and their tenants is that:

- the agreement of at least 70 percent of the tenants is required for housing improvement or an increase of the rent before a legal decision can be made.

Several aspects can lead to the rejection by the tenants. These aspects can hamper the implementation of those measures.

A second problem may arise with homeowners because:

- at least two-third of the owners have to agree on energy-saving measures in a general assembly of the members of an Association of Owners. At least two-third of the total amount of votes has to be casted.

Other difficulties involving the Association of Owners are the following:

- A housing association must abide by the so-called rent law and the apartment law. These two laws show some contradictions.
- Owners have the right to vote in an Association of Owners but tenants do not, although the interests of tenants may be different.
- In mixed complexes the decision-making goes through the Association of Owners. But those associations may not be active in all cases.

- An Association of Owners cannot make a long-term commitment (which would be obligatory for certain loans).

Financial difficulties
Energy-saving measures organized by an Association of Owners require adequate financial resources in the reserve fund of this association. A reserve funds may be insufficient.
To avoid this problem, several methods can be used, namely:

- by saving: a larger contribution of all owners to the Association of Owners.
- by negotiating a loan on name of the Association of Owners.
- by a one-off extra contribution by the owners.
- by outsourcing.

All these methods lead to an increase of the contribution by the owners. Due to this there may also be other financial difficulties:

- Not all homeowners can afford an increase of their contribution or a one-off extra contribution.
- It is not always possible for an Association of Owners to get a loan.
- It is not always possible for homeowners to get a loan.

Apart from the investments of owners, grants and a financial contribution of the housing association, a so-called dowry, are also possible. Sometimes it can be difficult to use a grant, for instance when certain regulations are attached.

Technical difficulties
When implementing energy-saving measures a housing association may encounter several technical difficulties. The involvement of homeowners in mixed complexes can amplify these difficulties. This applies to two situations in particular:

- if not all owners want to participate;
- if an owner has implemented technical changes in his apartment on an individual level.

Housing associations do not consider technical difficulties as insurmountable. Perhaps the implementation cannot be accomplished as intended, but there may always be an alternative method to realize the goal. This alternative, however, may cost more money or time. Therefore, the costs and benefits of the alternative will have to be considered in all cases. If a technique is not financially feasible the implementation will not succeed, but this is not the result of insurmountable technical difficulties.

MEASURES TO REDUCE DIFFICULTIES

Not all housing associations are experiencing the same difficulties. Problems may vary between associations and projects. Solutions are not always self-evident and many housing associations struggle with this issue. To reduce or prevent difficulties, curative and preventive measures are possible.

Curative measures

Curative measures are focused on building complexes that are already mixed. Measures to avoid judicial difficulties and to cover the financial problems are implemented in two models. These models are shown in figure 2 and 3. The particular situations define the applicable method(s).

Figure 2 shows the measures to avoid judicial difficulties in mixed complexes. A housing association has to deal with tenants, an Association of Owners and homeowners if they want to implement energy-saving measures. The judicial difficulties that may occur are shown in the pink text boxes and the model refers to the relevant measures. Sometimes several measures are possible.

The model in figure 3 shows the measures to cover the financial aspects. At first instance the financing of energy-saving measures will be based on the reserve fund, grants and a contribution (dowry) of the housing association. If these sources do not cover the necessary resources, an alternative measure is needed. A choice can be made between a savings model and an advanced payment model. Each model comprises several methods. Some methods can lead to additional difficulties. In these cases the model refers to alternative measures.

For example, a difference has to be made between individual and collective applications. Applications that can only be implemented in the rental apartments require different measures compared to collective applications that may have to pass through the Association of Owners. In figure 3 **I** or **C** shows whether an application is feasible on an individual and/or collective level.

Preventive measures

If a complex is not yet divided, certain problems can be avoided using preventive measures, such as:

- *preparation of the implementation;*
- requiring additional funding in case of a division;
- implementing the energy-saving measures in the form of a maintenance plan;
- making an extra contribution (dowry).

These measures can also be used if a part of the complex is already sold in order to prevent an aggravation of the situation.

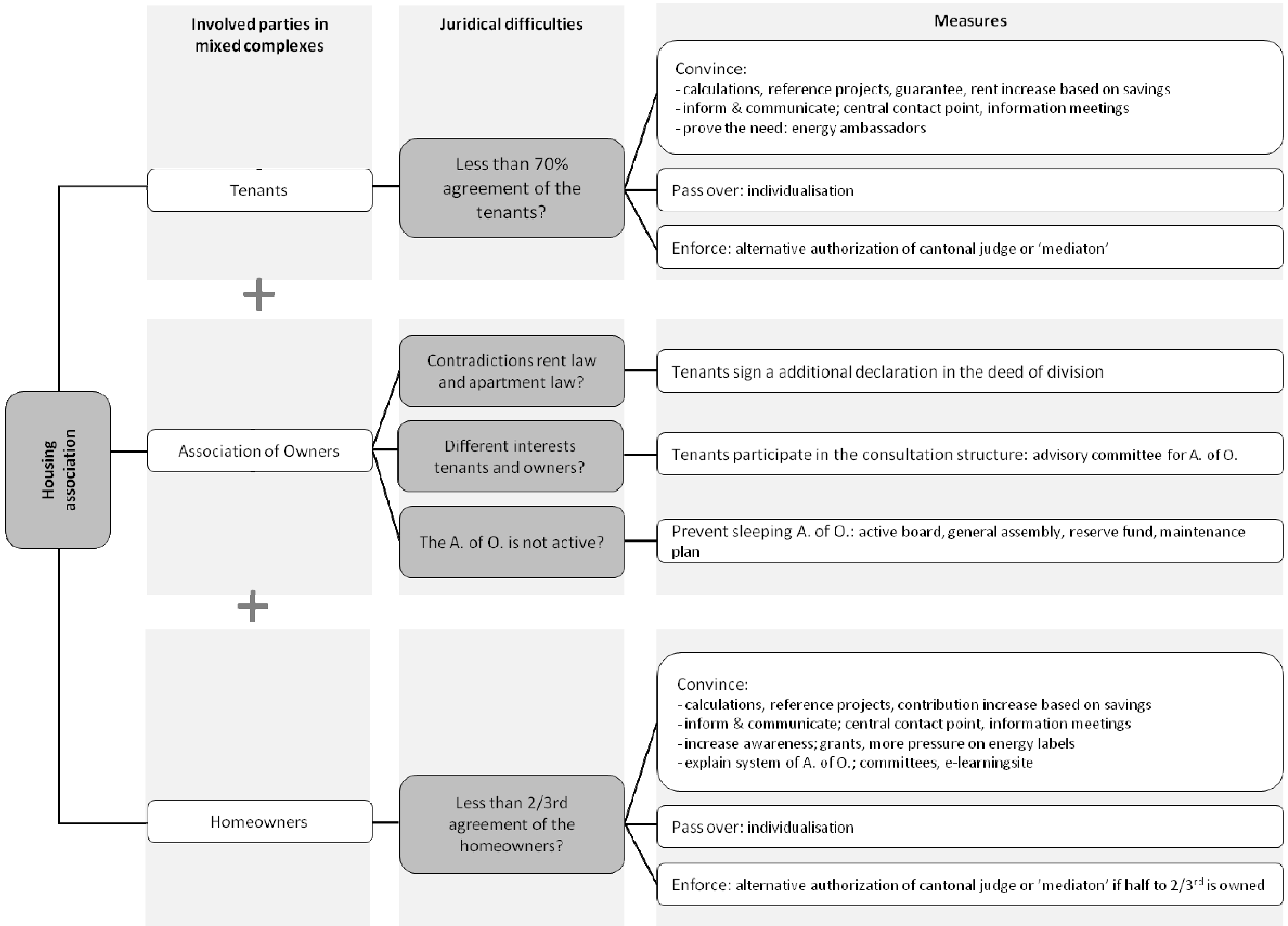

Figure 2: Measures to avoid juridical difficulties in mixed complexes

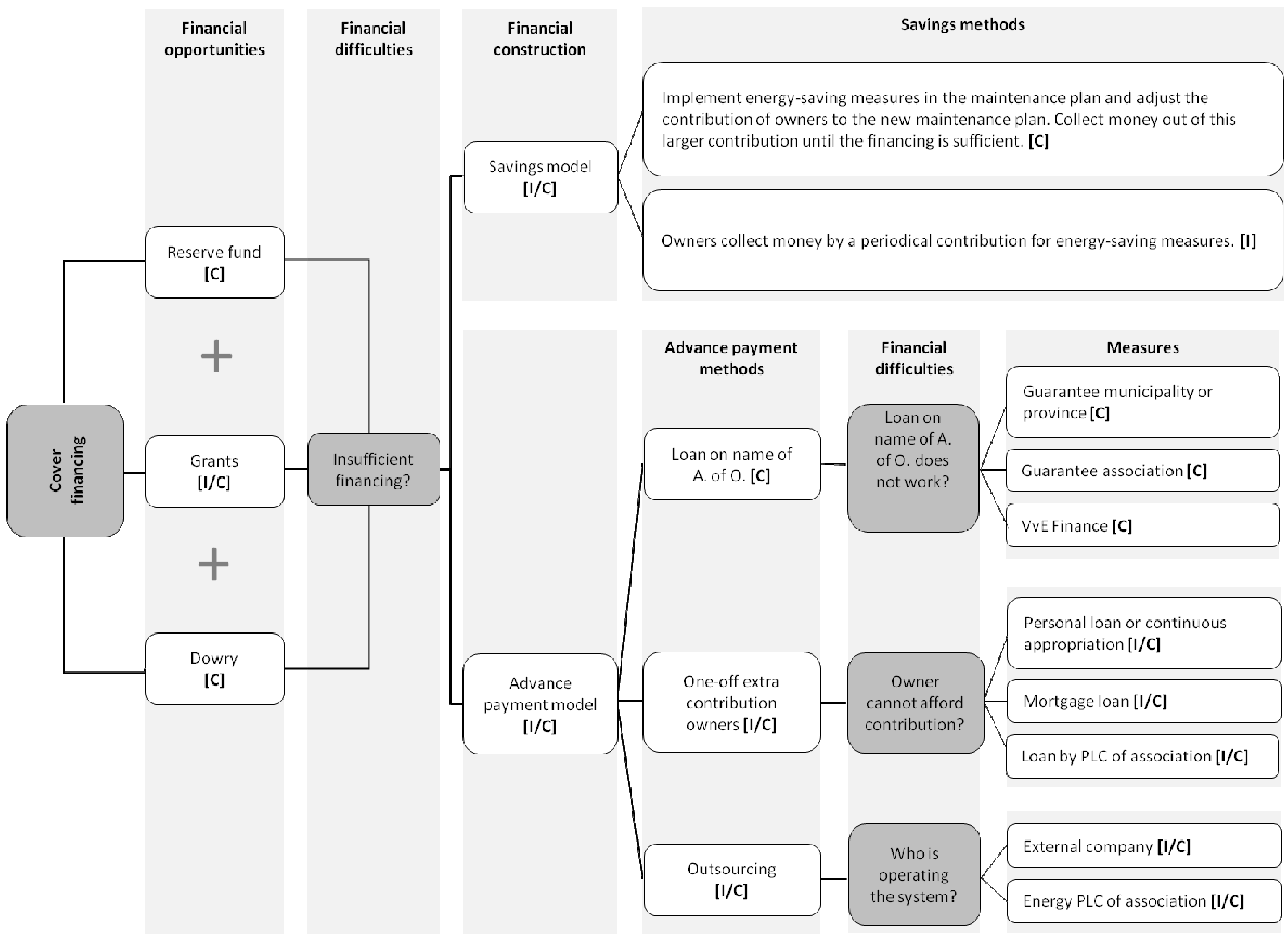

Figure 3: Measures to cover financial difficulties in mixed complexes

CONCLUSIONS
Difficulties that are encountered when implementing energy- saving measures in a mixed complex can largely be reduced or prevented. Initially prevention is a highly preferred solution. If a housing association has the intention to sell apartments in a rental complex, certain measures can be taken beforehand. This is only possible in a homogeneous rental complex. If a complex is already mixed to some degree, difficulties can be reduced with other means, including adequate persuasion tactics and financing.

There are no ideal solutions for all problems. Some solutions might not even be useful for all complexes. In other cases some methods can be used simultaneously. Which solution is most suitable depends on the situation.

DISCUSSION
The amount of research concerning difficulties in mixed complexes has increased but these studies usually only focus on one specific field, for example the judicial difficulties. This project shows all difficulties that can be encountered.

The literary study was supplemented by the interviews. These interviews provided a better perspective on reality. Housing associations defined several difficulties that did not follow from the literary study. The interviews also showed which difficulties are actually encountered in practice.

The validity of this type of research can be increased by a larger number of interviews (now seven). The data from these interviews varied. Although they provided an interesting view of the practical experiences of housing associations, it is not possible to generalize the results or to conclude that all possible difficulties are listed. The number of interviews was, partly, caused by the limited period of time for this research.

In personal interviews it is important to be aware of the subjectivity of the opinions of respondents, although most results refer to general experiences. The opinion is mostly expressed indirectly by accentuating certain aspects that are important to the respondent. This should be taken into account when analyzing and interpreting the data. The publication of the names of respondents may affect this phenomenon. Anonymous interviews could increase the reliability of the data.

Not all respondents had the same function. The ambition was to interview two employees of each housing association: one person involved in the Association of Owners management and one person involved in energy policy. In some companies the interview took place with only one person. Due to this the results of the interviews are not entirely comparable. The quality of the data could be enhanced if the interviews were done with employees with similar functions across housing associations.

RECOMMENDATIONS
The advice to housing associations is to be actively engaged in energy-saving measures in mixed complexes because of the increasing urgency to deal with low-energy houses in the existing housing stock. In addition, the number of mixed complexes is increasing.

It is advisable to pursue a proactive policy and to choose clear objectives and methods. For instance, a housing association can compose a standard procedure for dividing rental complexes, or specific procedures can be used to implement sustainable measures, such as a certain financial system. By pursuing a proactive policy the efficiency can be improved.

In view of the continuing damage to the environment, the permanent high energy costs and the more difficult financial feasibility of future measures, it is not advisable to postpone energy-related renovations in a mixed complex.

SUGGESTIONS FOR FUTURE RESEARCH

- More research has to be done into juridical aspects to formulate specific measures for housing associations.
- Guarantees on lower energy costs for tenants by housing associations can improve the willingness to consent. Further research on this method is recommended.
- Establishing a private limited company is often an unknown subject for housing associations. It is important to gain more insight into this solution.
- Gain more insight in the procedures and risks of guarantees on loans if the loans are contracted on the name of an 'Association of Owners'.
- Get a better perspective on the energy-saving measures that are taken by the housing association and those that go through the 'Association of Owners'.

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“Where there´s a will there´s a way.”

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WHAT OPPORTUNITIES IS SHRINKAGE OFFERING FOR SUSTAINABILITY?
The case Heerlen

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ABSTRACT
This research investigates the possible offering of opportunities for sustainability in shrinkage areas. The phenomenon shrinkage is elaborated and its meaning for The Netherlands. The extent of the issue for Parkstad Limburg and Heerlen as a pioneer shows us the effects for the future. The interaction between shrinkage and sustainability and the current approach in Heerlen offers insight into the possible solutions and opportunities. Possible improvements (product and process) in the form of an advice provide the municipality of Heerlen with tools to approach the sustainability issue in the shrinkage districts.

Keywords: population decline, sustainability, redevelopment, opportunities, Heerlen

INTRODUCTION
With Parkstad Limburg in the south of The Netherlands as a leader, more and more regions in the country will be facing population decline (shrinkage) in the future. The occurring problems vary from vacancy and deferred maintenance to a depleted offer of educational facilities, medical care and retail. The shrinking regions are positioned in a transition process that comes together with restructuring tasks, but at the same time it could offer new opportunities, e.g. in the field of sustainability.

The municipality of Heerlen has been dealing with the shrinkage issue for several years already. While searching for solutions the emphasis was mainly on the enhancement of the economical structure. Lately, the possible opportunities for a sustainable improvement of the residential, working and living environment have become clear. So that means there is awareness of possible opportunities for sustainability measures, but especially because of the complex context it appears to be difficult to focus on these opportunities, clarify them and seize them. The goal of this research is to give an advice to the municipality concerning the approach of sustainability measures in its shrinkage districts.

Research Questions
In order to try to solve the stated problem and reach the goal the following research questions have been formulated:

"Is shrinkage offering opportunities for sustainability in Heerlen?"

The main research question will be answered by using several sub-questions:

- What is shrinkage and what does it mean?
- What does shrinkage mean for The Netherlands: which regions are dealing with it and to what extent?
- What is the extent of shrinkage for (the region of) Heerlen in the (near) future?
- What is the interaction between shrinkage and sustainability?
- How is the municipality of Heerlen dealing with shrinkage in relation to sustainability?
- What are possible improvements (product and process) concerning sustainability for the municipality of Heerlen?

Research Design

The research is mainly characterized by a qualitative research strategy. The result is achieved by a significant portion of desk research with a thematic elaboration. There are mainly three parts; Literature Study, Advice and Conclusion. The Literature Study consists of the contextual orientation of shrinkage and of the approach of sustainability at the municipality of Heerlen, and the relationship between shrinkage and sustainability. The Advice contains recommendations about the approach of sustainability in shrinkage districts, based on previous gained knowledge. Finally, the Conclusion provides an answer to the research questions, discusses this research and gives recommendations for further research.

CONTEXTUAL ORIENTATION

Shrinkage is a phenomenon that more and more European countries are facing. Since the Industrial Revolution our thinking has been based on growth; both of the population and of the economy. That demands a shift in thinking. For this research, the context of the shrinkage issue in terms of what it stands for, what growth means on the opposite side, what the causes and effects are and what current policies comprise, have been investigated.

Shrinkage

The definition of shrinkage:

"Demographic decline is mostly defined as a decline in the total population number in a certain area." In the course of this research this approach is too narrow. Furthermore it is stated: *"Demographic decline comprises three aspects: (1) numbers (population, households), (2) demographic composition (age, ethnicity) and (3) household composition (size, life stage, income)."* (van Dam, de Groot, & Verwest, 2006)

In the current situation some specific trends are showing up in the demographic development: on one hand there are factors that infleunce the *composition of the population* (dejuvenation, aging, discoloration) and on the other hand there is the factor that influences *the size of the population* (births and deaths, settlement and departure); the relatively new phenomenon of population decline. The *structural character* of the current population decline in certain parts of The Netherlands is what makes it so special. (Derks, Hovens, & Klinkers, 2006)

Growth

On the opposite side of shrinkage we find growth:

"Growth is mostly seen as a linear process. Linear growth means an increase with a constant quantity per time unit. We speak of exponential growth when a quantity increases with a constant percentage per time unit. The amount is getting larger because the total accumulated amount increases." (Meadows, 1972)

The Club of Rome in 1972 already posed the question of the *Limits to Growth*. There is a long list of necessary conditions to fulfil to keep the growth going, there are roughly two categories. The first one consists of material conditions: food, resources, fossil and nuclear fuels and the ecological system of the planet. The world stocks of these material resources will ultimately determine the limits of growth of the planet. The second category comprises the necessary conditions in the social field: if the first category conditions are met, the growth of the economy and population will still be depending on factors like peace and social stability, breeding, employment and technological progress. These factors are much harder to determine and to predict. (Meadows, 1972)

Shrinkage versus Growth

In fact, shrinkage is a very normal phenomenon; it occurs everywhere around us in the world. Growth and shrinkage belong to each other, they form an organic and rhythmic process. Growth is always limited and temporary and shrinkage then offers a condition to new growth. In other words, they keep each other in balance. (Hospers, 2010) There is nothing new to this for physicists. To them, growth is a process of rise, decline and revival. But little research concerning shrinkage has been done in other disciplines. There are limits to growth, as the Club of Rome already pointed out in the 70s. More growth does not always lead to prosperity, moreover; more growth could eventually have adverse effects. (Hospers, 2010) So why do we not learn from Mother Nature, that endless growth leads to falling over? Take in mind the current economical and sustainability crises; shrinkage would then be a blessing then.

Shrinkage: Trends & Developments

Causes

There are roughly three causes identifiable for shrinkage: a socio-cultural (individualization, emancipation), a (regional-)economic cause and a planning cause. Reduced attractiveness is also often a reason for migration. Socio-cultural developments have impacted the number of births the most. Especially the emancipation of women in the 60s and 70s played a large role in this. Due to the rise of birth control and the increasing education and labour participation there was a large decline of the Dutch fertility rate. Besides, people are living together or getting married at an older age, many women have their first child later in life and an increasing number of couples stay deliberately childless. These developments have led to a strong aging and dejuvenation. Economic factors also influence the fertility rate; the desire of women to get an education and participate in the labour market is one of the causes. Besides, people's trust in the economy influences the housing market, the purchase of expensive consumer goods and especially having children. Also, more inhabitants move abroad (emigration) when the economy is in a downturn. The relation between economic, socio-cultural and demographic developments is mutual and therefore complex. (van Dam, de Groot, & Verwest, 2006)

The regional-economic situation can have a large share in the performance of shrinkage. The presence of a mono-industrial culture can have large negative consequences once an industry collapses or leaves the region. Another trend is the increasing longing for privacy and more personal space, leading to de- and sub-urbanization. Finally, the planning policy of the central government plays a large role in the development of a municipality or region. Some areas are e.g. pointed out as 'growth cores' while others are kept small. (van Dam, de Groot, & Verwest, 2006)

Effects

Shrinkage has effects on several aspects of society; housing market, living environment, facilities, mobility, regional economy, environment, spatial governance and demand for space. Concerning the housing market shrinkage is of direct influence. Not so much the decrease in total population, but especially the development of the number of households and the size of those households is relevant; they constitute the demand side. Changing demand-supply conditions at the regional housing market or in certain segments have direct consequences on local level. It can lead to vacancy, pressing of the value and price, decreased revenues and financial problems. The composition of households is also important. This implies a shift in thinking in terms of quantity to quality. Special attention is needed for the way in which the current housing stock has to be adapted, replaced or demolished. Especially the ongoing aging (= growth!) demands for special interventions. Finally, the liveability in districts is under high pressure as a result of shrinkage. Interventions are needed to avoid districts ending up in a downward spiral. (Reckien & Martinez-Fernandez, 2011)

Geographical orientation

In The Netherlands there is a 'two direction development'; in one region the population is declining or will decline in the near future (first generation) while in the other region an ongoing population growth is expected in the next decades (second generation). However, all regions in the country will face shrinkage at some point in the future (around 2040). Yet, growth areas can be found in the economic core areas (the Randstad and its outlet axes), while the main shrinkage areas are located in the periphery (Parkstad Limburg, Noordoost-Groningen and Zeeuws-Vlaanderen as the first ones). (Hospers, 2010)

In other countries the phenomenon shrinkage is also well-known. Germany, the USA, the UK and Russia are also dealing with the issue and several possible solutions are being tried there. The presence of a mono-industrial economy appears to be a large cause of the issue in many cases. Solutions vary according to region specific circumstances. (Shrinkingcities.com, 2004)

Historical orientation

Since the Second World War, the Baby Boom has been responsible for a large population growth in The Netherlands. Since the 70s the increase has been very gradual and the growth varies per region; the edges of the country and the north and south wings of the Randstad lag behind compared to Dutch average. At municipality level shrinkage is not a new phenomenon at all. Many municipalities in the Randstad faced a population decline in the 70s. Noordoost-Groningen and Zuid-Limburg also belong to this category. During the last 30 years Rotterdam has been the leader. The main causes are dilution of households and suburbanization. Nowadays the largest absolute decrease is occurring in Zuid-Limburg, Noordoost-Groningen and Zeeuws-Vlaanderen. The population of The Netherlands will grow until 2035, then the shrinkage will deploy in the entire country. (van Dam, de Groot, & Verwest, 2006)

Policies

The demographical developments in The Netherlands consist of four elements; dejuvenation ('ontgroening'), aging ('vergrijzing'), discoloration ('verkleuring') and population decline. These components lead to different situations from place to place, demanding for custom-made solutions.

Shrinkage demands a paradigm shift and all stakeholders have to learn to cope with the situation. Four shrinkage policies are currently known in the country, the so-called 'four B's':

- 'Bagatelliseren' (= deny): "In the unexpected event that shrinkage would occur in our region, it will stay limited."
- 'Bestrijden' (= fight): "We invest in city and region marketing to attract new inhabitants and we build dwellings for them."
- 'Begeleiden' (= guide): "How do we keep the current inhabitants from leaving?"
- 'Benutten' (= exploit): "Our happiness does not depend on population numbers, but on the quality of our living environment; we see opportunities." (Hospers, 2010)

PARKSTAD LIMBURG – HEERLEN

Parkstad Limburg and its centre city Heerlen are the pioneers of The Netherlands when it comes to dealing with shrinkage. Parkstad is a metropolitan area in the south of Limburg with a total population of almost 252,000 inhabitants. It is a highly dense area with four urban municipalities and four rural ones. Between 1900 and 1975 the area was well-known for its industrial extraction of coal. Presently, all coal mines are dismantled, but the marks of the closed mines are still present.

Heerlen

Heerlen is the largest municipality of Parkstad with almost 90,000 inhabitants (2011). The history of Heerlen dates back six thousand years in time. Thanks to the mining industry the city grew explosively during the 20th century; from 7,000 inhabitants in 1900 to almost 100,000 in 2000. Thousands of miners with families needed housing. In 1965 the Dutch government decided to close the mines; the region was dependent of its mono-industrial culture and as a result the economy began to face hard times. This led to problems in several fields, part of them still present. (Gemeente Heerlen, 2008)

Issues

Current issues in Heerlen are of diverse nature. First of all the population decline; present since 1997 and a trend that will continue for years. The individualization and social cohesion are also of problematic nature. Through the closure of the mines and the establishment of several government services, the 'we'-feeling is lost somehow. The social cohesion in the neighbourhoods was always very strong, due to the mining history. But the city never really managed to take over this role. The sense of insecurity and the occurrence of crime have been combated the last years, more and more successful. Globalization of the economy also has its impact. Scaling demands for more and more cooperation with other cities, while attention needs to be paid to the distinctiveness of the own city. Heerlen has large benefits in terms of its location, but concerning accessibility e.g. there are still major steps to be achieved. Finally, Heerlen has always had a 'following character' during the last century, because the developments came so quickly that the city could hardly anticipate. Since the end of the 20th century Heerlen has been relatively stable. The municipality has increasingly demonstrated its 'steering role' during the last years. The policies however are sectoral in nature, therefore goals remain somehow incoherent. (Gemeente Heerlen, 2008)

Vision

The current situation in Heerlen offers opportunities for the elaboration of experiments and innovation. The theme 'new energy' plays a major role, a theme that is connected to 'old energy'; fossil fuels, that once gave the region an enormous boost. In the 21st century the emphasis is on innovation, production and application possibilities of environmentally friendly fuels. (Gemeente Heerlen, 2008)

Shrinkage in Heerlen

Effects

Heerlen is experiencing a negative development on the housing market that is set in by the shrinkage of the population. According to forecasts the number of households will first stabilize as a result of household dilution, but in time it will decrease. At this moment Heerlen faces a vacancy rate of more than 5%. By doing nothing the surplus of dwellings will increase further. However, this does not mean there is no new estate needed. The households are not only changing in numbers, but their composition will also change. There will be more elderly and less younger people in the future. This involves other housing needs.

Some important aspects for the housing demand in Heerlen:

- The number of households will decrease less than the number of people in the upcoming 20 years (dilution).
- The age category 55-74 years will sharply increase (aging), while the categories up to 35 years and 35-54 years will decrease vigorously (dejuvenation).
- In 2040 the number of households will be decreased with 14% (shrinkage), mostly young households and families with children (dejuvenation).
- The number of 75-plus households by the time will be increased with 67% (!).
- The number of 55-plus households will reach its peak around 2030; 53% (!) of all households will consist of people older than 55 years of age. (Companen, 2011)

Sustainability approach of the municipality

Integration

The municipality of Heerlen is committed to climate and (new) energy; energy is a traditionally important theme for the city. In its Climate Policy Plan, the city adopted a reduction of 20% of the CO2 emissions within the municipality borders by the year 2020, through a 20% energy reduction and a 20% sustainable generation. The general goal of Heerlen is to focus on energy savings and the application of sustainable energy. The application of other sustainability measures is also being encouraged. Many existing (shrinkage) districts need intervention and it is a great opportunity to use these moments to make them more sustainable. (Gemeente Heerlen, 2010)

DPL ('DuurzaamheidsProfiel van een Locatie')

The municipality emphasizes on sustainability, also in area (re)developments such as the restructuring of shrinkage districts. To measure the sustainability score of certain districts the computer tool DPL ('DuurzaamheidsProfiel van een Locatie') is being used. The sustainability of a district is being measured by comparing it to a reference district. The tool includes three elements (People, Planet and Profit), 11 themes and 24 aspects to cover the total sustainability concept. The municipality is interested in the usefulness of the tool and the application of sustainability measures in shrinkage districts. (IVAM UvA BV, 2009)

SUSTAINABLE REDEVELOPMENT OF SHRINKAGE DISTRICTS

Sustainability in the built environment is often only focused on energy, i.e. energy savings, enhancement of the housing stock, energy poverty, residents' behaviour, financing structures etcetera. But when it comes to sustainability in urban redevelopment projects in especially shrinkage areas, a more integral approach is demanded.

Interaction between shrinkage and sustainability

The subjects, themes and aspects that are included in the DPL instrument covers a broad range of the aspects that we consider to be involved in sustainability as a general concept. Therefore, all 24 sustainability aspects are elaborated in their relation to shrinkage. Some of the aspects have a clear relation with shrinkage, while others do not have a significant connection with neither shrinkage nor growth. For example, 'Use of Space', 'Mixing of Functions', 'Flexibility', 'Quality of Facilities' and 'Quality of Dwelling & Surroundings' appear to have a strong relation with shrinkage. While aspects like 'External Safety', 'Sustainable Companies' and 'Soil Contamination' seem to weaker related.

Survey

Because the municipality is concerned with the implementation of sustainability and it is using the DPL-instrument to measure sustainability performances of districts, the opinions of policymakers about sustainability related to shrinkage are investigated.

Most policymakers find that the municipality is actively engaged with the topic sustainability, but more attention should be paid to it. Also, almost everyone sees shrinkage as an opportunity for the implementation of more sustainability measures. The topics 'People' and 'Planet' are valued the most, because liveability is seen as the major translation of sustainability. The most tangible/ concrete sustainability measures are considered to be the strongest related to shrinkage and the most promising; 'Energy', 'Green in the District' and 'Quality of District & Dwelling'.

Policymakers are worried about the social side of the shrinkage issue. Restructuring has to provide a solution for this. It is also remarked that restructuring of the housing stock is very much needed; shrinkage offers opportunities we will not be offered again in the upcoming 50 years.

Case studies

The municipality of Heerlen has been dealing with shrinkage for several years now. Some districts within the city are most urgent to tackle. Three districts are taken a closer look at; Meezenbroek-Schaesbergerveld-Palemig (MSP), Vrieheide (Vrieheide-De Stack) and Aldenhof (Centrum-De Dem). All three of them are currently in the process of restructuring, though all in a different phase. For this research the way of restructuring related to sustainability was investigated.

In MSP the municipality and housing corporations are cooperating to achieve spatial and economic-renewal. The district is dealing with socio-economic setbacks, an outdated housing stock and shrinkage. The district is undergoing a large restructuring; new facilities for elderly, a new shopping heart, a broad social facility and dilution and restructuring of dwellings. Besides, there will be highly focused on the social side of sustainability.

The small-scale project Aldenhof at walking distance from the centre of Hoensbroek, is in urgent need of restructuring; improvement of the housing stock, physical situation and social cohesion. Regarding the shrinkage issue it is time to strengthen the urban structure of the district. The demolition of most of the existing dwellings will make place for less new estate and 'life course steady' dwellings. A broad social facility will also be established. When it comes to sustainability, the goal for this project is ambitious.

The restructuring of the district Vrieheide is complex and dynamic. The restructuring of the housing stock is particular, because it takes place in a setting with mainly privately-owned dwellings. In the upcoming years the municipality wants to take a series of measures to improve the liveability in the district. The plans include the purchase of privately-owned dwellings and the new estate and renovation of dwellings. Currently the vision and designs for the district are being developed.

ADVICE

The advice concerning the approach of sustainability in shrinkage districts in Heerlen is addressed to the department of 'Stadsplanning' (City Planning). The structure of the advice is threefold; social, spatial and organizational.

Social & Spatial advice (product)

For Heerlen it is extremely important to improve the liveability in its shrinkage districts. Shrinkage reveals itself by social problems in the district; that is what inhabitants see and experience. Making a district more liveable is making it future-proof. An important component is the social side of the sustainability issue. The stimulation of improvement of the social safety and social cohesion by the municipality are important for the sustainable development of the districts. This includes the establishment of social facilities, but also the construction of green facilities. This involves certain physical measures, which lead to an improvement of the social aspects, resulting in more liveability and thus in a higher sustainability. Positive social developments create support among inhabitants and form a base for profound physical sustainability measures. Aspects that are highly-ranked on the list of interventions include 'Mixing of Functions', 'Flexibility', 'Quality of Facilities', 'Use of Space', 'Energy', 'Green in the District' and 'Quality of Dwelling & Surroundings'; merely the aspects that resulted from this research to be strongly related to shrinkage.

Organizational advice (process)

Besides improvable aspects in the social and spatial field there are also aspects in the organizational field that deserve attention. One of the main issues is 'communication'. This means communication within the municipality; within the department of City Planning and within the municipality. The advice is to make sustainability a more integral part of the process. The communication between the municipality and its inhabitants also needs attention, especially concerning the occurrence of shrinkage and the need for sustainability. It is of great importance to create support among stakeholders. Cooperation is very important to reach stated goals. The last part of the advice is about the computer tool DPL. DPL is useful to get an idea about the sustainability performance of a district and it is a nice base for further research and design. The usefulness for shrinkage districts could be improved, but it is a nice tool to get an impression of the performance of sustainability measured in shrinkage districts.

CONCLUSION

The research concludes that shrinkage indeed offers opportunities for sustainability.

Although shrinkage is perceived as a negative phenomenon, nature is furnished to growth ánd shrinkage; they keep each other in balance. Parkstad Limburg is a pioneer in the field of shrinkage. The issue in the municipality of Heerlen is quite severe; they get confronted with urgent bottlenecks like vacancy, deferred maintenance and impoverishment of the facility level. However, the structural character indicates the urge for interventions. Due to the 'exploiting' attitude of the municipality opportunities are seen on the horizon. Restructuring of many districts is needed and sustainability increasingly calls for attention. This creates possibilities for enhancement of the situation and they will not be offered again in the upcoming 50 years. The focus has to be on certain physical and social aspects, reinforcing each other and thus creating a sustainable base for the districts. Together with improvements at the organizational side future-proof districts in Heerlen are about to be born.

Discussion

The financial side of this story is not taken into account, but it is an important factor for the feasibility of the proposed advice. Also, sustainability could be approached from another point of view. The relations between shrinkage and sustainability are largely based on information from sources, but it is almost inevitable to incorporate an own opinion and perception. Finally, the conducted survey among policymakers was very interesting, but quite small in numbers. To achieve a more extensive result this investigation could be enlarged.

Recommendations
The relationship between shrinkage and sustainability can be investigated further. The comparison of DPL-profiles of shrinkage districts could be very interesting, but when performing this research sufficient data were unfortunately lacking. The sustainability approach and its elaboration are still in its infancy, despite the huge amount of knowledge present among stakeholders. An investigation of a more profound implementation is desired. The result of this research is quite adjusted to the situation in Heerlen. In order to generalize it more research in this field is required.

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"This research inspired me to learn more about the involved topics and our discipline. It also made me eager to bring my gained knowledge into everyday practice."

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DEPLOYMENT STRATEGIES FOR SOLAR PV PANELS
A latent class conjoint analysis to determine consumer preferences

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ABSTRACT
This paper contains the most important findings of researching deployment strategies for solar PV panels. With the rescinding subsidies on small scale sustainable energy generation new strategies have to be found to increase the deployment. In this thesis the preferences of the consumer on the different strategies are investigated. These preferences are determined using a conjoint analysis. With the use of a latent class model a segmentation is determined. The most important conclusion is that consumers prefer a quality mark, they prefer locally deployed panels and the payback time has a low decisive influence on the decision. You can clearly divide three groups concerning their willingness to invest in solar panels.

Keywords: Deployment strategies, conjoint analysis, latent class, decision behavior, consumer preferences

Introduction
In the media solar PV panels get a lot of attention. Several researches highlight the potential of solar PV. The most important question still remains: how to realize the potential? This thesis focuses itself on consumers as investors. In this way citizens are contributing to the energy neutrality of their city and they can profit from it. The lack of consisting policies did not encourage individuals to shift to PV panels. Financial incentives by the national government in the Netherlands are rescinded for small scale installations. So municipalities should find new alternative ways to reach their goals. To be energy neutral and achieve general understanding the deployment by individuals PV panels is essential. Solar PV panels are an easy way for civilians to generate renewable energy and increase the awareness to complete the transition to sustainable energy resources. The province of 'Noord Brabant' and the municipality of Eindhoven emphasize on solar PV and encourage the deployment (Gemeente Eindhoven, 2011). When a city strives for energy neutrality solar PV shows much potential, because it is easily applicable in the urban environment. Furthermore the electricity use will increase in the future, that is why the need for sustainable generated electrity will rise.

This all leads to the following problem definition. With the rescinding of subsidies on small scale, solar PV still shows much potential, but the deployment rates lag behind. How can new strategies increase the deployment of solar PV panels? *The goal was to get a clear picture of the decision criteria of individuals. This leads to a better understanding of the market and a foundation on which municipalities can build their strategy. Furthermore a segmentation will be determined to make the strategy more effective. The following research question will be answered:* Which deployment strategies will stimulate the deployment of PV solar panels the most? This question is divided in several steps. First of all the technology is elaborated, than the different deployment strategies are discussed. Thirdly the individual decision behavior for sustainable energy generation is addressed. This is the foundation for the conjoint analysis to determine consumer preferences to answer the main research question. After this the method used will be described. Then the results of this research will be elaborated. The results were transferred into a project plan with concrete recommendations to increase the deployment of solar panels. This all will lead into the conclusion and discussion of the thesis. This research focuses on the small scale generation of solar PV panels by individuals. The focus area is current estate, in this field there is a lot of potential which not have been deployed yet. In this way a true energy transition could take place. With this research municipalities could adapt to consumer preferences and maximize their deployment with low expenses. In this research bottom up market strategies are compared in a scientific way.

Literature study

The literature study contains three parts: the technology, deployment strategies and the sustainable decision behavior. With solar panels the way of energy consuming can change. Instead of paying a price per kWh you can generate energy yourself and invest in solar panels. The efficiency of the panels determines how much energy could be generated per panel. With the panels you cut your energy bill and you can gain back your investment. The energy price plays an important role in the predicted payback times. If the energy price increases for instance you save more on your energy bill and you gain back your investment sooner. The solar industry is a worldwide market which is constantly evolving. Already in Eindhoven a competitive industry is established (Berenschot, 2011). Solar panels are now reaching payback times of 12 years. In the coming years this could even lead to 8 years. To get full understanding of the deployment strategies one needs to understand the energy taxes in the Netherlands. Certain problems bound the success of solar panels. The orientation is extremely important; to get full efficiency it should be orientated to the south without any obstruction. A new problem is the quality problem. When the deployment rate is increasing, the need for sustainable produced panels is increasing. A total sustainable solution could be needed.

In the Netherlands several initiatives are developed to increase the deployment of solar PV panels. These are adoption programs, leasing programs, investment programs and local initiatives (Arcadis, 2011). Next to these programs still there are a lot of municipalities which offer some kind of grand to diminish the investment costs. This leaded to the two parameters which differed among the strategies and these will be used in the conjoint analysis; purchase service and organizational form. Next to this the decision behavior of individuals was elaborated concerning sustainable energy measures. On important study of Bouwfonds investigated the willingness to pay for sustainable energy generation systems in new estate housing (Bouwfonds, 2010). Next to this a research of Haas was conducted which determined the major factors in a willingness to pay study, he defined the major factors as: "Pure investment costs, affordability, transaction costs/efforts, technical performance/technical reliability, environmental benignity and the social acceptance of PV" (Haas, 2002).

The socio demographic which influence the willingness to invest are derived from different sources. Rogers claims the higher the education, the higher the willingness to pay (Rogers, 2003). The Bouwfonds study found out that a lack of knowledge is an important boundary is purchasing renewable energy generation systems (Bouwfonds, 2010). For the segmentation the adoption theory of Rogers was used. He defines five groups of adopters: 'early adopters', early adopters, the early majority, the late majority and the laggards (Rogers, 2003). This information will be used to compare the segmentation derived from the conjoint analysis.
The different attribute levels result in different strategies. The attributes should be determined independent from each other. The different attributes used in this experiment are listed below:

Table 7: Attribute and attribute levels conjoint experiment

Attributes	
Investment Costs	4000 – 8000 – 12000
Purchase service	Self-service – Standard – Personal guidance
Payback time	8-10-12 year
Organisation/ Location	Own roof – Local – external
Quality mark	No quality mark – Quality mark – Sustainable mark

The investments costs are based on the capacity of the panels. This means the number of panels. The purchase service is the service offered during the purchase. The payback time is based on the efficiency of the panels. The payback time will decrease in the coming years. The organisation and location is the fourth attribute. This concerns the location of the panels and how it is bought. The last attribute is the existence of a quality mark. These are the five most important attributes when deciding to purchase solar panels.

Method

To determine consumer preferences a latent class conjoint analysis was done. With conjoint analysis choice profiles are compared due to a full profile choice method to determine consumer preferences, in a dual response format. First the respondent was asked to choose between two profiles, then the respondent was asked whether he or she would purchase the chosen profile. With this method the most valuable results could be distinguished and the actual choice of the respondents could be simulated the best. Firstly, due to the large amount of profiles a full fractional factorial design was used. This leaded tot 18 profiles which were combined randomly, this leads to 9 choice sets. The interaction effects are not taken into account due to the fact that the independence from irrelevant alternative assumption is assumed. The different choice sets were shown in random order to the respondents. The different attributes were coded using effect coding (Kemperman, 2000).

Model

There were several models used to process the results. The multinomial model was the main model and it was used to process the results and construct the questionnaire (Kemperman, 2000). This model is based on the random utility theory which can be described in the following formula:

$$U_i = V_i + \varepsilon_i$$

The systematic component can be defined further. This is done by putting together the different path worth utilities. In this way low appreciation of one attribute can be leveraged by another attribute with high appreciation. In this way this component can estimate the utility of the total profile (Kemperman, 2000):

$$U_i = \sum_k \beta_k X_{ik} + \varepsilon_i$$

Taking into account the IID assumption the choice probability of the profiles are calculated as follows:

$$P(i \;/\; A) = \frac{\exp\,(\mu V_i)}{\sum_{i' \epsilon A} \exp\,(\mu V_{i'})}$$

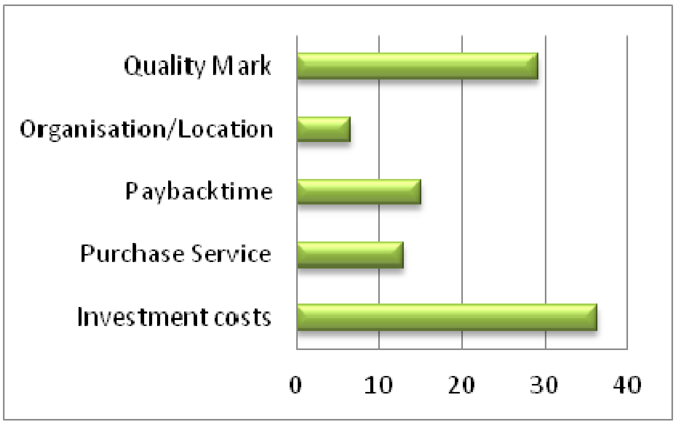
A latent class model was used to distinguish a segmentation between the population. The data was processed using Limdep. Next to this a binomial model was used, with and without the inclusion of the purchase question. Finally, an ordinal model was used to test the acceptance of the different strategies.

The questionnaire consisted out of eleven socio demographic questions which could influence the choice experiment. After this the respondent was asked to choose between the 9 different choice sets. The data was collected by doing an on line survey. The data was collected through the online panel of the municipality of Eindhoven, called the Digipanel. The Digipanel consist out of 4000 respondents. 2000 respondents were contacted for this research. The respondent's rate was high, with 42 percent. 854 people filled in the questionnaire completely. The sample has characteristics which indicate a more positive attitude towards solar panels than the average citizen of Eindhoven. Still all groups are represented and thus the sample is valid for further estimations. The sample contains mainly higher educated people and house owners. According to the literature they have a positive attitude towards sustainable energy measures.

Results:

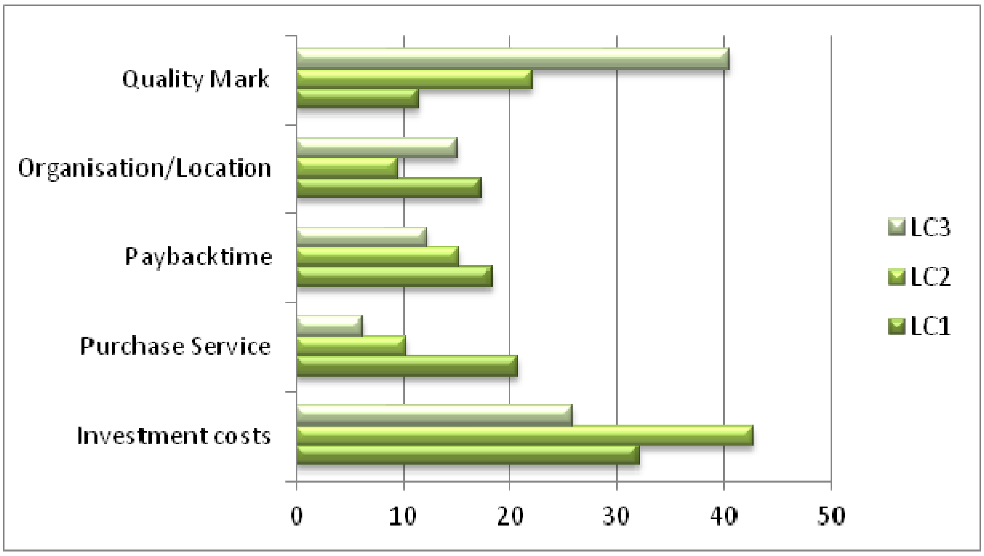
First of all the answers to the first socio demographic questions are discussed. Only three percent, 31 respondents, has already purchased solar panels. People's image of solar panels was highly positive, 73 percent defines it as a clear contribution to the building environment and it has a sustainable and modern image. In the questions which were related to the purchase reasons you can answer two options, this leads to the following percentages. The two main reasons to deploy solar panels are the depletion of energy and the independence of energy; these were chosen by 49 and 51 percent of the respondents. For 37 percent one of the main reasons to purchase solar panels is to push back the green house effect and for 36 percent the main reason is that it is an investment which pays itself back. The main reason for not buying solar panels are the investment costs, 79 percent of the respondents answered this option. The second reason is the payback time with 49 percent. The other reasons are less important. The main part of the respondent has a basic knowledge about solar panels, this part is 51 percents. 36 percent knows little about solar panels and 13 percent is well informed. TV, internet and magazines are the most important information sources to get information over solar panels. Only 16 percent was informed by friends or relatives. This means there is a lot to be won in this field, with more people deploying this number will increase.

Below the main results of the conjoint analysis are displayed. The chart gives the relative influence of the attribute levels on the decision. The investment costs play the most important role in the decision whether on not to purchase solar panels. Low investments are appreciated and high investment costs of 12.000 euro are highly depreciated. The lack of a quality mark is also highly depreciated by the respondents. The difference between a regular quality mark and a sustainable quality mark is low. The locally deployed panels are ranked the most positive of the attribute organisation. The payback time is the third important attribute. Self service is highly depreciated compared to the standard panel and the purchase with personal guidance. All these figures were expected by reading the literature. These path worth utilities could be transferred into relative importance of the attribute. Which attribute is the most important when making a decision? The relative importance of the attributes is described below:



The latent class model was used to determine different groups which gave corresponding answers. The three classes highly differ in their preferences of the attribute and attribute levels. The differences are displayed in the figure below.

Table 8: Relative importance latent classes



The different classes also relatively differ on socio demographic characteristics. The different characteristics of the classes are described in the table below:

Table 9: Characteristics latent classes

Characteristic	Latent class 1 'Skeptic'	Latent class 2 'Financially focused'	Latent class 3'Searching for security'
Age	Older people	Younger people	All ages
Reason to purchase		Energy depletion	Energy depletion Independence of energy price
Reason not to purchase	No trust in possibilities Disturbing objects	Too long payback times Too high investment costs	
Image	Not positive, not negative	Sustainable and modern	Sustainable and modern
Informed by who	Neighbors, not informed		Friends and family, internet
Information	Badly informed	Medium informed	Well informed
Education	Lower educated	Higher educated	Higher educated
Percentage:	0,342	0,436	0,222
Constant	Not willing to purchase	Medium willing to purchase	Willing to purchase

Three classes gave the most valid results with the highest rho squared. Below the rho square and the other important parameters are described:

Latent class					
Segments	Rho square	AIC	BIC	LLB	Difference
1	0,08721	1,73011	1,74005	-6637,8	
2	0,3672	1,396400	1,41719	-5343,36	1294,438
3	0,41588	1,29255	1,32418	-4932,25	411,109
4	0,42171	1,28286	1,32535	-4883,04	49,208

Project plan

Based on the results a project plan is elaborated to increase the deployment of solar panels in the municipality of Eindhoven. This plan describes location, process and organisation to maximize the local deployment. The vision is to increase the deployment due to local exploitation. In this plan the municipality should be represented by the local energy company. Locations have to be chosen with a local connection and which can build on a network, is this way people are more eager to join the cooperation. The process has clear decision moments in which things have to be chained so the next phase can start. In this way the projects have solid business cases. The new founded local energy company can have a leading role in the project (Gemeente Eindhoven, 2011). In this way the authority of the municipality can make use of the competitive market to offer the best deals to the citizens.

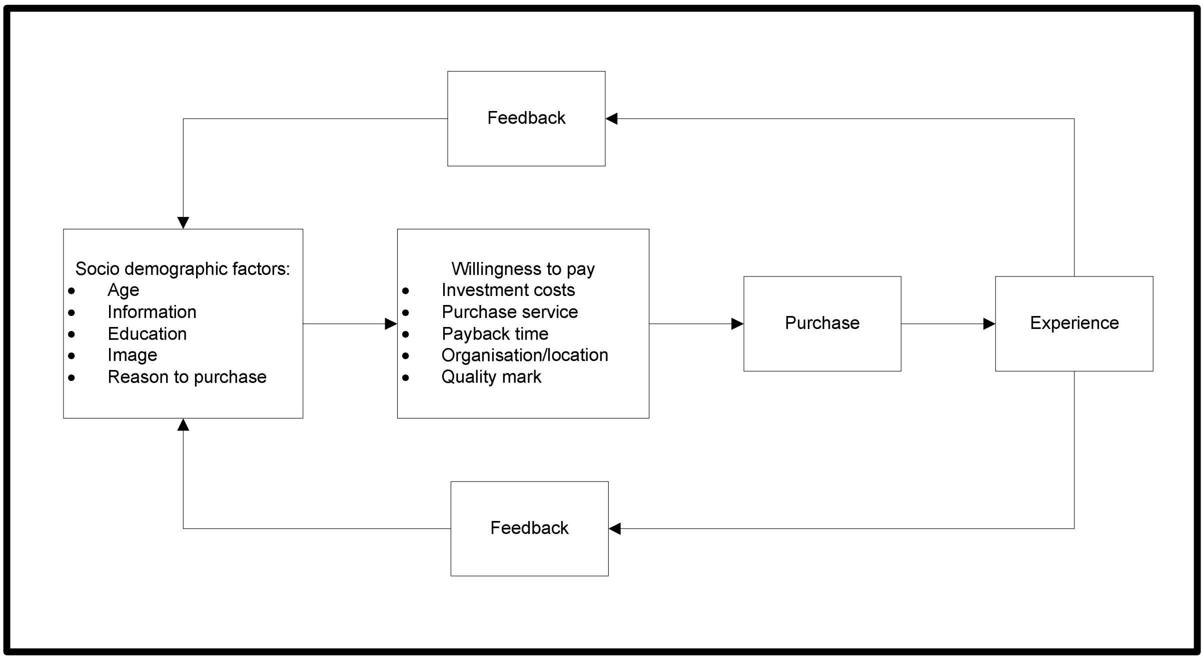
Conclusions:

On average this research confirms the great potential for solar PV panels. Nearly 60 percent of the respondents showed interest en willingness to invest in solar PV. The investment costs are the most important attribute in the decision making process. Lower investment costs are highly preferred and they still medium investments costs are positively appreciated. An important result is the depreciation of the own roof attribute level of the organization and location attribute. The location on the own roof is inextricable bound up with the purchase of solar PV panels. The governmental balancing system requires an own roof. As stated in earlier researches the lack of a quality mark is a serious issue regarding solar PV panels. This underlines the immaturity of the technology and this causes restraint among the respondents. When a quality mark is introduced people show more interest in purchasing solar panels. A sustainable quality mark is not more preferred to the regular quality mark. The regular quality mark is enough for the respondents. As the results show, the municipality of Eindhoven should supply information and an online service to encourage the deployment process. It is not necessary to give personal guidance according to the results of the questionnaire. The payback time has a low influence on the decision in general, also looking at the relative importance. The latent class analysis showed a segmentation which determined three different groups. The ‘Security’ group, latent class 3, is most likely to be persuaded and is persuadable by means in control of the municipality. To increase the willingness to pay the municipality of Eindhoven should secure a quality mark and supply standard packages. Furthermore this class prefers the organisation locally and they do value sustainable panels. The group consists of 22 percent of the respondents. They are mostly high educated, well informed and they have a sutainable and modern image of solar PV panels. The reason for this people to purchase is the depletion of energy and the possible independence of the energy price. All ages are represented in this latent class. The biggest class, latent class 2, is primarily financially focused and consists of 44 percent of the respondents. This group consists of mostly younger people who are medium informed and mostly higher educated. There focus lies on the financial parameters and overall they are medium willing to purchase. Their main reason not to purchase yet is the long payback times. They have a sustainable and modern image of the panels and with lower financial parameters they are willing to invest. They prefer the panels on their own roof and they do not care whether or not the panels are sustainable or only have a quality mark. This group will probably follow the latent class three if financial circumstances are more positive. The first latent class consists of 34 percent of the respondents. They are on average not willing to purchase solar panels. This group has low scores on significance, maybe due to a lack of interest. The constant is in this case extremely high. This group mainly consists of the elderly who are badly informed and lower educated. They have a neutral image towards PV panels.

The local strategies show more potential in the second and third latent class. Latent class 3 values the local deployment strategy the most. The willingness to invest corresponds with the choice probability of the local deployment strategy. This means that this strategy will increase the deployment the most. These choice probabilities are described in the table below:

Number	**Strategy**	**Latent class 1**	**Latent class 2**	**Latent class 3**
1	Standard Panel	0,304447	0,237983	0,178624
2	Adoption	0,14338	0,101819	0,205056
3	Individual	0,042713	0,114	0,137728
4	Local energy company	0,186512	0,313626	0,334381
5	Individual High service	0,322949	0,232572	0,144212

The ordinal regression shows biased results. The current situation with a local strategy is proven to be an acceptable strategy. This shows that with low investment costs a local energy company shows much potential to substantially increase the deployment of solar PV. Overall you could clearly define a role for the municipality to unroll solar PV panels. A new vision should be elaborated to maximize the deployment. Location should not be restricted to the own roof and new initiatives should be embraced. People do want connection with the panels, but locally placed panels are sufficient to fulfill this need. Furthermore people seek security of a generally accepted quality mark with separated responsibilities by joining a municipal program.



The figure above is based on the model of Ajzen, developed further by the Bouwfonds study (Bouwfonds, 2010). This model is changed and adapted to this research. The latent classes differ on different socio demographic factors as age, knowledge, education, image and reason to purchase. These factors influence the willingness to pay, the attributes used in the conjoint analysis. Important is the feedback loop, this represent the important feedback early adopters will have on the later adopters. This research sets general guidelines for future deployment of solar panels. When using this guidelines, Eindhoven could really be 'leading in technology' by turning in to a PV city.

Discussion
Further research could be done to specify this research. The preferences on the different locations could be researched more in dept. The interaction effects could be taken into account to determine the effects of combined attribute levels. This research is in financial aspects temporary of nature. The market is constantly evolving and things can change continuously. Nevertheless this research was based on the valid researches available.

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Bsc. Karel Adriaan Sormani

In his thesis all skills and capacities which I have learned the past 2 years came together. I have reached the goals I have set. It was great to get an insight in the market and the public regulations surrounding it. I hope you enjoyed reading it.

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DOOREXPLOITEREN, DUURZAAM RENOVEREN OF SLOOP GEVOLGD DOOR VERVANGENDE NIEUWBOUW?

Aanzet tot een multicriteria-analyse

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Samenvatting

Inleiding

Woningcorporaties hebben als doel: het bedienen van de primaire doelgroep. De te verwachten stijging van energieprijzen zorgt ervoor dat de primaire doelgroep steeds hogere woonlasten krijgt. Een belangrijk aspect hierin is het betaalbaar huisvesten van de primaire doelgroep. Wanneer de energieprijzen gaan stijgen is de primaire doelgroep een steeds groter deel van het inkomen kwijt aan wonen.

De te verwachten stijging van energieprijzen en de milieuproblematiek: opwarming van de aarde, stijgende zeespiegel, uitputting van hulp- en grondstoffen, en milieuvervuiling geven aanleiding tot een weloverwogen aanpak van de sociale woningvoorraad. De gebouwde omgeving is namelijk verantwoordelijk voor 45% van het energieverbruik in Nederland. Het is belangrijk dat hierin een grote kwaliteitsverbetering wordt gerealiseerd, woningcorporaties kunnen hier een grote bijdrage aan leveren. De totale woningvoorraad in Nederland bestaat voor 33% uit sociale huurwoningen (CBS, 2011).

Bij het aanpakken van de sociale woningvoorraad komen woningcorporaties te staan voor de strategische keuze tussen het doorexploiteren, duurzaam renoveren of slopen gevolgd door vervangende nieuwbouw van de sociale huurwoningen. Deze strategische keuze gaat gepaard met een hoge complexiteit. De hoge complexiteit wordt veroorzaakt door de veelheid aan criteria die van belang zijn bij het maken van strategische keuzes. De stijgende energieprijzen en de huidige milieuproblematiek zorgen voor extra criteria in het complexe beslissingsproces van woningcorporaties. Deze criteria hebben verschillende eenheden. Een MCA kan deze operationaliseren. Bij operationalisatie worden alle criteria naar een nieuwe schaal gezet, waarbij de waarden tussen de 0 en de 1 lopen. Hierdoor kunnen de criteria met elkaar vergeleken worden. Dit onderzoek heeft tot doel om woningcorporaties te ondersteunen in het complexe beslissingsproces.

Aan de hand van deze bevindingen kan de volgende doelstelling geformuleerd worden.

"Een aanzet maken tot een multicriteria-analyse (MCA) die woningcorporaties kan ondersteunen bij het maken van een strategische keuze tussen *doorexploiteren, duurzaam renoveren* of *sloop gevolgd door vervangende nieuwbouw* van sociale huurwoningen."

Om de doelstelling van het onderzoek te kunnen halen is de volgende probleemstelling geformuleerd:

"Welke criteria spelen een rol bij de strategische keuze van woningcorporaties tussen *doorexploiteren, duurzaam renoveren* of *slopen gevolgd door vervangende nieuwbouw* van sociale huurwoningen en hoe verhouden deze criteria zich tot elkaar?"

Ontwikkeling multicriteria-analyse

Vanwege de hoge complexiteit van de probleemstelling is in dit onderzoek gebruik gemaakt van een MCA. Een MCA is een vergelijkingsmethode waarbij verschillende onafhankelijke alternatieven vergeleken worden op basis van verschillende criteria. De hoge complexiteit wordt veroorzaakt door de veelheid aan criteria die van belang zijn bij de strategische keuze: *doorexploiteren, duurzaam renoveren* of *sloop gevold door vervangende nieuwbouw*.

Een belangrijke stap in een MCA is het definiëren van de alternatieven. De alternatieven staan voor de manieren waarop het probleem op te lossen is. Bij ingrepen in de fysieke staat van sociale huurwoningen dient onderscheid gemaakt te worden tussen planmatig *onderhoud* en *renovatie*. Planmatig onderhoud is gericht op het in stand houden van het bestaande en een renovatie is het aanbrengen van een wijziging en / of verbetering van het bestaande. In dit onderzoek worden de volgende drie alternatieven onderzocht:

1. *doorexploiteren;*
2. *duurzame renovatie*;
3. *sloop gevolgd door vervangende nieuwbouw*.

De criteria die worden toegepast in een MCA dienen als hulpmiddel om de verschillende alternatieven te toetsen vanuit een specifiek standpunt. Het uiteindelijke doel is om te komen tot een volledige set van criteria die alle informatie omvat omtrent de gevormde alternatieven. De samenstelling van de volledige set met criteria die een rol spelen bij de strategische keuze tussen de bovengenoemde alternatieven is tot stand gekomen uit een literatuurstudie en gesprekken met adviseurs van "Woonbedrijf". De volledige set met criteria is onderverdeeld in hoofdcriteria, criteria en subcriteria. De set bestaat uit de volgende acht hoofdcriteria:

1. milieu;
2. financiën;
3. sociaal aspect;
4. bouwtechnisch aspect;
5. woontechnisch aspect;
6. stedenbouwkundig aspect;

7. markt;
8. identiteit en imago.

De input van de MCA is een wooncomplex. Elk wooncomplex kent zijn eigen prestaties, hetgeen noodzaakt tot een onderverdeling van de woningen. Het woningbezit is in dit onderzoek onderverdeeld in archetypen. De verdeling in archetypen is gebaseerd op woningtypologie en op bouwjaar, beiden bepalend voor de woningkwaliteit en de prestaties. De kwaliteiten van woningen zijn door de bouwperiodes heen verschillend. Net zoals de veranderende prestatie-eisen van de huurders, zich uitend in bouwtechnische- en woontechnische prestaties van woningen. De verdeling in archetypen is:

- eengezinswoningen voor 1945;
- eengezinswoningen 1945 – 1965;
- eengezinswoningen 1966 – 1976;
- eengezinswoningen 1977 – 1988;
- eengezinswoningen vanaf 1989;
- appartementen met lift 1966 – 1976;
- appartementen met lift 1977 – 1988;
- appartementen met lift vanaf 1989;
- portiekwoningen 1945 – 1965;
- portiekwoningen 1966 – 1976;
- portiekwoningen vanaf 1977;
- duplexwoningen 1945 – 1965;
- duplexwoningen 1966 – 1976;
- duplexwoningen vanaf 1977.

De energetische prestatie van een woning heeft een grote invloed op de prestaties van de archetypen. De archetypen zijn daarom onderverdeeld in subarchetypen: energielabel A-B-C, energielabel D, energielabel E-F-G.

Vanwege de hoge complexiteit en de beschikbaarheid van data is dit onderzoek afgebakend tot drie van de acht hoofdcriteria. De criteria hebben verschillende eenheden. Om de eenheden met elkaar te kunnen vergelijken is in dit onderzoek verdieping aangebracht in de drie aspecten: People-Planet-Profit. Deze drie aspecten zijn afgeleid van de definitie duurzaamheid die in dit onderzoek is toegepast: "*De bewustwording van de effecten van het huidige gedrag, welke leidt tot de integrale afweging tussen People, Planet en Profit, met als doel het creëren van maatschappelijke meerwaarde nu en in de toekomst".* In de verdieping staan People-Planet-Profit voor woonlasten-milieubelasting-financiën. De verdieping resulteert in data voor de duurzame criteria. De data worden geoperationaliseerd. Door de operationalisatie zijn de data met elkaar te vergelijken en kunnen conclusies geformuleerd worden op de duurzame criteria.

Verdieping woonlasten (People)
Bij het bepalen van de data voor het criterium woonlasten is gebruik gemaakt van het onderzoek '*Woonlastenonderzoek Tilburg'* uitgevoerd door RIGO (2009) en case studies uitgevoerd bij Woonbedrijf.

Het sturen op woonlasten (netto huur + gebouwgebonden energielasten) wordt een steeds belangrijker onderwerp voor woningcorporaties. Door de sterk stijgende energieprijzen in combinatie met de energetische kwaliteit van de huurwoningen ontstaat een probleem voor de primaire doelgroep omtrent de betaalbaarheid van wonen. Bij het bepalen van de data voor dit criterium is rekening gehouden met de huidige woonlasten en de toekomstige woonlasten. Door de te verwachten toekomstige energielastenontwikkelingen worden de energielasten steeds meer bepalend voor de hoogte van de woonquote. Het alternatief *duurzame renovatie* heeft de hoogste score op dit criterium. De netto huur blijft beperkt en de energetische prestatie van de woning wordt sterk verbeterd bij dit alternatief.

Verdieping milieubelasting (Planet)
De data die gebruikt zijn voor het berekenen van het criterium milieubelasting zijn afkomstig uit een onderzoek uitgevoerd door TNO voor Woonbedrijf (de Vos & ten Broeke, 2011).

Zowel het energieverbruik in de gebruikersfase als de materialisatie die gebruikt wordt in een gebouw veroorzaken een milieubelasting. De milieubelasting wordt in dit onderzoek gemeten door middel van schaduwkosten. De bepaling van schaduwprijzen voor de verschillende milieu-effecten is op basis van prijzen voor emissiebeperkende maatregelen en emissienormen. De schaduwkosten zijn fictieve externe kosten die worden uitgedrukt in euro's. Voor de alternatieven zijn zowel de verandering in milieubelasting omtrent het energieverbruik als ook de milieubelasting voor de materialisatie bepaald. De som hiervan resulteert in de data voor dit criterium.

Bijvoorbeeld bij het alternatief '*duurzame renovatie'* wordt de milieubelasting van het gereduceerde energieverbruik opgeteld bij de milieubelastingen met betrekking tot de materialisatie van de renovatiemaatregelen, weergegeven in schaduwkosten. Bij de methode worden alle milieueffecten beoordeeld die optreden vanaf de winning van grondstoffen tot en met de tijd dat het product terecht komt in de afvalfase, wordt hergebruikt of gerecycled, kortom: de levenscyclus van een product.

Verdieping financiën (Profit)
Het waarborgen van de financiële continuïteit is een belangrijke economische randvoorwaarde voor woningcorporaties om haar maatschappelijke doelstellingen uit te kunnen blijven voeren. Binnen de financiële continuïteit zijn er twee belangrijke aspecten, namelijk de solvabiliteit en de liquiditeit. De solvabiliteit is de verhouding tussen het eigen vermogen en het vreemd vermogen. De alternatieven *duurzaam renoveren* en *sloop gevolgd door vervangende nieuwbouw* gaan gepaard met een onrendabele investering. Deze onrendabele investering heeft invloed op de solvabiliteitspositie van een woningcorporatie. Dit is een aspect dat gemeten wordt en deel uitmaakt van de data voor het criterium financiën.

Het andere aspect dat deel uitmaakt van de data is de liquiditeit. De liquiditeit wordt gemeten aan de hand van de operationele kasstromen. Jonger vastgoed heeft relatief hoge huurinkomsten en lage onderhoudskosten. Hierdoor zijn de prestaties van de operationele kasstromen van jonger vastgoed beter in vergelijking met ouder vastgoed. Hierdoor scoort het alternatief *sloop gevolgd door vervangende nieuwbouw* op dit criterium hoog in vergelijking met de andere twee alternatieven.

Resultaten verdieping duurzame criteria

De data, verkregen uit de verdieping in de duurzame criteria, zijn geoperationaliseerd. Hier zijn de drie criteria naar een nieuwe schaal gezet, waarbij de waarden tussen de 0 en de 1 lopen. Dit maakt het mogelijk om de criteria met elkaar te vergelijken en conclusies te trekken aangaande de score op duurzaamheid van de alternatieven. Uit de uitgevoerde MCA op de duurzame criteria blijkt dat woningen met een energielabel E-F-G het beste duurzaam gerenoveerd kunnen worden. Woningen met een energielabel A-B-C kunnen het beste doorgeëxploiteerd worden. Het alternatief *slopen gevolgd door vervangende nieuwbouw* is bij geen enkel subarchetype het beste alternatief. Hieruit kan geconcludeerd worden dat *slopen gevolgd door vervangende nieuwbouw* geen duurzaam alternatief is.

De resultaten van de duurzame criteria zijn getoetst aan de hand van een gevoeligheidsanalyse. Een gevoeligheidsanalyse wordt uitgevoerd om te zien hoe robuust en betrouwbaar de uitkomst is van de verdieping in de criteria woonlasten, milieubelasting en financiën. Uit de gevoeligheidsanalyse blijkt dat de veranderde waarden een sterke correlatie vertonen met de toegepaste waarden. Dit betekent dat er een sterke samenhang is tussen de gemeten reeksen. Dit duidt er op dat de toegepaste waarden relatief robuust en betrouwbaar zijn.

Het onderzoek is een aanzet tot een multicriteria-analyse. De verdieping is beperkt tot drie van de acht hoofdcriteria. Bij een verdieping op de hele set van criteria kunnen er andere resultaten uitkomen. Dit valt buiten de scope van het onderzoek.

Aanbevelingen vervolgonderzoek multicriteria-analyse

Dit onderzoek is slechts een aanzet tot een MCA waarin verdieping heeft plaatsgevonden in drie van de acht hoofdcriteria. Om een compleet inzicht te krijgen in deze strategische keuze dienen voor de overige criteria ook data verkregen te worden. Als voor alle criteria data verkregen zijn kunnen ze geoperationaliseerd worden. Hierdoor kan de volledige set met criteria vergeleken worden en kan er een onderbouwde beslissing genomen worden door woningcorporaties.

Dit onderzoek heeft als input van de MCA vijf verschillende archetypen. Bij een vervolgonderzoek geeft het de aanbeveling om te kijken naar alle archetypen waarbij woningcorporaties met de strategische keuze tussen *doorexploiteren*, *duurzaam renoveren* of *sloop gevolgd door vervangende nieuwbouw* te maken krijgen.

RENOVATE OR NEW ESTATE?
The challenge towards a sustainable future

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ABSTRACT
Housing corporations are facing a major challenge, the early post-war neighborhoods. They are over 60 years old and are characterized by poor technical quality and a lot of social problems. In order to solve those problems and realizing a more sustainable future two possibilities are possible, renovate or new estate. Mainly the feasibility study is the decisive factor or decision support model which the housing corporations base their decision on. However this research has developed a decision support model which took those aspects into account which are of much greater importance. Renovation is in most of the cases preferred over new estate because it is cheaper and it should better for the environment. It would more contribute towards a sustainable future in comparison to new estate. This research concluded that new estate has to be preferred over renovation in order create a real sustainable future.

Keywords: Decision Support Model (DSM), redevelopment, early post-war dwellings, System Dynamics (SD)

INTRODUCTION
Renovate or new estate is not an easy question to answer. But why is it so hard? Renovation has in general more advantages in comparison to new estate. Not only financially but also from an environment perspective. Buildings that can be reused do not have a negative effect on the environmental impact. They do not have to be demolished and the old building materials do not have to be decomposed. In line of this the materials do not have to be burned down or stored under soil. It is also preferred over new estate because it directly saves the use of raw materials and fossil fuels, which are needed for the production of new materials. Indirectly it will save the environment by saving energy and in line of this the discharge of carbon dioxide. Renovation will reduce the environmental impact on many fields. Different researches concluded that extending the buildings lifetime is more sustainable in comparison to new estate (Jonge, 2005; Sunikka, 2006). According to the research of Klunder (2005) are the best strategies to reduce the environment impact, lower down the material use, material type and also lifespan extension.

Not only from an environmental perspective is renovation advisable, it is also from a practical perspective. Prof. ing. Thomsen (Thomsen, 2002) has concluded that as a result of the 'low' production ratio the current lifetime of houses (50 years) will expand significant. A lifespan of 100 year will not be an exception anymore.

In the battle to make the Netherlands more sustainable the national government see housing corporations as the party which will play an important role in this process. Reason for the national government to focus on the housing corporations is because they have a market share of 33 percent (Blijie et al., 2009) New policies which are been implemented, or will be implemented, will stimulate or 'force' housing corporations to reduce energy consumption by upgrading their existing housing stock.
Beside this housing corporations are facing another, maybe more important challenge, which is the early post war housing stock. They are characterized by many technical and social problems. In order to solve this two options are possible, renovate or new estate. Take thereby all the changing legal regulations and policies into account, making the good decision will be far from easy.

So renovation looks like the best option from many points of view in order to create a more sustainable future. But there is one factor which is not mention yet but which will definitely have enormous influence, the market demand. Prof. ing. Thomsen (Thomsen, 2002) stated also that new estate should only be considered if renovation could not serve the demand from the market anymore. But when is a building not serving the demand anymore? In line with the rising lifespan meeting the demand of today but also in the future will be a real challenge. Therefore it is important to determine the demand in the future and the consequence this will have for the future. What if a building is renovated and after couple of years it should be demolished anyway because the market demand is changed. Was demolishing not the best option in the first place? **When is sustainable sustainable?**

METHODOLOGY

Decision making is always hard, especially making the right decision, but when it a decision the right decision? More important to know what the effect will be of this decision over a certain period of time. In order to make the right decision the effect of this decision needs to be simulated. SD is a modelling method that allows a system (in this case supporting as well renovation as well new estate) to be represented as a feedback system (Thompson and Bank, 2010). The feedback structure of a system is described by using causal loops. Those could be balancing (capturing negative feedback) or reinforcing (capturing positive feedback) (Smith and Ackere, 2002).

The System Dynamics method is already been applied on many fields e.g. land reclamation in the mining industry (Elshorbagy et al., 2005), and energy and power systems (Kadoya et al., 2005). But beside this SD is also been used in a wide variety of applications, in the social sciences and in engineering (Thompson and Bank, 2010). The area of (civil) engineering that has most commonly used the SD method is construction project management, where it has been used, for example, the design-build process (Pen˜a-Mora, and Li, 2001). After all System Dynamics is already applied in a wide variety of research fields which make it, in combination with the over time simulation, by far the best (DSM) decision support model to apply within this research. The impact over a longer period of time is hard to predict by using other Decision Support Models.

THERORETICAL BACKGROUND

Focus of this research is the early post-war neighbourhood, developed right after World War II (1945 - 1960). The need for housing was enormous, over 260.000 new houses needs to be built in the battle against the housing shortage (Blom et al., 2004) New building techniques and systems should speed up the construction process and lower down the construction costs (Blom et al., 2004). But those building techniques are causes the technical problems of today. Many of those houses are not insulated, not well ventilated and they are rather small in comparison to the standards of today.

The majority of those areas are owned by housing corporations. On average they have a market share between the 50 and 100 percent (Priemus, 2006). Solving the technical problems, caused by the past, and the social problems could be achieved by as well renovation as well by replacing the existing building for new estate. In most of the cases new estate is not even an option. Financial it is preferred over new estate because it is ‘cheaper’. From an environmental perspective renovation is also preferred over new estate. New estate is only an option if a building after renovation could not meet the demand of the market anymore (Thomsen, 2002). This market demand will be determined by three aspects, social, technical and political.

Social:

Most of the early post-war houses do have a floor space between the 50 and 70 square metres. 50 square metres for multifamily dwellings (apartment blocks). And 70 square metres for single-family dwellings. At the moment a minimum floor space of 90 to 100 square metres are already been used and required for new estate (Uytenhaak, 2008). This remarkable development is the result of change in lifestyle and living expectations. In order to a more sustainable future it will be good to know how the floor space demand will develop over time. According to the book ‘Steden vol ruimte: kwaliteit van dichtheid’ of Prof. ir. Rudy Uytenhaak (Uytenhaak, 2008) the average floor space as well per person as well per household will increase to 2050, to 108 respectively 195 (gross) square metre, see figure 1.

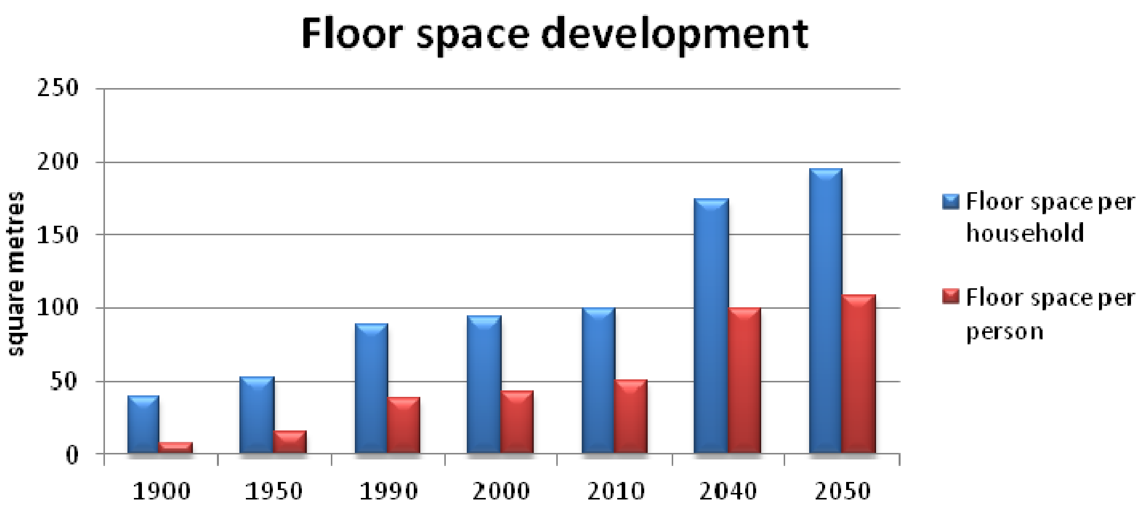

Figure 1; Floor space development

After interpolation it will result in a floor space per household in 2040 of approximately 175 square metres. Later on it will be showed that this development will have a major influence on as well renovation as well new estate.
The market demand is also determined by the population development, especially for new estate this is important to know. This will directly influence the number and type of dwellings. This research will focus on Amsterdam, in line of this not the average population development nationwide will be taken into account, but a more specific prediction. According to predictions of the CBS (Central Statistical Office) a population growth of 12 percent will be expected until 2040 (StatLine, 2011).

Technical
As already mentioned the poor construction materials and the new construction techniques are causing a lot of technical problems today. Beside the technical problems the energetic quality of the dwellings is also a problem. As a result of the then requirements those dwellings are far from our living standards of today. Consequence of the then used building systems is e.g. noise nuisance. 90 percent of the inhabitants discover this as irritating and frustration (Heeger, 1993). Result of the then requirements is also the lack of ventilation. Another point which is of great importance is the thermal insulation and the lack of it. Is does not take rocket science that the thermal insulation will help reducing the energy consumption for heating. But what most of the people maybe do not know is that thermal insulation also enhances the living comfort. Still the main purpose will be energy saving and the importance of this is only rising today, and it certainly will in the future. To stimulate energy saving measurements in the rental sector the national government has changed the WWS WoningWaarderingsStelsel).

Political
The national government has introduced many policies which have one common goal, reducing the energy use. One of those measurements was the introduction of the energy label. It was introduced in 2008 (renewed by 2010) and 'represents' the energetic quality of a building. Before 2010 the energy label does only shows the presence of insulation, e.g. wall insulation or double glazing. In spite of that the energy label is mandatory not all the houses which are for sale do have one. This could be explained as follow, the label is only needed if the buyer wants so. 2 years (by the end of 2009) after introduction only 25 percent of the total housing market does have a label (CBS, 2010). Of this total merely 5 percent (approximately 70.000) is devoted to the private property market. But it is also mandatory for the rental market. Within the rental market conversely it is more a success, here have 95 percent (which is 1.5 million) already an energy label.

To determine the monthly rental price the so called WWS (WoningWaarderingsStelsel) is been used. This WWS is a scoring system to determine a 'reasonable' monthly rental price. There will become a new WWS which differs not that much in comparison to the scoring systems which is been used nowadays. But on one element it does, which is the energetic quality. Within this new WWS the energy label will be adopted. It will replace the existing scoring system which only devotes points for insulation and heating, with a maximum of 26 points. Within this new WWS system a maximum score for single-family dwellings of 44 points is obtained (label A++) and a minimum for label G, 0 points. For multiple family dwellings this will be 40 points for label A++ and 0 point for label G.

Consequence of the integration of the energy label in the WWS is that housing corporation will be stimulated or get 'forced' to upgrade the energetic quality of those dwelling. This upgrade means that the energetic quality of the dwelling needs to be upgraded by two energy labels at least or to label B. This could have an influence on the decision to choose for renovation as well new estate.

THE MODEL

Within this research a System Dynamics model is been used to determine the influence of the changing lifestyle and expectations of living. And to predict the influence of it for as well new estate as well renovation. There are four sub-systems in this SD model, which are, namely, social developments, technical and energetic quality, construction and renovation time and finance. The effective relations between the four sectors, within this research, are visualized in figure 2, the causal loop diagram. All the different aspects and developments are situated around the central decision loop, number 2. Loop **1** represents the social loop. Loop **2** is the central decision, loop **3** is the technical loop and loop **4** represents the financial loop. This causal loop diagram is been more or less the backbone of the other SD model.
Causal loop diagrams like this are simply showing the causal links among variables with arrows from a cause to an effect (Sterman, 2000).

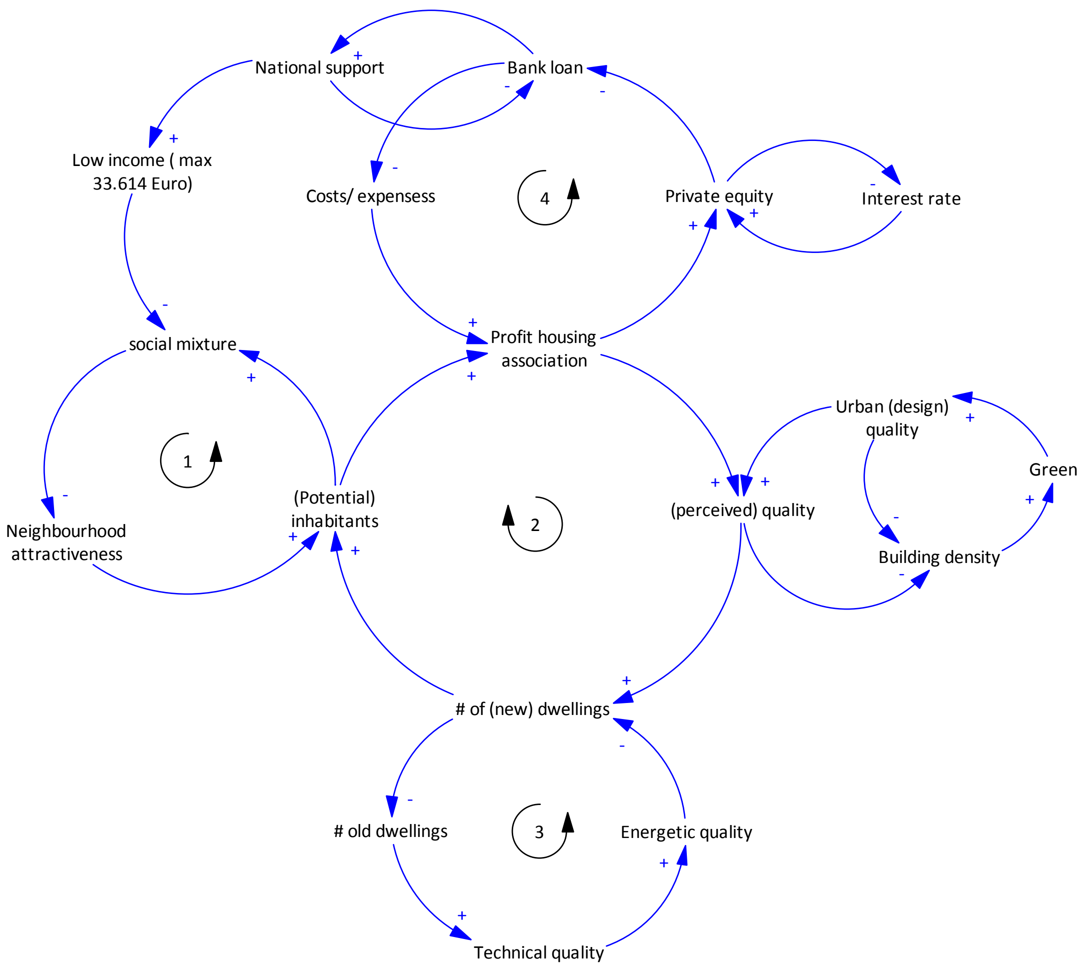

Figure 2; Causal loop diagram

The aim of this model is to discover what the social, technical and political effects are on the level of occupation of the existing social housing stock until 2040, showed in figure 3. In order to make a well based decision for as well renovation as well new estate.

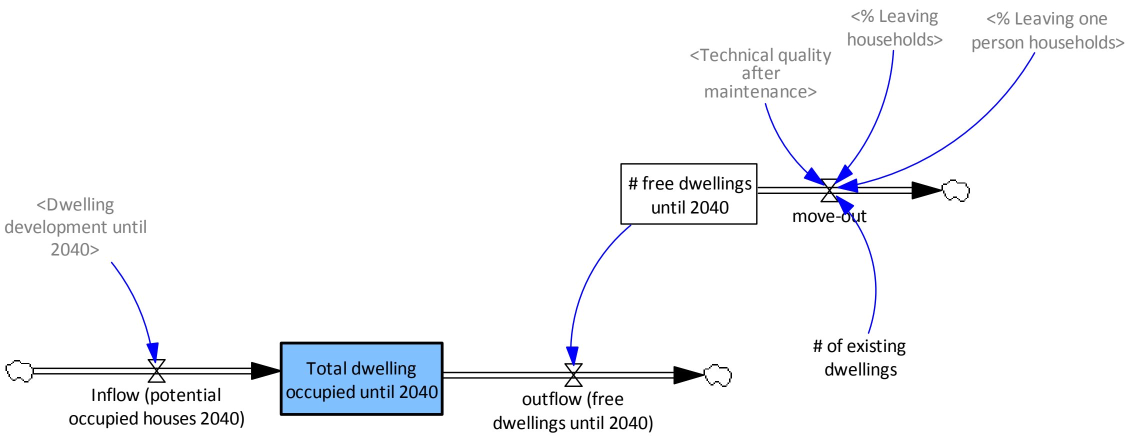

Figure 3; Stock and flow to determine the # of occupied dwellings

The most important stock and flow of the whole SD model is the above showed model. It represents the difference between the inflow and the outflow. These are respectively '*dwelling development until 2040*' and '*# free dwellings until 2040*'. The inflow is be determined by two different factors. First factor is the population growth, like mentioned before a population growth of 12 percent is expected until 2040. The other factor is the number of free dwelling, which depends on the stock *'# of free dwelling until 2040'*. This number is influenced by three different variables, all part of another sub-system of the system dynamics model. A research done by the municipality of Amsterdam has showed that the tenants will leave for three reasons (Gemeente Amsterdam, 2008). First the dwelling floor space is not meeting the demand anymore and 37 percent will leave for this reason. 32 percent will leave as a result of the level of criminality within this neighbourhood. And for 24 percent the technical quality of the dwelling is the decisive factor to leave. Those aspects are taken into account to determine the number of free dwelling. Important to notice is that the model is set up in such a way that if the gap between supply and demand will change, also the move-out percentages will change. This will means that if the e.g. the floor space demand will increase, the gap between the supply and demand will increase and as result of that the move-out percentage will increase. This is the same for the other way around. The number of occupied dwellings will also have it influence on the financial situation, particularly for the rental income. And this will of course also have an effect on the decision for choosing renovation as well new estate.

Simulations

The model is been applied on a case study, which is Amsterdam Slotermeer Noord Oost. As already mentioned the aim of this research was to develop a DSM (Decision Support Model), which could make the decision for new estate of renovation easier. In order to make the right decision, renovate or new estate four different simulations are been simulated. This is been showed in the following figure, figure 4.

Simulations					
Category	**Existing situation**	**Simulation 1** (Maintenance)	**Simulation 2** (Label upgrade)	**Simulation 3** (Renovation)	**Simulation 4** (New estate)
Building characteristics:					
Dwellings	4200	4200	4200	4200	4200
Floor space (dwelling)	50 m^2	50 m^2	50 m^2	50 m^2	**100 m^2**
Energy label	E	E	**C**	**A**	**A++**
Rc- value	0 $m^2 \cdot K/W$	0 $m^2 \cdot K/W$	0 $m^2 \cdot K/W$	**3.5 $m^2 \cdot K/W$**	**5 $m^2 \cdot K/W$**
EPC	n.a.	n.a.	n.a.	n.a.	**0.6**
Heating/ water	CR- ketel	CR-ketel	**HR-107 ketel**	**HR- 107 ketel**	**HR- 107 ketel**
Ventilation	Natural	Natural	Natural	**Nat. + mech.**	**HRU**
Sound insulation equal to:	120 mm	120 mm	120 mm	**250 mm**	**280 mm**
Execution speed	-	-	**1000 dwel./ year**	**20 blocks/ year**	**8 blocks/ year (new)**
-Additional speed					**12 blocks/year (demolition)**
Execution costs	-	-	**€ 1.800,-/ dwelling**	**€ 1.800,-/ m^2**	**€ 2.000,-/ m^2 (new)**
-Additional costs	-	-	-	-	**€ 100.000 per block (demol.)**
Overhead costs	€ 2.000,- dwel./ year	€ 2.000,- dwel./ year	€ 2.000,- dwel./ year	€ 2.000,- dwel./ year	€ 2.000,- dwel./ year
* Cells written in **bold** differs in comparison to the existing situation					

Figure 4; Different simulations used within this research

Results of the simulations

The four different simulations are been simulated within the System Dynamics model with a surprising outcome. The simulation has showed that as a result of the differences between the supply and demand the number of occupied dwellings will be influenced.

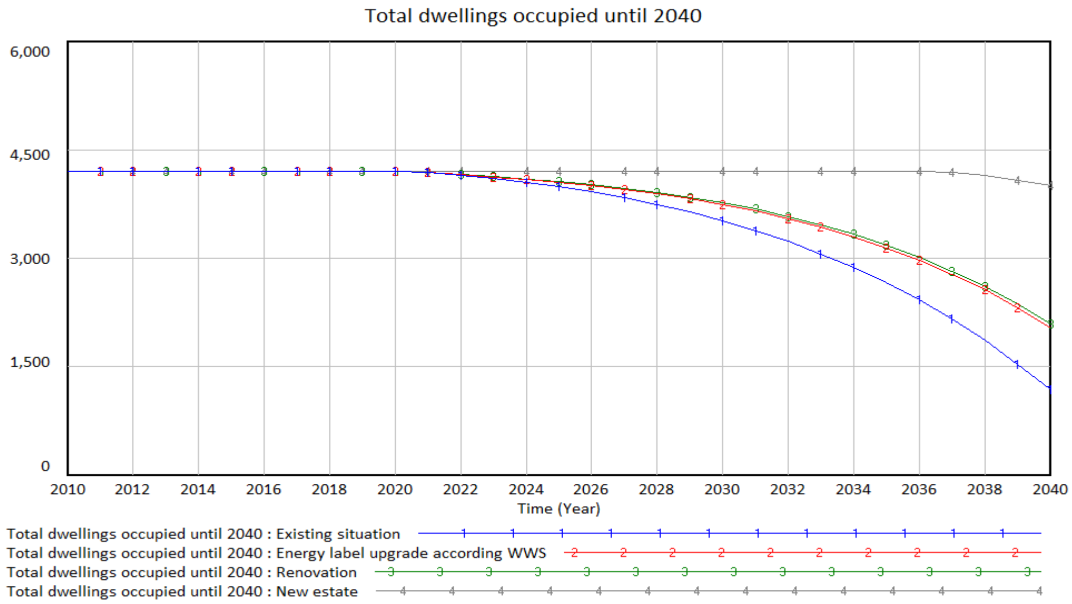

Figure 5; Dwelling development until 2040

Remarkable is the large differences between the existing situation, simulation 1 and new situation, simulation 4. In all the four simulations the number of occupied dwellings will

drop, but by one harder than the other one. Striking is it that three of the four simulations, simulation 1, 2, and 3 the starting point of decline is almost the same. They will all start to decline at the same time, around the year 2020. But what differs is the decline acceleration. In all the three the simulations this is different, resulting that in all the three the simulations the level of occupied dwellings is different until 2040.
Simulation 1 will end up around the 1175 occupied dwelling in 2040, simulation 2 will end on approximately 2040 occupied dwelling. And in simulation 3 the level of occupied dwellings will be declined to almost 2100 in 2040. Simulation 4 conversely is really a different story. Also here the level of occupied dwellings will decline, but is will start 16 years later, namely in 2036, in comparison to simulations 1,2, and 3. The number of occupied dwelling will only drop by approximately 190 dwellings, to 4010 in 2040.

Figure 5 shows clearly that renovation or new estate will definitely influence the number of occupied dwelling in comparison to the existing situation. This could be devoted to the gap between the supply and demand, with regard to the higher living standards. This figure shows that from a social perspective new estate needs to be preferred over renovation.
The number of occupied dwellings will beside the liveability in the neighbourhood also have an effect on the financial situation of the housing corporations.
The effect it financially will have is showed in figure 6.

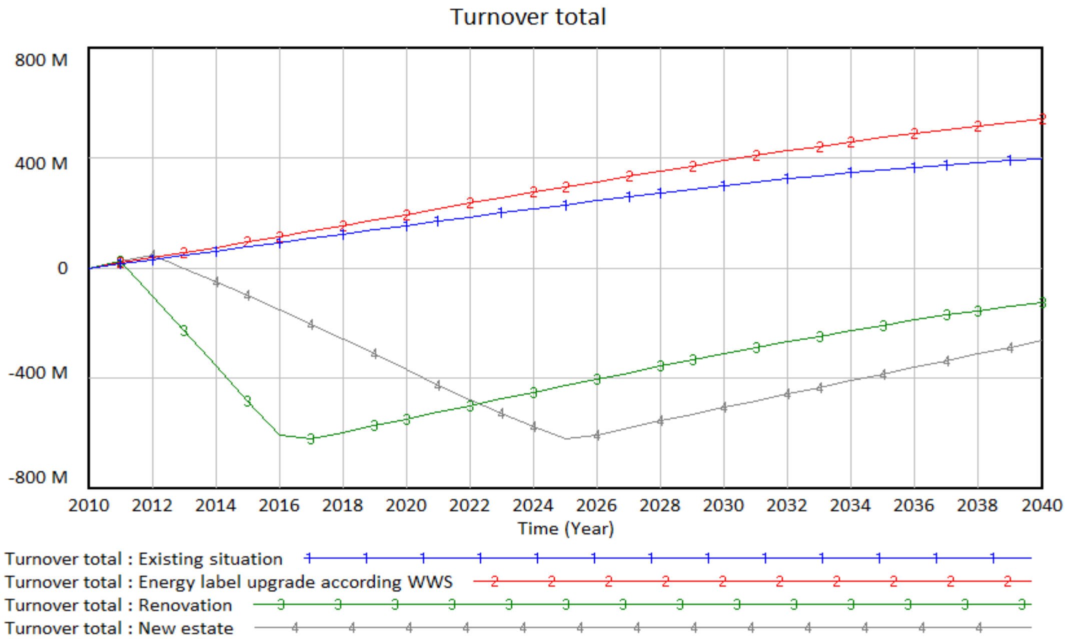

Figure 6; Financial situation

At first glance is to see that as well simulation 1, as well simulation 2, will have a positive effect on the financial situation. In both simulations a profit is generated of € 395 respectively € 540 million up to 2040.
As well the renovation simulation as well the new estate simulations are both not making any profit in a timeframe of 30 years. Simulation 3 will result in a loss of approximately € 127 million by 2040, simulation 4 conversely will have a loss of approximately € 263 million by 2040. This does not mean that simulation 3 and 4 will not make any profit at all, they will but over a longer period of time. Extrapolate will give roughly the position of the breakeven point which is for simulation 3 around 2054 and for simulation 4 around the year 2052. For renovation the break-even point can be found around the year 2054. In spite of the higher

investment costs new estate will reach break-even around 2052.This could be easily explained because the level of occupied dwelling will decline by the renovation simulation. In the extension of this it will be doubtful if after renovation break-even will be reached anyway!

CONCLUSION

Feasibility studies are mainly the used decision support model for redevelopment projects in sense of renovation or new estate. But this research concluded that other aspects like expectations of living are much more important over a longer period of time. This research concludes further that sustainable development towards a more sustainable future is much more than only taking some energy saving measurements. Sustainable is sustainable when it fully meet the expectations of living of today and in the future.

Renovation of buildings is mainly preferred over new estate from different perspectives. Financial it is mainly preferred because is relative 'cheaper' in comparison. And in line with the importance of a more sustainable future renovation is preferred because the environment impact is much lower. However this research concluded that new estate has to be preferred over renovation towards a sustainable future. Like figure 5 shows renovation is only a temporary solution, without adjusting the dwelling floor space. In spite of all the benefits which renovation over time almost nobody would be interested anymore in those dwellings as a result of the growing expectations of living, e.g. the floor space.

Another remarkable conclusion is the Dutch building decree. As long as the 'minimum' requirements for renovation are different in comparison to new estate it will be doubtful is renovation will contribute towards this more sustainable future. Further concludes this research that as a result of the 'lower' 'minimum' requirements for renovation, renovation can/ will be seen as a possibility to avoid the much higher and stricter requirements for new estate.

DISCUSSION

Within the research the renovation simulation contains only some energetic and technical measurements. The existing floor space will not change within this simulation. A possibility which is not been simulated and mentioned is the combination of two dwellings, with a floor space of 50 square metres each, to one dwelling. Combining two dwellings to one will not automatically means that also the monthly rent will become twice as high. This is the result of the WWS scoring system.

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The more complex processes become the higher the challenge will be!

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A CAP, FINE & REWARD POLICY FRAMEWORK;
Creating energy consciousness and urging residents to save energy?

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ABSTRACT
Governmental authorities seem to lack the means to urge residents to energy savings and creating energy consciousness among them. However, in this research a new policy framework is designed named Cap, Fine & Reward seeming to have the potential to create energy consciousness and urge residents to save energy. The policy framework can be characterized as a stringent, long term policy framework, aiming to increase the household energy savings by affecting the residential energy using behaviour. A stated conjoint choice experiment is used to test the acceptability of residents towards this policy framework and to do research to the potential of the system.

Keywords: Cap & Trade, Policy framework, stated conjoint choice, residential energy savings.

INTRODUCTION
All over the world there is much attention to decrease the dependency on fossil sources for economic and environmental motives. This can be realised by a two sided approach; the production of renewable energy should be increased, however using the available energy more efficiently is equally important. For this research the focus is to energy savings in the residential sector resulting from behavioural changes and increased energy awareness of residents.

Besides the importance, research has shown that the energy use varies dramatically per person, by region and even by neighbourhood (Salon & al., 2010). Although, people often seem to be aware of the environmental and energy problems, they often do not act in line with their concerns, and total household energy use is still rising. This seems to be partly caused by a lack of insight in the relation between behaviour and energy use (Steg, 2008). Furthermore, many people attach only a low priority to saving energy and since energy use is not only driven by concerns about environmental and energy problems, this lowers the energy savings. Despite all efforts being undertaken by governmental authorities, the energy-saving rate is still very low (Nieuwenhuijsen, 2010). This is also supported by Abrahamse, who states that household energy use keeps rising and the governmental financial incentives appear to be inadequate (Abrahamse, 2007). When aiming for substantial energy savings it is important to implement soft measures in combination with hard measures (Delft, 2006). This is supported by expert H. Nieman who stated that during the journey to reach the energy goals *"it is a matter of persuading and forcing"*. The soft measures represent the persuading, and the stringent measures the forcing. A relatively new high potential phenomenon; the Cap & Trade system, which is based on promising basic principles, might have the potential to provide the governmental authorities with a hard policy measure to achieve the goals set. However, since there is a lack of insight in the potential and public acceptability of such a system research is required.

RESIDENTIAL ENERGY USING BEHAVIOUR

Research states that large differences are found in the residential energy use, this implicates that energy savings can be achieved by affecting the using behaviour. Human behaviour and in particular creating a change in consuming behaviour is essential in reducing the energy use. However, changing behaviour seems to be a complex matter (energy-behave, framework); behavioural factors such as awareness, knowledge, norms and values, and attitude, lead to an intention for making the decision to implement the solution. This intention may suffice to start the change in behaviour, but it will not be carried out unless the individual has the required resources and skills, and no barriers stand in the way.

When designing a policy affecting the human behaviour it is stated that a mix of soft and hard policy measures achieve the best results (Energieraad, 2006). Since the research of I. Nieuwenhuijsen focussed to soft policy measures, this research is focussed to developing a hard policy measure. The policy focuses to achieving energy conservation by behavioural change of residents. This direct reduction should result from behavioural changes such as decreasing the shower time, lowering the heating temperature and other direct behavioural energy savings. In the longer term the policy might also influence the awareness of the energy use of technical appliances.

The above is supported by (Tambach, Hasselaar, & Itard, 2010)who conclude that the current Dutch energy transition policy instruments for the existing housing stock, which are largely focused on communication, need to be complemented by more traditional and long-term energy policy instruments. Since the regulating energy tax is not achieving the intended results an alternative should be developed. A Cap & Trade based measure seems to have the potential to become a structural measure to create energy consciousness among residents and urge them to save energy.

CAP & TRADE

This research is focussed to develop a city based Cap & Trade system urging residents to save energy, and to do research to its potential and to the acceptability among residents. A Cap & Trade based measure seems to have the potential to become a structural measure to create energy consciousness among residents and urge them to save energy. Furthermore it provides a framework for carbon reductions (Tambach, Hasselaar, & Itard, 2010). In principle the mechanism enables participants to compensate for their emissions where it is cheap and simple. Besides this, the inclusion of the trading function results in a rewarding and fining mechanism in the scheme.

Personal Carbon Trading comprises various downstream emission trading schemes addressing the end users of energy. The common objective are the same; limiting the overall carbon emissions from society effectively, efficiently and equitably, by engaging individuals in managing their carbon emissions. However, at the moment none of the versions of PCT is fully worked-out policy proposal and all require further development (Fawcett, 2010). The various PCT schemes proposed all have their own strengths and weaknesses. Niemeier, (2008) developed a proposal with a scope covering only household energy, the system would concern for about 25 % of the energy use within Eindhoven. It can be described as household carbon trading and is defined as follows;

> A yearly carbon emissions cap is set for residential energy use based on emissions reduction targets. Allowances are allocated to each household on an equal per household allocation basis via utility service providers who place the allowances in each user's account. These are deducted periodically by the utility according to energy use, and additional allowances must be purchased if the account is in deficit. The carbon allowances are fully tradable. At the end of a compliance period, the state collects the permits from the utilities and determines compliance with the cap. Household carbon trading was proposed in California and examined against its emission targets (Niemeier, 2008).

It is clear that any PCT as it is described in this chapter would be a relatively expensive policy to introduce and maintain, however there is also evidence for suspecting that PCT could deliver a wide range of non-economic benefits (Fawcett, 2010). In spite of the benefits, the previous implicates that simplicity and effectiveness are key when aiming to design an applicable policy measure for the municipality of Eindhoven.

The different PCT schemes face quite similar issues when considering the practical implementation. The major issues are political and individual acceptability and equity issues. However, research states (Parag & Eyre, 2010) that the political acceptability is highly depending on the individual acceptability. The individual acceptability is on its turn is heavily leaning on the fairness and effectiveness (Fawcett, 2010) and the initial allocation of permits (Bristow & al., 2010). When addressing in particular these last three aspects properly, a significant part of the political and individual issues seem to be addressed.

This paragraph describes the key principles of PCT, besides this it is shows that there is potential for a Cap & Trade based policy framework. However, no research is done to the potential and acceptability of such a mechanism on a city scale within The Netherlands. In the next chapter a Cap & Trade based policy framework is designed suitable for a city in The Netherlands.

DESIGN; A CAP, FINE & REWARD POLICY FRAMEWORK

Since PCT is never been realised in practice and the research is all done outside of The Netherlands, this research aims to design and test a policy design applicable to The Netherlands based on literature research and expert interviews. The design elaborated in this paragraph is different from al PCT variants, therefore it is named as a 'Cap, Fine & Reward' policy framework.

Goal,

This policy has the goal to provide the municipality with a stringent, long term policy measure urging residents to save energy and enhancing energy consciousness. The policy measure should urge residents to safe energy by changes in first instance in the energy using behaviour, and in the longer term by changes in the purchase behaviour for appliances.

Examples of such behavioural changes are savings caused by a lowered heating temperature or the purchase of an A label refrigerator. Critical is that investments in housing characteristics, such as isolation or double glazing are beyond the scope of the policy. Other policies however can stimulate these improvements. Besides this policy measure, other regulations can stimulate investments in the real estate.

Key principles

By setting a strive target to the households utility energy use, and combining this with a financial incentive this policy measure aims to save energy by changing the residential energy using behaviour.

The trading function, normally included in a Cap & Trade based system, is not included in this policy proposal because of multiple reasons, first the trading aspect is complex to realize in practice, requiring from the regulator to supervise a policy with a significantly higher complexity because all households can buy and sell permits from each other. Furthermore it enables speculation with energy permits, this is thought to be undermining the main goal of the policy and is therefore prohibited. The positive aspects of the trading function is still incorporated because a household can sell the remaining permits to the regulating organisation, or buy extra permits when exceeding the strive target. Selling remaining permits results in a reward, and buying extra permits results in a fine.

Scope

The policy framework is focussed to providing an *energy* target for households. By using an energy target instead of a carbon emission target, no calculation has to be made for translating the used energy (natural gas, electricity, heat) to the emitted carbon dioxide. Besides this, it is the most straight forward manner for residents and therefore it is thought to be the best way to create conscious energy using behaviour.

Briefly described a household energy Cap, Fine & Reward structure is proposed, using existing household utility accounts electricity, heat and natural gas. Niemeier stated that limiting the scope of the program does limit possible efficiency gains, but reduces the complexity, risk, and political opposition. Although the scope is limited, the practical applicability is increased enabling the concept to realize efficient and effective energy savings.

Design variables

The previous describes the main elements of the Cap, Fine & Reward framework. However, to investigate the potential of the framework and test the acceptability of the framework to the Eindhoven residents different designs need to be tested. Therefore, various design variables are appointed in the design of this policy measure. However, to remain the experiment and in particular the questionnaire suitable for the respondents, deliberate choices have to be made about which variables to include. The included variables are described below:

1. Permit allocation

As stated in the literature research, the perceived fairness of the permit or energy allocation is essential to the acceptability of the policy design. The attribute allocation represents the manner of setting the energy cap for a household.

When reasoning from the perspective “we are all the same”. Someone might favour an *equal* amount of energy for every person since this is in line with the perception that every individual has an equal right to use energy and emit carbon dioxide. Since the scope of this scheme is an allocation per household the allocation per person should be multiplied with the number of residents of a house. The allocation based on the *need* is intended to be an allocation perceived as being fair in the sense that everyone receives an cap based on the need, taking in account the number of household members and the housing characteristics.
The third level is based on the *current* levels of consumption and is incorporated to do investigate whether this is perceived as a fair allocation.

2. Remaining permits

When a period with a length of one year has passed, a household is short in energy permits or has a surplus of permits. This attribute assesses the respondents’ perception about what to do with these remaining permits.
When the first level is incorporated the surplus energy permits must be *sold* to the regulating organization, this results in financial gains for the energy saver for example through a discount on the energy bill. The second level allows households to *save* the surplus energy permits for the years after. In the latter years extra consumption freedom could be gained by using the saved permits. The remained permits can only be turned in financial benefits when the permit life expires. In this situation it is important to set an appropriate permit life. The last level enables households to *choose* whether they want to sell or bank the permits.

3. Purchase limits

When a period with a length of one year has passed, and a household is short in energy permits extra limits need to be bought on top of the free allocated permits. Some might favour *limiting* permit purchases in order to avoid excess personal use of carbon or energy (Bird, Jones, & Lockwood, 2009). Others might find this patronizing or restrictive and prefer the option to buy extra permits *unlimited*. The level in between enables households to buy extra permits; however there are still limitations. Theoretically the levels above enable the situation that a household exceed his cap and also on top of that exceeds the purchasing limit. Since excluding a households from the utilities would be not possible in practice. Therefore an extra fine, significantly higher than the purchasing cost, could be set when exceeding the purchase limit.

4. Permit price

The rewarding and fining is regulated per unit energy and is being managed by the regulating organisation; all transaction will proceed via this organisation. The manners elaborated below are differentiate in the height of the fines and rewards.

- ✓ The *rewards is higher than the fine*; this results in higher cost for running the policy measure.
- ✓ The *height of the fine and reward are equal*. This implicates that the potential benefit equal is to the potential correction.
- ✓ The *fine is higher than the reward*; the potential correction is higher than the potential reward.

This attribute is added to see whether respondents prefer that good behaviour is rewarded, or prefer that the emitter pays extra.

5. Regulator

This attribute is about the regulator managing the allocation and energy permits accounts. Between the levels differentiation is made in a *public regulator*, a *private regulator* and a *combination* of both. A governmental organisation might be in favour because of the private data incorporated in the allocation, besides this they might find social aspects more important than private companies. A non profit private company might be more specialized to the task and therefore more efficiently. A third level is an option which is a combination of both. For example, the allocation and determination of the prices could be done by the government, and the verification and the managing of the accounts could be done by the network operator.

METHODOLOGY EXPERIMENT

By using conjoint analyses an optimized policy package with the highest acceptability and potential is determined. The following research questions have been described:

1. *What combination of attributes and levels results in an optimized policy package?*
2. *Is this optimized policy package acceptable for the Eindhoven population?*

Conjoint stated choice experiment

Conjoint stated choice experimentation involves the design of product profiles on the basis of product attributes specified at certain levels, and requires respondents to repeatedly choose one alternative from different sets of profiles offered to them (Haaijer, 1999).
The respondents make choices between the policy packages based on their preferences, therefore it is possible to test the acceptability and potential of a particular policy package.

Experiment design

Incorporating all the alternatives requires too many choice packages($3^5 = 243$) to be incorporated in the experiment. Therefore a fractional factorial design is created, which still enables the discovering of main effects for each variable level (Montgomery, 2005). The orthogonal generator function of SPSS 19 is used to design the fractional factorial design, holding 18 policy packages.

Analyses techniques

Random utility theory is used to analyse the choice behaviour of respondents. The Random utility theory is based on the following assumption; if an individual must choose between two sets of alternatives, the set with the highest random value will be chosen (Oppewal & Timmermans, 1993). Each choice package consists of different attribute levels. Therefore the total utility for an alternative is the summation of the utilities of the attribute levels. Binary logistic regression and ordinal regression enables analyzing data in which causality might be involved. The ordinal regression have in this case been used to determine the influence of particular variable levels (cause) to the acceptability of the policy package. The method estimates a threshold representing in this research the turning point between not acceptable to acceptable. When the sum of all variable levels exceeds this threshold the package would be accepted according to the estimation; when the sum is lower than the value of the threshold the package is unacceptable. For performing the ordinal regression SPSS is used.

Data collection

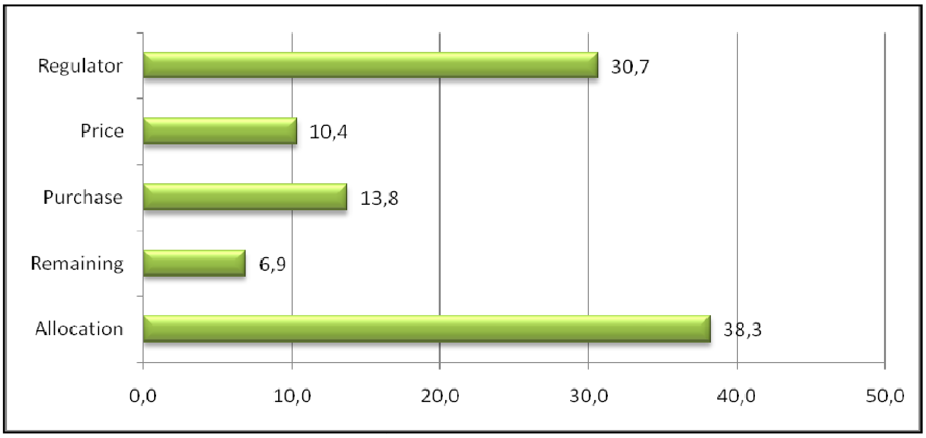
The respondents have been approached via a research institute of the municipal of

Eindhoven named Digi panel. This panel of civilians can be used for asking their point of view about a wide range of matters via a web based questionnaire. Although the panel members are not selected, there is something to notice; it could be questioned whether the sample group is reflecting the Eindhoven population entirely since people have to subscribe to become a panel member. However, since the number of responses is very critical and this is only an exploratory research to the potential and acceptability of a Cap, Fine & Reward policy framework the sample is still found usable. In total 2083 respondents have been approached, 34 percent from the approached have finished the questionnaire. A number of 703 valid responses have been received.

RESULTS

Binary regression analyses

The data gathered from the respondents is used to perform the binary logistic regression and determine the relative importance per variable, this is pictured in figure 1. Key variables seem to be the variables concerning the allocation and the regulator; these are significantly more important than the others. With 38.3 percent the allocation is the most important; implicating that the respondents seem to find it key that the policy framework is fair. Second important is the regulating organisation with a relative importance of 30.7, this seems to be implicating that privacy concern still is an important issue for the civilians. The other variables concerning the regulations about buying permits, selling permits and the fine & reward structure are far less important.



Ordinal regression

The output of an ordinal regression provides a threshold value, this threshold is an indication for the respondents' reaction (acceptable or unacceptable) towards a particular policy package (combination of variable levels). The threshold (red line in figure 2) in this analyses is 0,391, indicating that the sum of the part worth values from the variable levels of a particular policy package should be above 0,391 to be acceptable for the respondents.

Since the part worth values are known, policy packages can be combined predicting the acceptability for the Eindhoven population. The policy measure is developed to provide the municipal with a tool to urge residents to energy savings. Therefore the packages are created from the viewpoint of the municipal. Generally this means that the packages are defined to achieve energy savings fairly and as cost effective as possible. Besides the insight this creates in the acceptability it generates insight in the potential of a Cap, Fine & Reward policy framework.

1. *Acceptability;* the first policy package elaborates the combination of variable levels resulting in the highest prediction for the acceptability of the respondents.
2. *Optimal;* the second package elaborates the combination which is found optimal for the municipality of Eindhoven. This package is characterized by creating as much energy savings as possible, obtained in a fair manner, and with the lowest cost for the municipal.
3. *Fine & reward;* in this policy package the focus is to achieving high energy savings in a fair manner, besides the variable level 'fine & reward' the package is entirely the same as the optimal package.
4. *Reward;* This package focuses also to fairness and energy savings, however the focus in this package is to rewarding the energy savings.
5. *Choose;* this package is the same as the 'optimal' package accept for the variable 'remaining'. Under this package the households are free to choose for selling or keeping the remaining permits.

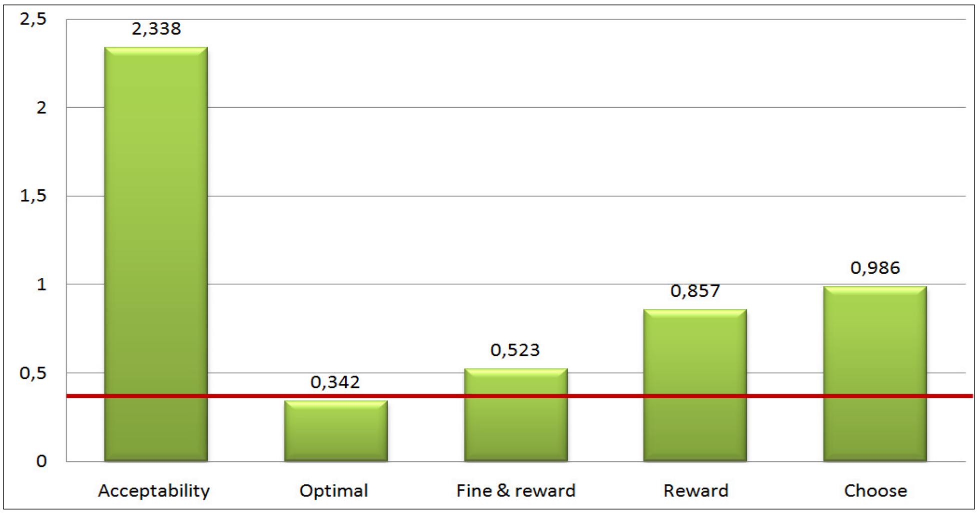


Figure 2, Predicted acceptability to a Cap, Fine & Reward policy framework.

CONCLUSION

In this study first a literature research is performed creating insight in the energy consumption behaviour of residents and in the Cap & Trade mechanism. Based on this research a policy framework is designed with the goal to provide the municipality with a stringent, long term policy framework urging residents to save energy and enhancing energy consciousness. The mechanism sets a strive target to the households utility energy use (natural gas, warmth, electricity), and combining this with a financial incentive this policy measure aims to save energy by changing the residential energy using behaviour. Five main design variables are appointed each containing three variable levels, these variables are used to develop different policy packages. A questionnaire is used to gather data and reveal the respondents preferences for particular variables and variable levels.

Based on the main effect analyses it can be concluded that the importance of the energy right 'allocation' and the regulating authority is significantly more important than the variables 'remaining, purchase and price'. When analysing the results more specifically per variable level several conclusions can be found which are also supported by the literature research:

- ✓ Residents prefer to have an allocation of energy permits based on the current use or the energy need of a household.
- ✓ Residents prefer to choose what to do with remaining energy permits.
- ✓ Residents strongly prefer to be able to buy energy rights unlimited.
- ✓ Residents prefer that an public authority is involved in regulating the policy measure. No clear difference is found between the public and private-public regulating authority.
- ✓ Residents have a strong preference for a reward focussed price variable. That this will result in an more expensive policy measure seems to be neglected or not noticed.

The above is implicating that residents tent to prefer having as much freedom of choice as possible, furthermore people prefer an fair system which is focussed to rewarding.

Based on the ordinal regression the optimized Cap, Fine & Reward policy framework considered from the municipals perspective and with regarding the responses of the residents is determined, the package is elaborated in table 1. The policy package is characterised by creating energy savings, obtained in a fair manner, providing freedom of choice to the residents and with the lowest cost for the municipal. The required value for an acceptable policy package is at least 0.391, with a total acceptability value of 0.986 this package is considered to be acceptable of the Eindhoven population.

Attributes	Levels
Allocation;	need
Remaining;	choose
Purchase;	unlimited
Price;	stress to fine
Regulator;	public private organisation

Table 1, Optimized Cap, Fine & Reward policy framework for Eindhoven

DISCUSSION

This research adds insight in the potential of a downstream Cap, Fine & Reward policy framework focussed to the energy utilities of households. By designing a relatively simple policy framework with a small scope the chances for creating an acceptable policy framework are maximized, which is reflected in the research outcome.

The Cap Fine & Reward policy framework has the potential to be realized and being acceptable for residents; however, a well considered combination of variables is required. Key in this combination are the variables concerning the allocation of energy permits and the regulating authority executing the policy. Several policy packages have been created from the viewpoint of the municipal, the optimal combination is found and elaborated. The optimal policy package can be characterised as a package urging residents to save energy, obtained in a fair manner, providing freedom of choice to the residents and with the lowest cost for the municipal.

When generating the outcomes of the analyses it appeared that the predicting values are rather low; the Rho square is below the required 0,2. This might be the result of respondents filling in the questionnaires inconsistently; implicating that it is found complex by respondents to fill in the choice sets. Because the predicting values are low the research outcome should be handled with care. However for an exploratory research it does create additional insight.

For future research it seems to be interesting to investigate the implementation and realization for this policy framework, possibly even on national scale.

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During the three years of my master education I have learned a lot in the field of construction management, particularly in the project and process management. Besides this, it has been a valuable for my personal and social development.

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AN EXPLORATORY STUDY ON THE COMPETITIVE POSITION OF A GENERATION IV NUCLEAR POWER PLANT IN THE NETHERLANDS

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ABSTRACT:
Nations worldwide encounter energy provision related difficulties like air pollution, fossil fuel availability, reliability and security. The Dutch government set forth its aims in the reliable, affordable and clean policy stressing that the Netherlands should become less reliant on other countries, high prices and polluting fuels. New nuclear power plant permits have been turned down over the last three decades but the government is now open for issuing new permits. Thereby, the size of the market that can be supplied with electricity from Dutch power plants is increasing due to the expansion of the number of interconnections and increased integration with electricity markets in neighbouring countries. Consequently the share of nuclear power plants is expected to grow. At the time typical advanced light water reactors set the standard in technology and economics, however, prospective fast reactors hold an incredible potential in terms of resource utilization and waste management. This research explored the competitive performance of one type of fast reactor and compared it with a current established light water reactor through the use of Grey Relational Analysis (GRA) and Analytical Hierarchy Process (AHP) modelling. The results of the GRA show that the fast reactor has a higher overall performance technically however in sheer terms of economics the light water reactor excels. The stakeholders that were involved in the AHP rated the significance of costs related performance attributes clearly as predominant factor, which ultimately pleads for the light water reactor. Hence the light water reactor at this time is considered as most competitive.

Keywords: fast reactor, generation IV, competitiveness, Analytical Hierarchy Process, Grey Relational Analysis

Introduction
Natural gas is the most important and abundant natural resource in the Netherlands and the Dutch natural gas extraction accounts for one fifth of the European gas extraction. The Dutch have the highest natural gas consumption rate in Europe and besides, the Dutch are net exporter. The Netherlands cover more than 75% of their own energy needs compared to 60% on average in the rest of Europe, mostly due to natural gas.

However, it is concerning that - business opportunity or not - natural gas is not an exhaustless resource and will run out over the next decades. The Dutch ministry of Economic Affairs (EA) expects that by the midst of this century, the Dutch will become importer of natural gas instead of net exporter as today (EA, 2008).

Therewith, the negative environmental impact of energy production, transformation, handling and consumption becomes increasingly significant. Bearing these developments in mind, the future of the Dutch energy provision system will be under pressure. Therefore, it really needs thorough reconsiderations and at the time, there are only a few realistic options for securing national electricity generation; 'increase efficiency in electricity generation and use; expand use of renewable energy sources such as wind, solar, biomass, and geothermal; capture carbon dioxide emissions at fossil-fuelled (especially coal) electric generating plants and permanently disposal of the carbon and; increase use of nuclear power.'

When considering the nuclear option above, it is necessary that our understandings must be revised compared to the first nuclear era for continuing nuclear energy usage in the future. These understandings are mostly related to safety, management and storage of the high-level radioactive waste (HLW). Geological disposal is technically feasible but execution is not yet demonstrated or certain and not every European nation has pointed out, or is capable with long-term geological storage. Moreover, the Dutch government needs to decide on long-term waste deposit siting by 2016.

A fast reactor therefore appears a profound solution to mitigate the volume of spent fuel and HLW. Though at this point, there is no clear perception of the potential of revolutionary nuclear reactor systems – that are more sustainable in HLW management and mitigation– due to the lack of satisfactory demonstrated practical experience and urgency. Therefore, the trend has been to continue the utilization of typical light water reactors (LWRs). Additionally, the market entrance of newly developed nuclear power plants is generally a matter of financial profitability and capital risks.

The aim of this research is to tell if a more sustainable nuclear reactor can be part of our future energy mix. In other words, the aim is to disclose if a revolutionary nuclear reactor system; (1) can offer a sustainable solution to future energy challenges and; (2) is a competitive option on tomorrow's energy market. This research effort focused on the generation IV nuclear reactor designs and the Lead-cooled Fast Reactor (LFR) was considered particularly.

The aim as explained above is dependent on the LFR's competitive economics and operational performance. Therefore, this research investigated the cost structure of this particular LFR system so it can be compared with the market supply systems. It then examined a tool by which mutual nuclear power plant performance can be measured. The purpose of this tool is to assess the advantages and disadvantages of the LFR's performance compared to a current established LWR. For this assessment, prominent stakeholders' preferences are also taken into consideration, since they decide what is important.

Dutch energy provision

The annual energy demand of the Netherlands was approximately 128 TWh in 2007 (ECN, 2007). Industry is the most energy consuming sector, mostly due to the large (petro) chemical industry and greenhouse farming. More than half of the industrial energy consumption concerns the use of energy commodities as raw materials for processing products like plastics from petroleum. Petroleum is only extracted in small amounts on Dutch soil and therefore it has the biggest share of imported energy commodities, followed by coal which was extracted in the Netherlands before it became uneconomical.

Natural gas is the primary fuel used for electricity generation in the Netherlands and contributes to the total national electricity production for over more than 60%. A small amount of electricity is generated by the single currently operated nuclear power plant Borssele (approx. 485 MW) in the southwest of the Netherlands, which accounts for about 1.3% of the Dutch energy consumption. Speaking in sheer electricity terms this share is higher and the currently operated Borssele reactor provides about 4% of total generation, namely 4.1 TWh net in 2007 (WNA, 2011). In 2007, a total of 103 TWh gross was generated. Natural gas provided 60 TWh, and coal 28 TWh. Renewables (mostly biomass) added 8.7 TWh (WNA, 2011). Regarding the demand structure, the future tells that it will increase ever due to an increasing population, technology advancements and a strong GDP (Statistics Netherlands, 2007). The European that can now be provided with electricity from the Netherlands will stress this demand even further.

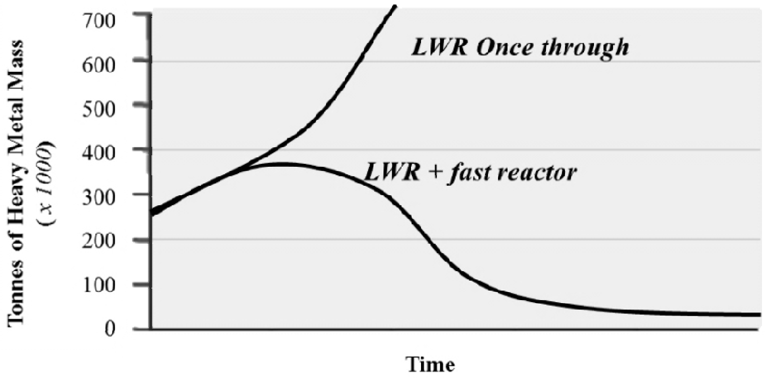
Generation IV nuclear advancements

As explained in the introduction, nuclear power systems need to be advanced to meet future needs. To support these advancements, several nations cooperating as the Generation IV International Forum (GIF) have formed a framework for international cooperation in research. They stated their intentions and research objectives in a technology roadmap that serves a future generation - Generation IV - nuclear energy systems. The Generation indication stands for the contemporary nature of the nuclear reactor design and stage of technology. Some Generation IV nuclear reactors – like the LFR – are distinguished by a closed fuel cycle with recycling.

For this research, a closed fuel cycle with fully recycling is of topical interest. Namely, closed fuel cycles could include the use of a dedicated fast reactor that can be used to breed fissile material or can be used for the transmutation of selected isotopes that have been separated from spent fuel, burning as it were, the highly radioactive material. **When the LFR is designed to transmute actinides from spent LWR fuel, nearly all long-lived actinides can be transmuted to short-lived isotopes, which would: (1) reduce the amount of radioactive waste that needs deep repository to a fraction of what is needed for once-through cycle, and; (2) by removing the actinides (Americium, Neptunium, Curium) the radioactivity would be significantly reduced within 100 years (Hore-Lacey, 2006).** The sustainable property of the closed fuel cycle with fully recycling has a very evident effect on permanent waste storage as shown in figure 1.

For this research effort, the Lead-cooled Fast Reactor (LFR) was considered. 'The LFR system is top-ranked in sustainability because a closed fuel cycle is used, and in proliferation resistance and physical protection because it employs a long-life core. It is rated good in safety and economics.' (GIF, 2002) The safety is enhanced by the choice of a relatively inert coolant (Pb) compared to sodium for example.

Figure 1: Spent fuel inventory with and without the introduction of fast reactors



Adapted from: Generation IV International Forum, 2002 p.13

For this research effort on the LFR system, data of the European Lead-cooled fast reactor SYstem (ELSY) design is adopted as a reference design. All further used data, characteristics and calculations are based on this specific ELSY design. 'The ELSY reference design is a 600 MWe pool-type reactor cooled by pure lead. Sustainability was a leading criterion for option selection for core design, focusing on the demonstration of the potential to be self-sustaining in plutonium and to burn its own generated MAs.' (Alemberti et al, 2009)

Integrated Nuclear Energy Economics Model

To determine the economics of Gen IV systems, the GIF has set up the Economic Modelling Working Group (EMWG). The EMWG is in charge of the development of future generation cost estimation methods. They proposed the Integrated Nuclear Energy Economics Model (INEEM). The EMWG Code of Accounts (COA) system and G4ECONS excel based computing software were used to calculate the costs of the concerning LFR as no data of the costs is yet available. The accounts that were used can be found in the GIF-EMWG cost estimating guidelines (GIF-EMWG, 2007).

Table 1: Results of the INEEM for the *NOAK* LFR power plant expressed in 2009 €/MWh

	discount rate 5%	discount rate 10%
Capital costs including financing	34.80	87.75
Operation	7.29	10.58
Fuel cycle front end	6.86	12.51
Fuel cycle back end	2.24	4.78
Fuel cycle total	9.10	17.29
D&D sinking fund	0.017	0.04
Specification TCIC	5,549	6,360
Total LUEC	**51.36**	**115.66**

The ultimate aim of the costs calculations is to determine the LFR's levelized unit of electricity costs (LUEC). The LUEC expresses the euros it costs to generate one MW of electricity. The purpose of the LUEC is that this figure makes it is now comparable to other electricity generating systems. This is important to determine its economic competitiveness.
Two plant cost models were considered, namely a first-of-a-kind (FOAK) plant, because there are no specific LFRs of this type to date and an nth-of-a-kind (NOAK) for identical follow up LFRs. Because of the goal is to find out if the LFR could be a competitive attractive option;

the NOAK plant cost figures will further be used to assess its economic advantages, assuming that market parties will only opt for a LFR after it is fully demonstrated. The calculations have been carried out un G4ECONS and processed in table 1. For the plant, two different discount rates were taken into consideration namely: the 5% discount rate and the 10% discount rate, so that it can be compared with the other source of energy generation in the future.

When evaluating the future market developments with e.g. the International Energy Agency's 'Projected Costs of Generating Electricity – 2010' (IEA, 2010), some remarkable developments take place. Simply put, fossil fuels costs will go up and renewables costs will go down; the LUECs of these electricity sources are highly influenced by future policy objectives and market developments. It almost comes to a turning point where these sources trade places; except for the fact that renewables still are doubtful regarding their practical feasibility. Regarding nuclear energy (generation II/III), little changes will occur. Nuclear fuel will remain extensively available and the European share in nuclear hardly increases (IEA, 2009). Nuclear energy will remain highly competitive in terms of economics for at least this century and because it does, the LFR will not become anywhere near competitive with these older systems. Nevertheless the LFR can be financially competitive with fossil fuel fired power plants and renewables.

Table 2: Nuclear power plant configurations and their performance attributes

Attribute:			EPR	LFR
A11	Fuel consumption	*mt/yr* [1]	1.35E-04	9.18E-05
A12	Waste production	*mt/yr*	2,46	1,15
A13	Radio toxicity	*Svt/TWh* [2]	1.85E+10	2.29E+07
A21	Load following flexibility	*%*	100	100
A22	Cooling water consumption	*10^5 m^3/hr* [3]	4.914	1.552
A23	Space requirements	*hectare*	8,571	8,498
A31	Capital costs	*€/kWh* [4]	52.78	80.93
A32	O&M costs	*€/kWh*	8.34	10.62
A33	Fuel cycle costs	*€/kWh*	5.33	9.10
A34	D&D costs	*€/kWh*	0.030	0.048
A41	Licensing time	*months*	36	36
A42	Licensing uncertainty	*%* [5]	25	25
A51	Active/ passive safety	*%* [6]	100	100
A52	Public safety hazard	*p/km^2* [7]	160	160
A6	District heat generation	*GWh/yr*	0	0

1: metric tonnes per year
2: decay radiation in Sievert per Terawatt-hour
3: 100,000 litres per hour
4: costs A31-A34 are derived from the standard 10% discount rates
5: 25% means low uncertainty, proven concept. 75% means high uncertainty, unusual concept
6: due to very strict safety regulations concerning plant licencing, plants perform equal
7: accommodated population per square kilometre within the vicinity on average

Multi attribute decision making tool

The competitiveness beyond mere economics is finally measured in comparison with another nuclear power plant (NPP). Namely this comparison it is done with an European Pressurized water Reactor (EPR) that is most plausible to be built in the Netherlands in the near future. The final part of this research is the mutual classification of both the LFR's and the EPR's configurations with the help of a multi-attribute decision making (MADM) tool. From these configurations, 15 performance attributes were extracted for comparison as shown in table 2 which are expressed in figures. Henceforth, two methods are introduced to rank these performance attributes by both mathematical relativisation and by stakeholders' judgements. To elaborate such MADM tool, two methods are introduced, namely the Grey Relational Analysis (GRA) and the Analytical Hierarchy Process (AHP).

Grey relational analysis

According to literature (e.g. Lee and Lin, 2011; Kung and Wen, 2007; Wei, 2011): 'GRA is proven to be useful for dealing with problems under discrete, poor, fragmented, incomplete and uncertain data sets and solving their complicated inter-relationships between the multiple factors and variables. In GRA, the global comparison between multiple sets of data is undertaken instead of using local comparison by measuring the distance between two points. It measures the degree of similarity or difference between two sequences or discrete data sets based on the grade of relation.' With the LFR still in the design phase, its operational performance figures are based on calculations until demonstration experience is measured in practice. For the EPR goes that its performance data is either factory released, i.e. data is provided by the supplier, or calculated.

GRA procedure

The main procedure of GRA consists of four steps: Grey relational generating, reference sequence definition, Grey relational coefficient calculation, and Grey relational grade calculation (Lee and Lin, 2011). In Grey relational generating step, GRA firstly translate the performance of all alternatives into comparability sequences. According to these sequences, a reference sequence (ideal target sequence) is defined at reference sequence definition step. Then, the Grey relational coefficient between all comparability sequences and the reference sequence is calculated. Finally, based on these Grey relational coefficients, the Grey relational grade between the reference sequence and every comparability sequences is calculated. If a comparability sequence translated from an alternative has the highest Grey relational grade, that alternative will be the best choice.

The sum of the Grey relational coefficients for each plant after calculations is shown in table 3, where goes, the higher the sum, the closer the NPP is to the optimum sequence.

Table 3: Grey relational coefficients

	EPR	LFR
Summed Grey relational coefficients	11.000	11.667

Clearly the LFR rates higher than the EPR. Thus it can be said that the LFR does hold the best overall performance. These Grey relational coefficients however do not hold any factor of importance. Although, the LFR rates highest, another nuclear power plant might still be best when considering the significance of these weights. These weights usually depend on the decision maker's judgements (Lee and Lin, 2011). Though, this can be done in a setting where the modeller is the stakeholders or where stakeholders are closely involved in the decision making process, it is less suited for these circumstances.

AHP procedure

The AHP procedure consists of the following steps: first, the hierarchal structure needs to be designed which arranges all the criteria and sub-criteria. The criteria are used to label rows and columns of the pairwise matrix, called the comparison matrix. At each level of the hierarchal structure, a pairwise matrix is created according to the corresponding (sub-) criteria. The next step is to fill the intersections between them with a numerical preference value. These preferences values can be obtained by stakeholder judgments by means of a questionnaire. Then, the judgements are checked for consistency. Thereafter, the matrices' eigenvector is calculated by normalising the values of each row. The resulting eigenvector is the principal eigenvector elucidating the relative preferences for each of the alternatives.

The preference values extracted from these questions were collected through individual questionnaires. Five groups of respondents were selected as prominent stakeholders, namely: nuclear physicists and researchers; utility exploiters not operating a NPP in their energy portfolio; nuclear power plant exploiters; citizens of Eindhoven and students from the University of Technology Eindhoven of the major subject Construction Management and Engineering. They were asked to individually compare each criterion with the next, repeatedly until all criteria were compared to one another. The respondents had to use the scale from 1,3,5,7,9 where 1 is equal important and 9 is very strongly more important.

Furthermore it was chosen to perform a rather qualitative than quantitative questionnaire. The number of respondents of each group invited to the questionnaire had a minimum of two and a maximum of five. This was done because of two reasons; (1) there is only one commercial nuclear power plant in the Netherlands, what makes it impossible to ask a large population of nuclear power plant exploiters; (2) the pairwise comparison method demands carful considerations, and expectations were that mostly citizens and students are not able to return perfect consistent questionnaires, making large populations even more unusable.

Table 5. Stakeholder's ratings of each performance attribute

	Nuclear scientist	Utility exploiters	NPP exploiters	Citizens of Eindhoven	Students
Fuel consumption	0,0258	0,0633	0,0376	0,0837	0,0382
Waste production	0,0439	0,0331	0,0345	0,0986	0,0921
Radiotoxicity of waste	0,0290	0,0134	0,0106	0,0565	0,1524
Load following flexibility	0,0790	0,0787	0,0178	0,0351	0,0683
Cooling water consumption	0,0236	0,0098	0,0071	0,0235	0,0225
Space requirements	0,0112	0,0141	0,0148	0,0235	0,0235
Capital costs	0,1603	0,1521	0,3103	0,0173	0,0445
O&M costs	0,0545	0,1165	0,0836	0,0477	0,0353
Fuel cycle costs	0,0293	0,0380	0,0678	0,0491	0,0139
D&D costs	0,0313	0,0383	0,0382	0,0225	0,0254
Licensing time	0,0191	0,0442	0,0396	0,0417	0,0169
Licensing uncertainty	0,0804	0,0066	0,0396	0,0474	0,0253
Active/ passive safety features	0,1958	0,2472	0,1876	0,2734	0,2706
Population within area	0,1800	0,0934	0,0839	0,0560	0,1113
District heating	0,0366	0,0515	0,0270	0,1239	0,0598

The results from the questionnaires were processed into table 5. Of the other groups, five nuclear scientists replied, two utility exploiters, two nuclear power plant exploiters, five citizens of Eindhoven and five students of the University of Technology Eindhoven. The ratings in table 5 show the individual group's ratings of the importance of each criteria. The highest rating of each group is expressed in bold.

With the calculated Grey relational coefficients and with the results of the questionnaire, each groups' most preferred NPP can be distinguished. This 'ideal' NPP is expressed by the highest Grey relational grade. The final grades that were generated are represented in table 6 below.

Table 6: Grey relational grades. These grades express each group ultimate preferred NPP

	EPR	LFR
Nuclear scientists	**0,7538**	0,6592
Utility exploiters	**0,8132**	0,6725
NPP exploiters	**0,8539**	0,5904
Citizens of Eindhoven	0,7115	**0,8109**
Students	0,7121	**0,8519**
Geometric mean	0,7257	**0,8153**

It is the industry that ultimately judges which NPP is economically attractive and therefore which power plant will be deployed in the future. Thus, with costs rated as the major driving forces, the LFRs performance will not be competitive enough to become feasible on the short term.

Conclusion

At the moment, the Dutch energy provision is incredibly dependent on its natural gas resources that – on the short term – cause volatile market developments because of the high export standards and pricing and – on the long term – will become an evident difficulty when depletion comes closer.

The LFR certainly has benefits for the futures energy mix when considering its stability, waste burning capability and fuel utilization. In addition, nuclear power plants are one of the few remaining type of power plants that can continue to deliver electricity in environmental friendly and reliable ways. The present Dutch government stated that the security of energy supply would remain a policy spearhead, along with efforts to cut carbon dioxide emissions in line with European targets. Hence "the government will be open to issuing permits for new nuclear power plants." Another spearhead of the present government's policy is that 'energy security must be increased and more attention must be paid to the potential profitability of energy'. In terms of security, the LFR will perform excellent, however, in terms of profitability, the current and future Gen III/III+ LWR reactors will prevail. In addition, the capital at risk is far higher than with the current generation nuclear power plants.

The investigated LFR is not competitive compared to an EPR, nor is the closed fuel cycle with full recycling compared to the once through cycle at this moment. The share of nuclear power plants will not increase drastically next decades. The urge to make the transition to closed fuel cycles with fully plutonium recycling and burning minor actinides will probably not be made in the 21st century as costs of uranium will not likely rise that fast. The MADM tool has proven to be useful in the assessment of the advantages and disadvantages of the two compared nuclear power plants. The results clearly show that the LFR has the highest Grey relational grade which indicates a slightly higher overall performance. This is mainly due its fuel and waste handling characteristics. When the stakeholders' opinions are taken into consideration, the best performance becomes twofold. Namely the industry rates the EPR as best performing, whilst the non-industry rates the LFR as best performing. This conclusion shows that the non-industry – confirming to the general survey that was held nationwide (Smart Agent Company, 2009) – perceives the waste-handling performance of a LFR as the key performance indicator. On the contrary, the industry pointed out capital investment costs as the major key performance indicator.

Discussion

Only the potential of fast reactors in general was investigated and the research proceeded with taking only one very particular Gen IV reactor into consideration. The competitiveness of other Gen IV reactors remains therefore unknown and will be of interest in further research. The costs input for the LFR came from preliminary designs as the input from the EPR mostly came from the supplier and can therefore differ from reality. This unfairness was straightened out by running the EPR data through the same G4econs model as the LFR was calculated with. The fact still remains that the EPR is already under construction today and comparison will be more reliable when the LFR becomes in the same advanced stadium. It goes for the investigated LFR that it is not operational before 2040. Therefore, when the LFR becomes in a further design phase where more detailed costs estimations can be made, it can be recommended to review its cost competitiveness.

Furthermore, the LFR has been compared with an EPR. This EPR however, is developed with different objectives in mind. Comparison between these two might not reveal as much information as when the tool would be used to compare nuclear power plants of the same technical scope and objectives. Consequently a logically step would be to use the MADM tool to compare future Gen IV systems or even more particular Gen IV lead-cooled systems when more of these systems' technical data becomes available.

Recommendations

Nuclear is a mature technology and no specific incentives are needed. It could easily be the backbone of the Dutch national energy provision, once gas production is near exhaustion. The Dutch government then needs to seek ways for skimming proportional profits so that all the Dutch share benefits. However, for nuclear energy to be really cost effective and to really be a source of energy future generations can rely on, the Dutch government needs to formulate clear policies and probably have to cooperate with both utility companies as civilians in order to match interests. High upfront costs of investment in these facilities again make the issue of regulatory uncertainty crucial; as long as this is not clear, no investor will risk their money on a LFR waste burner or on reprocessing infrastructure. As for now; every EU member state has to deal with the nuclear waste issues themselves. It would be sensible that the Dutch government considers these investments and infrastructure for high radio-active waste in cooperation with neighbouring countries.

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In my study career, I educated myself mostly in schools for vocational education. During secondary school, I was more interested in technology in practice, so I decided to follow vocational training from fourth grade on. This is a less common training process in the Netherlands, because most students directly go to a university after graduating on secondary school. I finally decided to apply to the university to obtain a master in science degree, to be able to adapt theoretical knowledge and way of thinking and synchronize it with my practical background. Completing the challenging and long way to a university pays off in technical and everyday practice and I still enjoy this decision on daily basis.

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SUPPORTING TENANTS' DECISIONS ON ENERGY-SAVING MEASURES
How housing corporations can propose work

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ABSTRACT
Housing corporations experience reluctance in tenants to accept energy-saving measures, even when the expected financial outcomes are positive for the tenant. Possibilities to improve the presentation of the proposed energy measures are looked for. Previous research in decision-making suggests that advantages of the measures can be made more prominent to nudge tenants to participate. Also, supplying extra information is suggested; to broaden the scope towards the future gains and towards other energy measures, paid from another mental budget. Interviews with tenants suggest yet another possible improvement; supplying an individualized calculation of the energy saving to reduce tenants' uncertainty of the outcomes. The suggested improvements are actualized in information materials and tested in an experiment.

Keywords: decision making, existing social housing, housing corporations, tenants, energy-saving measures

INTRODUCTION
Energy-saving measures in rental houses contribute to the solution of climate problems as well as (anticipated) problems with living expenses. Housing corporations are in a good position to make a contribution in solving these problems. Taking energy-saving measures involves substantial investment costs that can (partly) be passed on to the tenants by means of a rent increase. When deciding whether to accept energy measures proposed by their corporation, tenants have to trade off the benefits of reduced energy costs and increased comfort of living against the costs of the rent increase and the temporary discomfort during renovations.
Housing corporations experience that tenants are reluctant to give their consent, even when the benefits outweigh the costs (Aedes, 2010). This reluctance indicates suboptimal choice behavior. Decision-making research aims at explaining such suboptimal choices. The present research investigates which explanations may hold for the suboptimal choice of (some) tenants.

Aim of the research

The aim of this research is to investigate what factors influence the decisions of tenants to accept or reject rent-increasing energy-saving measures, and to recommend how this knowledge can be used to help tenants make more well-informed decisions.

Research questions

The research aim can be broken down into the following research questions:

- What factors influence the decisions of tenants to accept or reject rent-increasing energy-saving measures?
- How can tenants be helped to make well-informed decisions?
- Do the suggestions to help tenants make well-informed decisions work in practice?

It is assumed that the corporation's proposal has a positive outcome for the tenants. Then, the optimal choice after weighing up the advantages and disadvantages is to accept the energy-saving measures. The opportunity to reject should always remain, because exceptions can occur that render the acceptance of the measures suboptimal in specific cases.

This research addresses both a practical societal problem and a scientifically relevant decision- making issue. A translation is made from theory to practice by proposing an intervention to help people make well-informed decisions.
The research is conducted in Eindhoven at two housing corporations, Domein and Woonbedrijf. Although the outcome of this research is of interest for those corporations, the focus is broader and results apply to tenants of other corporations too.

Outline of summary

The following steps are taken to answer the abovementioned questions. After a broad outline of the socio-technical background of the research problem, an overview of relevant decision-making theory is provided. To complement the results from literature research, information from practice is gathered through interviews with tenants and a review of current brochures. Several suggestions are given, comprising the enhanced, more prominent presentation of the advantages of the energy-saving measures, the individualization of the expected energy saving, and a focus-broadening elaboration of some specific advantages. The suggestions are actualized in informational brochures, inserts and a webpage and tested in an experiment. The hypotheses that are tested in the experiment are presented. The experiment is described and the results are discussed. Recommendations are given both for further research and for practical application of the research findings by housing corporations.

SOCIO-TECHNICAL BACKGROUND

Policy and instruments to stimulate improvement of the energy performance of houses have developed over the last decennia. When we look at the actors involved and their relationships, it appears that most stakeholders are involved in these developments.

The instruments mainly originate from the governmental actors. Negotiation takes place between them and the housing corporations at regional level and with the interest groups Aedes and the Woonbond at the national level. Housing corporations, contractors and suppliers are furthermore affected by subsidies. Tenants however, are less affected. They will be addressed through the provision of energy labels in the advertisements for vacant dwellings. However, this does not affect sitting tenants.

In other words, housing corporations seem to be addressed more directly and have a more active role than tenants. This is reflected in the intentions that many corporations show to take energy-saving measures, and the reluctance to participate that they encounter in some tenants.

Therefore, the tenant's decision whether to participate in energy-saving measures or not is an interesting subject to investigate. This individual decision of the tenant is investigated here, and not the influence of other actors, e.g. discussions with relatives and neighbors. The research results in recommendations for housing corporations on the communication toward their tenants about the proposed energy-saving measures.

SUGGESTIONS TO SUPPORT TENANTS' DECISIONS

In answer to the first research question, several factors that influence tenants' decisions are identified from decision-making theory and from interviews with tenants who recently had to decide on energy-saving measures. From the influencing factors, suggestions are derived that will help tenants in their decision. These provide an answer to the second research question.

Suboptimal decision making and nudging

People do not have a ready answer to such decisions as whether to accept or reject rent-increasing energy-saving measures. Rather, they construct their preferences during the process of thinking about choice. This process is not always the same as it is influenced by the way a question is put or the context in which a decision is made. Different thinking processes can lead to different preferences and consequently to different choices, while the available options stay the same. In this way, people can easily make choices that are not optimal for them.

However, this also offers the opportunity to set up a decision in such a way that people are more inclined to choose the optimal solution. Thaler and Sunstein (2009) propose to nudge peoples' choices in a certain direction in such a way. They reason that since it cannot be avoided that people are influenced by the way a choice situation is arranged, purposely or not, it is to be favored that such choice situations are designed conscientiously. They propose to "… help people make better choices (as judged by themselves) without forcing certain outcomes upon anyone…" (Thaler, Sunstein & Balz, n.d., p.1).

Suggestions from decision-making theory

Based on decision making theory several factors that influence tenants decisions on energy-saving measures can be pointed out. One is the order of presentation of advantages and disadvantages. By first reading the advantages and then the disadvantages, a preference for the energy measures develops more readily. Another influencing factor is the default option. People choose an option more often if it is the default than if it is not.

Another factor is people's focus on the present. Because of this, they will easily overlook that the advantage increases in the future, as energy prices increase more rapidly than rents. Moreover, when this is brought into focus, people cannot be expected to understand the exponential growth of the advantage directly. Exponential growth is not understood intuitively; cognitive reflection is needed.
A last influencing factor that decision making theory points out is the focus on the proposed measures. By comparing them with other energy-saving measures a broader mental budget is addressed. Tenants will then more readily accept the rent increase. Also, the evaluability of the energy saving is increased, because it can now be compared with that of the other measures. It becomes clear that the proposed measures are highly effective.

From interviews with tenants

A number of interviews with tenants, who recently had to make a decision about energy-saving measures, brought up another factor that was important in the decision of many. This was uncertainty over the outcomes. Moreover, the interviews showed that tenants do not know the cost of energy and have trouble judging the effectiveness of several energy measures. This suggests that providing additional information to reduce uncertainty can help tenants in their decision about proposed energy measures.

Review of current brochures

A review of current brochures that include energy-saving measures shows that the suggestions to support tenants' decisions are not or only partly applied yet. To find out if they work in practice, they are tested in an experiment.

EXPERIMENT: TESTING THE SUGGESTIONS

An experiment is conducted to test the hypotheses. 1400 tenants of Domein and Woonbedrijf are presented with a hypothetical proposal for maintenance work and energy-saving measures. These are presented in two different sample brochures that are sometimes supplemented with an individualized calculation on an inlay and/or a web address to look up additional information.

Hypotheses

The suggestions to help tenants make well-informed decisions are used as hypotheses to be tested in the experiment. The hypotheses are:

> **Hypothesis 1**: Tenants are more inclined to choose for energy-saving measures if the advantages of those measures are presented more prominently.
>
> **Hypothesis 2**: Tenants are more inclined to choose for energy-saving measures if they receive an individualized calculation of the expected energy saving.
>
> **Hypothesis 3**: Tenants are more inclined to choose for energy-saving measures if they appreciate the future advantage of those measures better.
>
> **Hypothesis 4**: Tenants are more inclined to choose for energy-saving measures that the housing corporation proposes if they compare them with other energy-saving measures that they can take themselves.

Method

The first hypothesis is actualized in the two brochure variants, a base brochure similar to current brochures and an alternative brochure with prominent advantages. In the alternative brochure, the advantages of the energy-saving measures are described before the disadvantages, they are described in more detail, and the execution of the work is presented as default.

The second hypothesis is tested using a supplementary sheet with an individualized calculation of the energy saving. This is one way of reducing uncertainty by providing individualized information. The outcome of the calculation is equal for all subjects. The text suggests to them that they already provided the information that is needed for the calculation earlier, and now are given the outcome.

The last two hypotheses are both actualized on a webpage where the additional information about future advantages and other energy-saving measures is provided. The time is measured that people watch each part of the information.

The two brochures, the supplementary sheet with an individualized calculation and the web page with additional information are combined into eight conditions. They are shown in the overview below (figure 1).

A questionnaire measures the willingness to accept the energy measures based on the received information material. It also measures potential covariates that contribute in the statistical analysis to find an effect of the conditions.

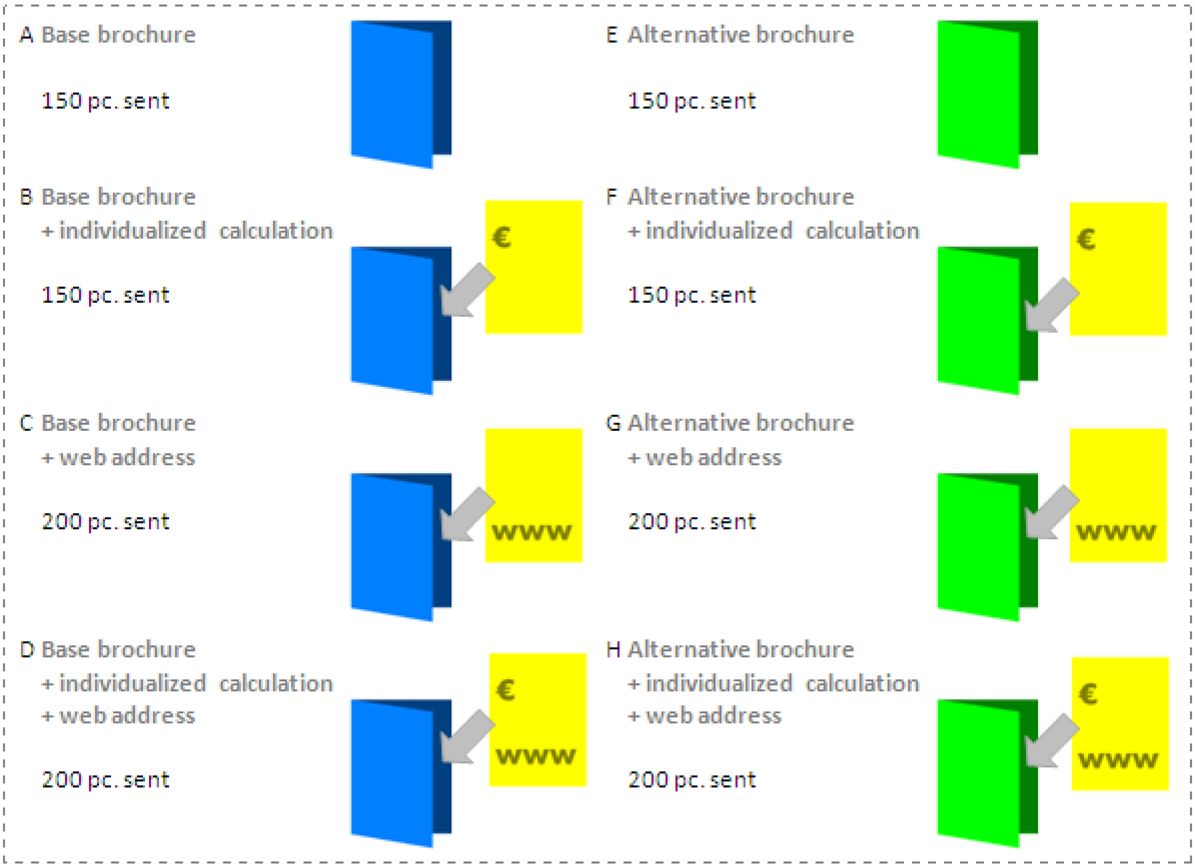


Figure 1: Overview of conditions

Results and discussion

About a quarter of the questionnaires are returned. More than half of the respondents (51.3%) say that they would certainly accept the energy-saving measures if these were proposed to them. Another third (35.6%) is not certain but still thinks they would accept. See figure 2.

This skewness of the distribution makes the dependent variable unsuitable for linear regression analysis. Therefore it is dichotomized so that logistic regression can be done. The certain accepters form one group; all others are combined into the other group.

Acceptance of energy-saving measures

After reading the information, would you accept the energy-saving measures?

	%	cum.%
Certainly	51.3%	51.3%
Probably	24.9%	76.2%
Rather would, than not	10.7%	87.0%
Rather not, than would	4.6%	91.6%
Probably not	3.8%	95.4%
Certainly not	4.6%	100%

Figure 2: Distribution of acceptance of energy-saving measures

The webpage was viewed only 28 times. This is insufficient to do data analysis. Therefore, hypothesis 3 and 4 could not be tested.

Hypothesis 1 and 2 are tested in a regression analysis including both manipulations and their interaction. The alternative brochure and the individualized calculation by themselves do not have a significant effect on the acceptance of energy-saving measures.

The effect of the manipulations could be obscured by other variables that have an effect on acceptance. Therefore, the potential covariates that were measured in the questionnaire are included in the analysis.

Three covariates are found that have a significant effect on acceptance. The probability of acceptance is affected by household income, by the effort one takes to save energy and by the extent to which one feels environmentally engaged.

Tenants with a household income above €20,000 are more inclined to accept the energy measures. The alternative brochure does not change their acceptance rate. See figure 3. However, the alternative brochure has a substantial positive effect on tenants with lower household income. So the suggestions to describe the advantages first and to present the execution of the work as default are effective for this group. (NB This research does not demonstrate whether these manipulations also work separately.)

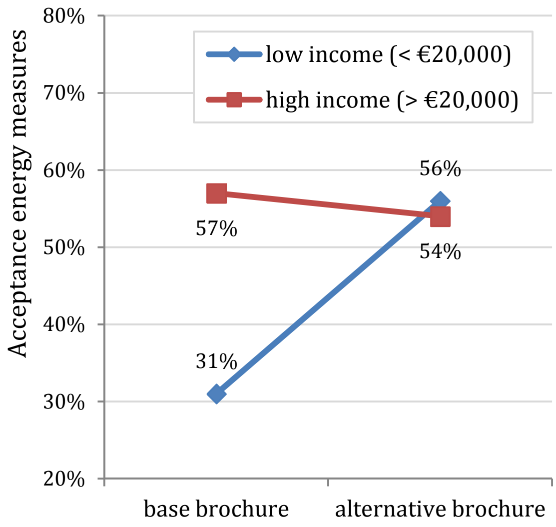


Figure 3: Effect of household income and brochure variant on acceptance

Tenants that take more effort to save energy than others and tenants that feel more engaged with the environment are more inclined to accept the proposed energy measures. When controlling for these covariates, a significant positive effect of the alternative brochure is again found. Furthermore, there is a significant interaction between the individualized calculation and being an energy-saver. This is shown in figure 4.

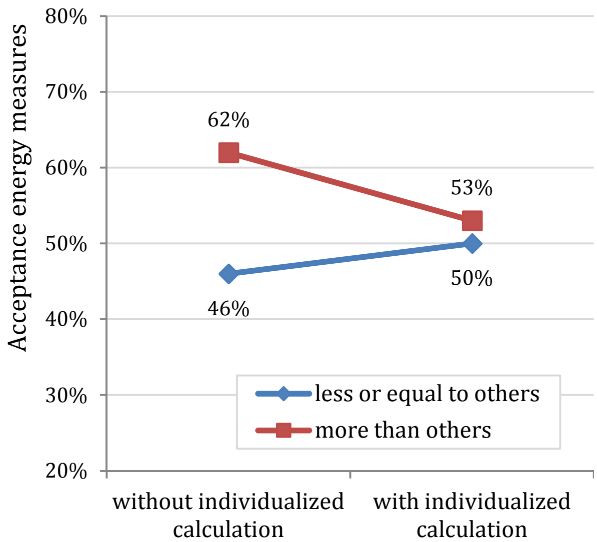
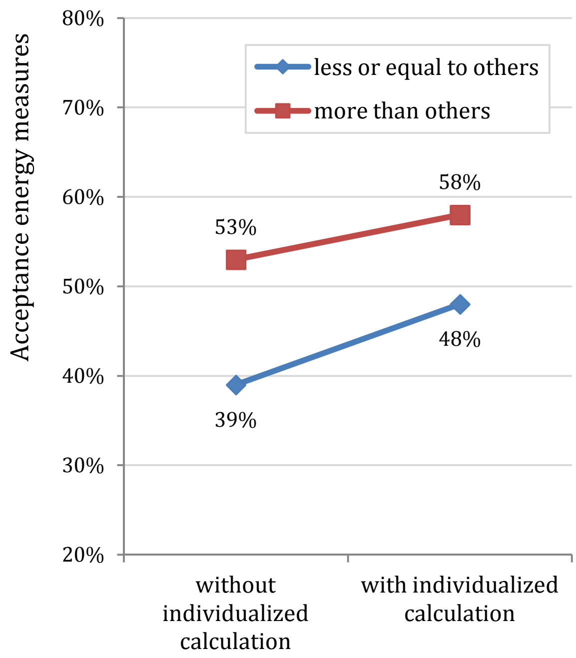


Figure 4: Effect of energy saving effort and individualized calculation on acceptance

The figure shows a negative effect of the individualized calculation for persons who take more effort to save energy. The effect for persons who take little effort to save energy, on the other hand, is positive.

To investigate the unexpected negative effect, a split is made between the respondents who received the base brochure and those who received the alternative brochure. The graph is then redrawn for both groups. This results in figure 5 and 6.



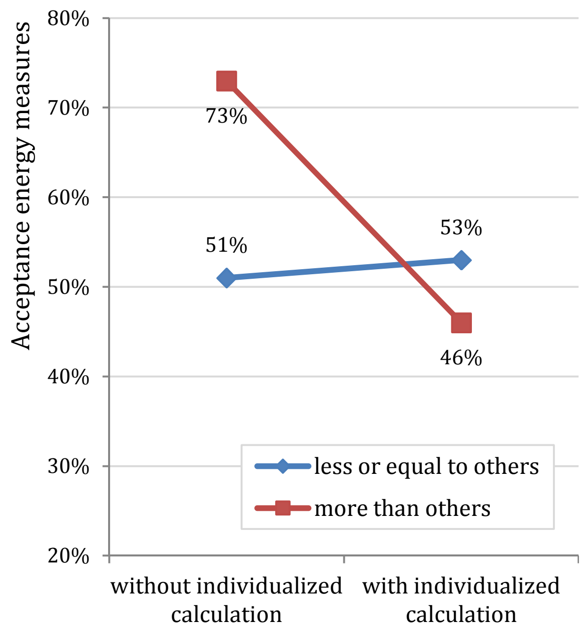


Figure 5:** Effect of energy saving effort and individualized calculation on acceptance **for respondents receiving <u>base brochure</u>

Figure 6:** Effect of energy saving effort and individualized calculation on acceptance **for respondents receiving <u>alternative brochure</u>

These graphs show that the negative effect only occurs in the group of respondents that received both the alternative brochure and the individualized calculation. For all other respondents, the calculation has a small positive effect, which is marginally significant.
This result might be explained by the individual energy saving being lower than the average presented in the brochure. However, this cannot be tested in this research. Therefore, hypothesis 2 cannot be confirmed nor rejected at this point.

Conclusions

Hypothesis 1 is partly confirmed. Making the advantages more prominent increases the acceptance of low income households.
Hypothesis 2 is neither confirmed nor rejected. The individualized calculation has a negative effect on enthusiastic energy savers that received the alternative brochure, and a small positive effect on all others. The negative effect cannot be explained with certainty, but might be caused by disappointment. It is recommended to do further research into this.
Providing individualized information is suggested in the field as an opportunity to convince tenants. This could not be confirmed by this research. If the proposed explanation of the lower individual outcome is correct, this has consequences for the use of individualized information. After all, part of the tenants will always have lower results than average.
Further research is also advised for hypotheses 3 and 4. They could not be tested due to lack of data. The suggestions to broaden the scope to the future advantage and to other energy-saving measures are supported by decision making theory, and offer new opportunities that are not suggested in the field yet.

RECAP OF RESEARCH QUESTIONS AND ANSWERS

1. What factors influence the decisions of tenants to accept or reject rent-increasing energy-saving measures?
   - The order of advantages and disadvantages;
   - Which option is the default;
   - Focus on the present;
   - Focus on the proposed measures;
   - Uncertainty about the outcomes.
2. How can tenants be helped to make well-informed decisions?
   - Discuss advantages before disadvantages;
   - Present the realization of the energy measures as the default;
   - Bring into focus the future advantage and explain its exponential growth;
   - Compare the proposed measures with other energy-saving measures;
   - Provide additional information to reduce uncertainty.
3. Do the suggestions to help tenants make well-informed decisions work in practice?
   - The first two suggestions are bundled and have a substantial effect for tenants with a household income below €20,000. For higher income households, these suggestions have no effect, but they are more inclined to accept the measures already.
   - The two suggestions to broaden focus -to the future and to other energy measures- could not be tested.
   - The last suggestion, to reduce uncertainty with additional information, is tested by providing an individualized calculation of the energy saving. This had a marginal positive effect, except for tenants who received the improved brochure (in which the first two suggestions are realized) and who also indicated that they take more effort to save energy than others. For these people the individualized calculation had a substantial negative effect. The cause for this could be disappointment in the lower energy saving, but this is not certain. Therefore, it remains uncertain whether this suggestion works in practice.

RECOMMENDATIONS FOR HOUSING CORPORATIONS

- Make an offer that is beneficial for (most of) the tenants.
- In communication about the energy-saving measures, discuss the advantages before the disadvantages.
- Describe the execution of the work as the default option, not as an extra choice.
- Explain the increasing advantage in the future.
- Compare the proposed measures to other energy-saving measures that tenants can take themselves.
- Reduce uncertainty about the outcomes. This can be done in many ways, for example by providing individualized information, by means of a show house, or by exchanging experiences with other tenants. Be aware that more certainty can also lead to disappointment if the expectations are too high. So do not create too high expectations beforehand.

RECOMMENDATIONS FOR FURTHER RESEARCH

Further research is recommended into:

- the individual effects of the order of advantages and disadvantages and the presentation of the execution of work as the default option;
- the cause of the negative effect of the individualized calculation for a specific group of tenants that take much effort to save energy and that furthermore received the alternative brochure;
- the effectiveness of explaining the future advantage;
- the effectiveness of comparing the proposed measures to other energy-saving measures.

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Thaler, R.H., Sunstein, C.R., & Balz, J.P. (n.d.). Choice architecture. Retrieved from http://ssm.com/abstract=1583509

Wolters, Maria Johanna (Rianne)

Although many factors influence the decisions of tenants on accepting rent-increasing energy-saving measures, my research indicates that tenants may be nudged to accept a good proposal by means of well-informed choice architecture.

1999 – 2003 Bouwkunde (unfinished)
2003 – 2007 Bachelor’s program Technische InnovatieWetenschappen
2007 – 2011 Master’s program Innovation Sciences

APPENDIX

November 2010

Samenstelling Wim Schaefer en Erik Blokhuis

VERSLAG STUDIETRIP FREIBURG

Inhoudsopgave

Voorwoord

In het najaar 2009 is het KENWIB project van start gegaan 'Kenniscluster Energie Neutraal Wonen in Brainport'. Met dit project is de samenwerking verankerd tussen de Gemeente Eindhoven, De Provincie Noord Brabant het fonds Promotie Installatie Techniek (PIT) en de Technische Universiteit Eindhoven. KENWIB heeft tot doel om energie neutrale ontwikkeling van de stad te bevorderen door (inter-) nationale oriëntatie, onderzoek, kennisspreiding en stimuleren van nieuwe bedrijfsactiviteiten in relatie tot nieuwe energie concepten voor de gebouwde omgeving.

Binnen het kader van KENWIB is in november jl. een korte studietrip georganiseerd naar Freiburg. Er waren veertien deelnemers: studenten, wetenschappelijk medewerkers en vertegenwoordigers van bedrijven en instituten. De deelnemers hebben de kans gehad om ontwikkelingen te zien op gebied van stedelijke energie-management oplossingen, die in Nederland (nog) onbekend zijn, dan wel niet toepasbaar zijn. De opgedane kennis en inzichten zijn uitgebreid bediscussieerd tijdens en na de reis. Met deze reis is wellicht een groep ambassadeurs gevormd, die elk op hun eigen plek, binnen hun eigen persoonlijke netwerk ontwikkelingen kunnen voeden, op weg naar energie neutrale stedelijke gebieden. De reis is mede mogelijk gemaakt door financiële bijdragen van voornoemde partners in het KENWIB project. Last but not least: door de gedegen voorbereidingen van Rob van de Berg, Petra Quirijns, Rianne Wolters en Suzan Timmers is de reis bijzonder leerzaam en plezierig verlopen. De teksten in dit verslag zijn door alle deelnemende studenten vervaardigd.

Wim Schaefer
TU/e, 1 december 2010

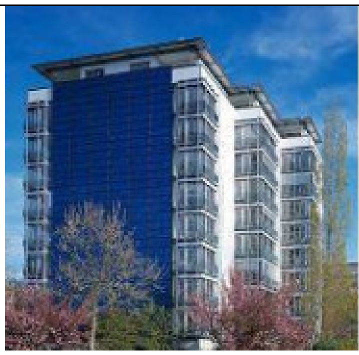
1. Beknopt overzicht en toelichting reisprogramma

14 november
Reis Eindhoven – Freiburg

- Bespreking reisdoelen programma
- Toelichting van studenten op afstudeerprojecten
- Introductie deelnemers

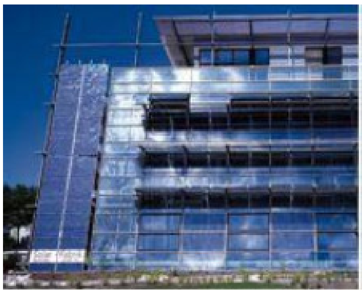
15 november
Studiedag verzorgd door Erhard Schulz

Tijdschema	*Omschrijving*	
9.00 – 10.00	**Historical and actual development of the old town** The historical town centre of Freiburg was in the World War II largely destroyed. Due to the complex reconstruction and the establishment of the pedestrian zone, the heart of Freiburg is today as an attractive and vibrant centre. . Current projects like a new tramway line and the extension of the pedestrian zone set the course for the future. - Oberlinden: Visit of the medieval city centre - Konviktstraße: Refurbishment of the old town during the 1970s - Organisation and enlargement of the pedestrian area -Tram network in Freiburg since 1901 - Parking management	 
10.00 – 11.00	**Visit to one of the most ecological hotels of the world** with solar collectors, solar modules and 4 small wind power installations on the roof garden, energy and water saving measures, a heating plant using wood pellets, a ground water cooling system and an excellent breakfast buffet of local foods.	

11.00 – 11.30	**Solar modernization** Inspection of the outside of two high rise buildings constructed in1970 that were refitted with a highly visible facade of photovoltaic modules in 2000. Heat insulation and winter gardens as well as solar hot water installations on the roofs of the buildings are further aspects for which numerous awards were given to this project.	
11.30 – 13.00	**Introduction lecture to the SolarRegion Freiburg:** From the beginnings of the environmental movement to Solar City Learn more about the use of regenerative energies in Freiburg, the city's climate protection goals and citizen participation as the motor for renewable energy use.	
13.00 – 14.30	Lunch	
14.30 – 15.45	**The model district Vauban** Vauban is a former military barrack that was built in 1938. Since the 1990s it has been converted into a new city district with a very special quality of life. Learn how this district has become an internationally celebrated example of sustainable residential development: - Concept for mobility and Green corridors - Renewable energies - Citizen participation - Passive and low energy houses - Building groups In the year 2010 the Vauban city district will be presented at the EXPO in Shanghai as an example for sustainable city planning.	 
15.45 – 16.30	**Visit of the Heliotrop® from outside** Discover the future with this rotating Plus-Energy House®, the Heliotrop®. Photovoltaic modules on the roof produce more energy than the building requires. Passive solar energy is optimally gained by the house rotating with the sun. Rain water use, a composting toilet and a small constructed wetland are additional plus points.	

16.30 – 17.30	**The solar housing estate** **Visit of the Sonnenschiff:** Discover the world’s first ever service center in a highly efficient energy-saving construction (Rolf Disch). It houses two supermarkets, offices and the renowned Eco Institute. State of the art technologies like triple glass, vacuum panels, systems for heat recovery and phase change material (PCM) have all been installed. **Energie Plus® houses:** The future belongs to low, passive, and Plus-Energy Houses®. Day by day they save energy and reduce the burden of rising energy prices for fossil fuels on the inhabitants. Living in a Plus-Energy house with a solar power installation on the roof that feeds energy into the public electricity network and thus brings in additional money, is a good way to plan for the future. *Tour of a private house – Depending on availability*	  

Dinsdag 16 november

Tijdschema	*Omschrijving*	
8.30 –9.15	**Passive house modernization of a high rise** The modernization of a high rise from the 70s is worldwide unique. The topical project will be concluded in 2010. With the complex reconstruction the heating energy can be reduced about nearly 80%. Besides, with the rebuilding additional living space is created. Flats without barriers allow to remain then also to older inhabitants in the long term in her flats.	
9.15 –10.15	**Energy Modernization** Visit from outside of two apartment blocks from 1961 that have been modernized to reach the low energy standards of 60KWh and 40KWh. The project was launched by the German Energy Agency which aimed at establishing the differences of prices between the two building standards. Housing construction companies will benefit from this valuable information for their own modernization plans.	
10.15 –10.45	**External visit of the Solar-Fabrik AG** The Solar Factory produces high quality solar modules and is an example of prize winning solar architecture. Its energy needs are 100% covered by renewable energies. The Solar Factory produces: • Solar modules, Solar cells • Mounting structures • Converters	
10.45 – 11.30	**Rieselfeld** Another new district for 11.000 inhabitants: Topics are urban planning, mobility conception, citizen participation, architecture, ecological and social sustainability.	
11.30 – 12.30	**Hydropower plants** 2 medium size hydropower plants along the Dreisam River. One of them is a "hydrodynamic screw". Mr. Schulz has access to one of the turbines.	

17 november – Martin Zeumer

Rondleiding door Martin Zeumer (Technische Universität Darmstadt) in *'The Solar Decathlon Building'*. Team Duitsland heeft in 2009 gewonnen in Washington. Het huis staat inmiddels weer in Darmstadt en hierin worden wij ook rondgeleid. De rondleiding duurt ongeveer een uur, met de mogelijkheid tot het stellen van vragen. Martin Zeumer zal naast de rondleiding door het surPLUShuis (zie de informatie hieronder) ook nog wat vertellen over de universiteit zelf en beleidsaspecten.

SOLAR DECATHLON 2009
TEAM GERMANY

Team Germany - Technische Universität Darmstadt
Team Web site: www.solardecathlon2009.de

2. Inleiding

De delegatie vanuit het platform KENWIB die is afgereisd naar Duitsland krijgen gedurende 3 dagen meer te horen over energiebesparende projecten in en om de stad Freiburg.

Freiburg is een stad in de zuidwestelijk gelegen Duitse deelstaat Baden-Wurttemberg. De stad heeft ongeveer 222.000 inwoners en ligt aan de rivier de Dreisam, dicht bij het zwarte woud. Freiburg wordt gekenmerkt door het hoge aantal studenten en de vele leuke cafeetjes en culturele activiteiten. Daarnaast staat Freiburg bekend als 'zonnestad' van Duitsland. De stad ligt met 1.800 uren zonneschijn per jaar namelijk in een van de zonnigste gebieden van het land. Het ontvangt 1.12 kWh per m2 zon radiatie. Typerend is de sterke betrokkenheid van de inwoners bij een gedegen energieaanpak. Meer dan 23% heeft gestemd op de Green Party bij de laatste verkiezingen in Duitsland. In 1970 wilde de Duitse overheid graag een kerncentrale bouwen op 30 kilometer afstand van Freiburg. De weerstand onder de bevolking was zeer groot, en mede dit heeft geleid tot het veranderen van de plannen. Met name vanaf de jaren negentig zijn veel groene energieprojecten van de grond gekomen. Gedurende het bezoek aan Freiburg worden verschillende van deze projecten bezocht.

De eerste 2 dagen wordt een gevarieerd programma gevolgd, opgesteld door Innovation Academy. Deze non-profit organisatie is gevestigd in Freiburg en verzorgd diverse excursie, lezingen en workshops omtrent het onderwerp klimaatbeheersing. Zij beschikken over een ruime hoeveelheid kennis vanuit verschillende invalshoeken, zoals beleid, management, ontwikkeling en stadsplanning. Op deze manier is er een voor ieder interessant programma samengesteld, gezien de verschillende achtergronden van de deelnemers. Vanuit Innovation Academy wordt de groep begeleid door de heer Schulz.

Voor maandag 15 november staan er een groot aantal projecten op het programma. Zo gaat de dag van start met een bezoek aan het historische centrum van de stad Freiburg. De uitbreiding van het voetgangersgebied en nieuwe tramverbindingen dragen bij aan de levendigheid in het centrum. Deze actuele ontwikkelingen richten zich ook op de toekomst van de stad. Gedurende de wandeling door het stadscentrum worden ook enkele zonneprojecten aangedaan, zoals zonnepanelen op het dak van het gemeentehuis. Daarnaast wordt aandacht besteed aan de zogenaamde 'bächle', de goten die door de stad heen lopen. Vroeger dienden deze als riolering, tegenwoordig wordt hierin regenwater afgevoerd. De tour vervolgt met een bezoek aan Hotel Victoria, een hotel van de keten Best Western die wordt bestempeld als één van de meest ecologische ter wereld. De ochtend wordt afgesloten met twee appartementencomplexen uit 1970, die 10 jaar geleden uitgebreid zijn met verschillende energiebesparende installaties, en een interessante lezing over 'Zonnestad Freiburg'. Na een uitgebreide lunch komen in de middag diverse grootschalige projecten aan bod, zoals het district Vauban. Een woongebied dat internationaal bekend staat om haar duurzame karakter onder andere door passieve en *low energy* woningen. Ook Sonnenschiff, een hoog energiezuinig gebied met voorzieningen ontworpen door Rolf Disch, en Energie Plus®-woningen worden bezocht. Een erg bijzonder ontwerp van een Energie Plus®-woning is de rond draaiende Heliotrop®.

Ook de dinsdagochtend staat in het teken van energiebesparende projecten. Denk hierbij aan Rieselfield, een nieuw stadsdeel van Freiburg waar 4.200 woningen ontwikkeld worden. De Solar Fabrik, die zorg draagt voor de productie van zonnepanelen, kan natuurlijk niet ontbreken in het programma. Ook worden een enorm draaiend zonnepaneel gelegen aan de snelweg, herontwikkelde sociale woonappartementen en herbouwde appartementencomplexen die 80% van de verwarmingsenergie besparen bezocht. Ondanks het feit dat Freiburg bekend staat als zonnestad sluit Innovation Academy af met een bezoek aan twee waterkrachtcentrales.

Op de reis terug van Freiburg naar Eindhoven wordt nog een korte stop gemaakt bij een veld vol zonnepanelen langs de snelweg. Ook wordt de Technische Universiteit van Darmstadt bezocht. Zij werden in 2007 en 2009 eerste tijdens de Amerikaanse Solar Decathlon. Hierbij is het de opdracht om een huis op zonne-energie te ontwerpen en bouwen met een optimale energieproductie en maximale energie-efficiëntie. Onder begeleiding van een gids, en tevens de ontwerper van het winnende ontwerp, wordt het ontwerp van 2009 bekeken. In de volgende hoofdstukken zal uitvoerig op de bezochte projecten worden ingegaan.

3. Freiburg: De stad

Rondleiding door centrum
Freiburg heeft een historisch centrum. De gotische kathedraal is kenmerkend met zijn 116 meter, en wordt ook wel als inspiratie gezien voor de Domtoren in Utrecht. Door het centrum lopen kleine kanaaltjes, die functioneerden tegen brand en gebruikt werden als drinkwater voor dieren. Dit geeft een speciaal karakter aan de stad.

Hoewel de binnenstad auto-onvriendelijk is gemaakt, zijn er ook strenge regels voor het fietsverkeer. Fietsen is niet zomaar overal toegestaan. Er wordt waarde aan gehecht het oude karakter te bewaren. De gemeente heeft zich bijvoorbeeld ingezet om een oud vervallen straatje te herstructureren met de eis dat er smalle hoge panden kwamen met onderin winkeltjes, waarbij de eigenaars verplicht waren boven de winkel te gaan wonen.

Energiezuinig hotel
Vele technieken komen samen in het onlangs gerenoveerde hotel Victoria. Bij dit hotel liggen er PV-panelen op het dak, die gezamenlijk 20kWp (kiloWattpiek) genereren voor het hotel. Ook staan hier 4 windturbines op het dak die elk 0,5 kW generen. Grotere turbines waren helaas niet toegestaan op deze locatie.

Het hotel serveert een gevarieerd ontbijt met allemaal streekproducten. Hierdoor hebben de producten niet veel gereisd, en dus minder energie verbruikt. Andere interessante snufjes zitten in de waterbesparende douchekoppen, badkuipen die naar het lichaam gevormd zijn, en daardoor minder water verbruiken, en het gebruik van LED lampen door het gehele hotel heen. In de zomer genereren de zonnecollectoren voldoende warmte voor tapwater. In de winter wordt er met behulp van de palletverbranding bij gestookt.

De recente renovatie kostte 2,4 miljoen euro. De helft kwam voor de rekening van de energiebesparende maatregelen. Het hotel heeft 4 sterren, en daarbij hoort ook een koelsysteem in de kamers. Airconditioning was uitgesloten om energie te besparen. De kamers worden gekoeld met een systeem dat warmte uitwisselt met het grondwater. Het systeem heeft twee bronnen/putten. De bron die koude levert zit 23 meter diep. Er wordt mechanisch geventileerd in de kamer, waarna de via een warmtewisselaar opgenomen warmte weer de grond in gaat, in de tweede put op 12 meter diepte. Het temperatuurverschil tussen de twee putten is 3 graden. De koelcapaciteit van het systeem 70 kW. Voor dit systeem is wel een vergunning nodig. Zodoende kan men garanderen dat niet de gehele straat de grond aan het opwarmen is en/of verschillende systemen elkaar kunnen beïnvloeden.

Fig. Een zakje pellets levert 1 kWh, voldoende voor 4 minuten douchen.

In de kelder staat een generator op hout oor de voorziening van warm tapwater. De installatie is gebouwd in Oostenrijk. Voorheen werd op olie gestookt en was 50.000 liter olie per jaar nodig. De biomassa-installatie die er nu staat levert 300 kW. Daarvoor is per jaar 100 m^3 aan houtpellets (geperste bolletjes hout) nodig. Die worden lokaal geproduceerd in het Schwarzwald en kosten 170 tot 180 euro per m^3.

Deze verwarmingsinstallatie is drie keer zo duur in aanschaf als een installatie op olie, maar de pellets zijn veel goedkoper dan olie. Het zou nog goedkoper zijn om houtsnippers te gebruiken, maar daarvan is meer volume nodig (200 tot 300 m^3 per jaar) en dus ook meer voorraadruimte. Die is in het hotel niet beschikbaar.
Op de vraag waarom er geen warmtepomp wordt gebruikt voor verwarming, krijgen we geen duidelijk antwoord. Het lijkt een voor de hand liggende optie, aangezien voor koeling in de zomer al warmtewisseling met het grondwater wordt gebruikt.

Renovatie jaren-70-flats
Ook renovatieprojecten zijn gebruikt om PV-cellen te introduceren en energie-efficiëntie te verbeteren. Van een appartementencomplex uit de jaren 70 (zie foto) zijn de balkons gesloten en de gevels geïsoleerd met 20cm isolatiemateriaal. Eén van de façades is bekleed met 229 m^2 PV-panelen met een vermogen van 27 kWp. Zonnecollectoren op het dak leveren 172.000 kWh aan warmte per jaar. In de kelder staan twee grote tanks voor de opslag van warm tapwater. Er is een gescheiden watercirculatie voor de zonnecollectoren en de distributie van het tapwater, zodat het risico op legionella-besmetting wordt verminderd. De eigenaar is een woningbouwvereniging zonder winstoogmerk. De huur vóór de renovatie was 4,50 euro/m^2; de huur erna is 6 euro/m^2 Gedurende de renovatie konden bewoners in hun huis blijven wonen.

Solar Turm
Deze onderzoeksruimte is gebouwd in 1993. Op het dak zijn verschillende typen zonnecollectoren aangebracht om de efficiëntie ervan te kunnen meten. Het betreft zowel plaat- als buiscollectoren. Ook de lichtinstraling wordt gemeten, zodat de prestatie bij

verschillende omstandigheden vergeleken kan worden. Er zijn ook storage collectors aangebracht, waarvan we in het gebouw ook een doorsnede zien. Deze zijn eigenlijk alleen geschikt bij veel direct zonlicht, dus niet in het lokale klimaat. Ze vangen zonne-energie op doordat de bovenste laag, die bestaat uit kleine buisje, wel de korte golven van licht binnen laat, maar niet de langere golven van infrarood laat ontsnappen. Dit principe wordt ook wel gebruikt als isolatiemateriaal, waarbij er achter de buisjes geen collector maar een zwarte laag is aangebracht. Zo wordt zonne-energie passief benut. Een nadeel van dit isolatiemateriaal is dat het duur is: meer dan 200 euro per m^2.

In het gebouw staan naast de meetapparatuur van de zonnecollectoren ook een aantal innovatieve producten als studiemateriaal. Er staat bijvoorbeeld een brandstofcel. Waterstof voor deze brandstofcel kan opgewekt worden met kracht die geleverd wordt op een hometrainer.

Lezing door Erhard Schulz

In de Solar Turm krijgen we een lezing van Ehrard Schulz. Hij zet zich al jaren actief in voor het milieu in de omgeving van Freiburg. Hij is medeoprichter (in 1970) van Aktion Umweltschutz e.V., medeoprichter en lid van de raad van bestuur van de Bund für Umwelt und Naturschutz Deutschland in de provincie Baden-Württemberg, oprichter (in 1976) en organisator van de ÖKO-Messe (eco-beurs) en andere ecologische beurzen, en medeoprichter en lid van de adviesraad van het ÖKOMEDIA instituut. Hij vertelt ons over klimaatverandering, energiebesparende maatregelen, voorbeeldprojecten, en toepassingen in de regio van Freiburg.

In Freiburg komt een belangrijke motivatie voor het gebruiken van zonne-energie voort uit de weerstand die ontstond toen er in 1970 op ongeveer 30 kilometer afstand van Freiburg een kerncentrale werd gepland. Een grote groep burgers, onder wie ook professoren, demonstreerde tegen de komst van die kerncentrale. Er ontstonden 26 burgerinitiatieven die wilden laten zien dat er een alternatief was en dat ook uit te voeren. De kerncentrale is er niet gekomen en het gebied waar hij was gepland is nu beschermd natuurgebied.

In de regio waar Freiburg deel van uitmaakt is nog steeds 80% van de inwoners tegen kernenergie. Dit verklaart de vele investeringen in hernieuwbare energie. Dhr. Schulz noemt als voorbeeld een kleine gemeente in de buur, die uit hernieuwbare energiebronnen 140% van de door de gemeente benodigde energie genereert. Dit gebeurt niet vanuit de (lokale) overheid, maar door burgerinitiatieven.

Een voorbeeld is een buurt, die geïnvesteerd heeft in milieuvriendelijk vervoer. Er rijden in

Freiburg zo'n 30 Solarmobielen. Dat zijn kleine 2-persoons auto's op zonne-energie. Er zijn op verscheidene plekken oplaadpunten voor de mobielen. Ze wegen zo'n 200 kg, hebben een actieradius van 100 km en verbruiken dan 4 tot 8 kWh. Dit is vergelijkbaar ben 0,5 tot 0,7 liter benzine.

In Freiburg is een onderzoeksafdeling van het Fraunhofer instituut gevestigd dat zich bezighoudt met zonne-energiesystemen. Zij heeft PV-cellen ontwikkeld met een efficiëntie van 40%. Dat is veel hoger dan de gemiddelde 14 à 15% die de meeste PV-cellen bereiken. Een ander project in de regio is een grote windturbine die met erfpacht bij een boer is geplaatst. De investering voor de turbine is gedeeld door 124 bezitters. De windturbine voorziet 1000 huishoudens van stroom. De turbine heeft een direct aangedreven generator (of ringgenerator), waardoor een tandwielkast ontbreekt en de daarmee vaak gepaard gaande problemen uitblijven. De stroom levert 9,1 eurocent per kWh op. Met zo'n 6 miljoen kWh per jaar, zorgt de turbine dus voor 500.000 tot 600.000 euro aan inkomsten. Daarvan moet een deel afgedragen worden aan belasting (ongeveer 100.000 euro) en moet ook de pacht betaald worden.

In de regio staan meer 'burgerwindturbines'. Volgens de spreker is dit typisch voor deze regio. Erhard Schulz noemt een lijst van bouwprojecten die vooruitstrevend zijn op gebied van energiegebruik en dus als voorbeeldprojecten gezien kunnen worden.

- Het Solarhaus Freiburg-Tiengen werd in 1979 als pilotproject voor zonne-energiegebruik gebouwd door Freiburger Stadtbau GmbH.
- Het Ökostation is een milieueducatiecentrum waar duurzame materialen zijn gebruikt en energie duurzaam opgewekt wordt.
- Iemand heeft een woonhuis gebouwd, dat niet gekoppeld is aan het elektriciteitsnet, waar de opgewekte elektriciteit wordt opgeslagen in een grote accu-installatie. De accu's waren destijds nog niet erg efficiënt en erg groot. De bewoners moesten er rekening mee houden, dat ze niet alle huishoudelijke apparaten gelijktijdig aan konden zetten.
- Op het beursgebouw is een zonnedak aangebracht, dat een vermogen van 700 kWp heeft.
- Het energieautarkisch huis van het Fraunhofer instituut is energieneutraal.
- Heliotrope is het woonhuis van en ontworpen door Rolf Disch. Het is een plusenergiehuis / energieleverend huis, waarvan de restenergie aan het net geleverd en verkocht wordt. De PV-cellen op het dak zijn zowel horizontaal als verticaal draaibaar. Hierdoor levert de installatie 30% meer op dan een gefixeerde installatie. Het is echter wel zeer duur om de installatie draaibaar te maken. Er is gebruik gemaakt van 3-dubbel glas met argon. Dit heeft een U-waarde van 0,5. Deze woning hebben we later ook bezocht. Zie verderop in dit verslag.
- Freiburg heeft een kleine voetbalclub, die zich tot doel heeft gesteld de eerste 'solar'-voetbalclub te worden. Op het dak van de tribunes zijn PV-panelen geplaatst. Deze zijn betaald door en in het bezit van fans van de club, die ieder een deel van de installatie konden kopen. Ze hebben een vermogen van bijna 100 kWp. De investering bedroeg 1 miljoen euro.
- In het bestemmingsplan voor een nieuwe wijk heeft de gemeentelijke overheid vastgelegd, dat alle huizen op het zuiden georiënteerd moesten zijn.
- De gemeente heeft een kaart gemaakt van de stad Freiburg waarop alle dakvlakken zijn gemarkeerd, die geschikt zijn om zonnecellen op aan te brengen. Dhr. Schulz geeft echter

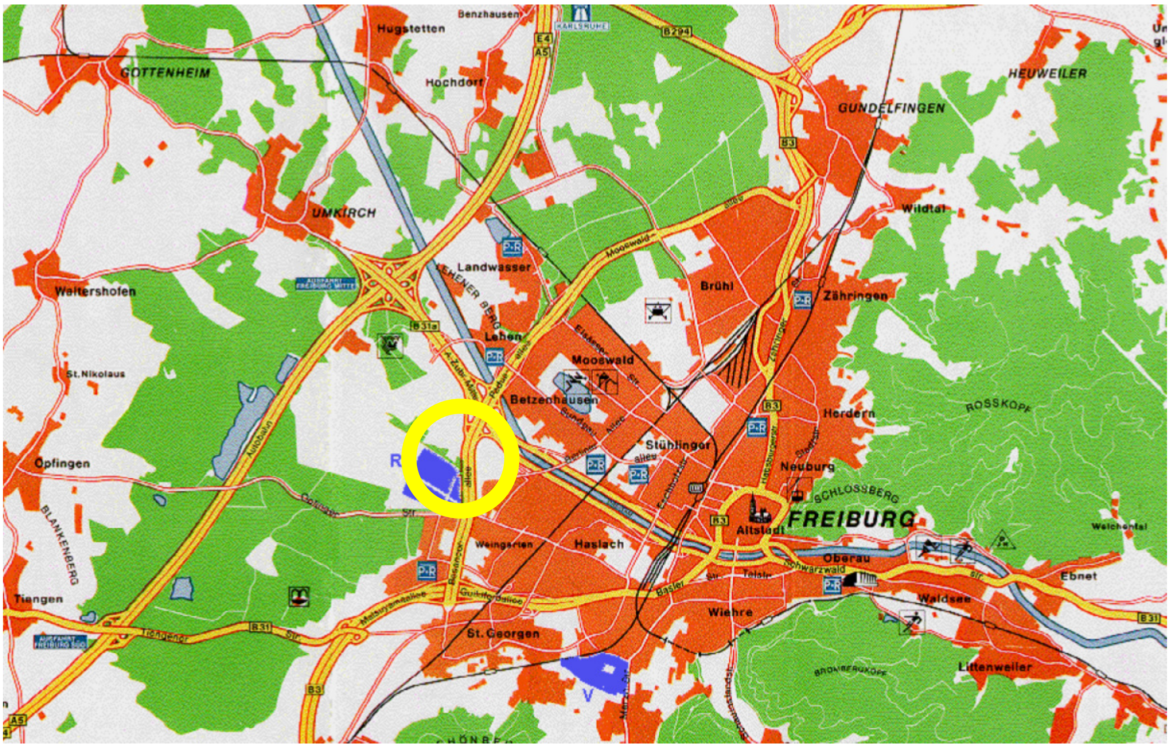
aan dat windenergie beter betaalbaar is dan zonne-energie. Eén moderne windturbine levert meer dan de totale huidige zonne-energie in Freiburg. Er zouden ongeveer 15 windturbines nodig zijn om in de totale energiebehoefte van de stad te voorzien.

- http://www.solarhaus-info.de/ Dit huis gebruikt enkel zonne-energie voor de verwarming. De centrale koker is een tank met water. Het huis heeft drie verdiepingen: kelder, begane grond en bovenverdieping. Op het dak staan zonneboilers om te verwarmen. Ook heeft de woning PV-cellen voor de opwekking van elektriciteit.
- In het stadsdeel Vauban is per inwoner een vermogen van 100W aan PV-cellen geïnstalleerd.

4. Uitbreiding Rieselfeld

Inleiding

In de jaren ’80 had Freiburg een gebrek aan woonruimte en was in het bestemmingsplan onvoldoende grond aangewezen als woningbouw locatie. De gemeenteraad heeft daarom besloten om het 320 ha grootte ‘Rieselfelder’ gebied, eigendom van de stad, aan te wijzen als nieuwe woonwijk. Rieselfeld is een gebied aan de westelijke rand van Freiburg (zie figuur 1)



Figuur 1; Het gebied Rieselfeld is gelegen aan de westelijke rand van Freiburg

De naam Rieselfeld kan vertaald worden naar ‘vloeiveld’, dit was ook de functie van het terrein voor de herontwikkeling. Dit grote gebied onderhield aanvankelijk de stad Freiburg als een natuurlijk afvalwater infiltratie gebied. Het regenwater van de stad Freiburg werd naar dit gebied getransporteerd, waarna het op natuurlijke wijze werd gefilterd en geïnfiltreerd in het gebied. Echter, sinds 1986 heeft het gebied deze functie al verloren.

Figuur 2; stedelijke rand in het gebied Rieselfeld

Kenmerken van het gebied en doelstellingen

De totale oppervlakte van Rieselfeld (320 ha) is toegewezen als afvalwater infiltratiegebied. Hiervan wordt momenteel 70 ha ontwikkeld als stadsdeel (Technische Universiteit Eindhoven). De resterende 250 ha is aangewezen als natuurgebied. Het stadsdeel bestaat uit ongeveer 4200 woningen voor ongeveer 10.000 tot 11.000 inwoners met 1.000 nieuwe arbeidsplaatsen in de dienstensector (Freiburg im Breisgau, 2009).

Het gebied is daarmee een van de grootste nieuwe ontwikkelingsprojecten in de deelstaat Baden-Wurttemberg.

De nadruk van de ontwikkelaars was om een compacte structuur te ontwikkelen om zo min mogelijk land te gebruiken en om het openbaar vervoer te stimuleren. De stedenbouwkundige uitgangspunten zijn:

- Het oplossen van het conflict tussen de bescherming van de natuur en de recreatie-eisen van de bewoners;
- Hoge kwaliteit van de private- en openbare gebieden, met recreatiemogelijkheden;
- Het ontwikkelen van een biologisch concept voor het gebied wat in het regionale biologische netwerk is te integreren;
- Een geschikte woonwijk voor zowel gezinnen als ouderen;

Een compacte woonwijk,

- met een hoge dichtheid; en
- Een vooruitstrevend vervoersconcept met de nadruk op openbaar vervoer en niet-gemotoriseerde voertuigen.

(Brunisng, Möller, & Woxforth)

Naast de stedenbouwkundige uitgangspunten zijn ook een aantal politieke uitgangspunten als grondslag aan het stedenbouwkundige concept:

- Een flexibel stedenbouwkundig principe wat zorg draagt voor de actuele ontwikkeling en welke ruimte biedt voor aanpassingen in de toekomst. De ontwikkeling wordt in vier fases opgesteld, met tussenpozen van twee jaar, zodat elke keer gekeken kan worden naar nieuwe ontwikkelingen ("adaptive planning");
- Het voorkomen van een duidelijke scheiding tussen woon- en werkruimte door de integratie van gemengde- en industriële gebieden. (Het creëren van 1000 banen);
- Het creëren van een evenwicht tussen woonvormen. Bijvoorbeeld het mengen van privaat gefinancierde en gesubsidieerde woningbouw;
- Om verschillende doelgroepen te bereiken worden verschillende constructievormen geïntroduceerd, van duplex woningen tot vijf verdiepingen tellende appartementenblokken;
- Oriëntatie op de ecologische doelstellingen, zoals energiezuinig bouwen, stadsverwarmingnetwerken gevoed door een WKK-installatie, de integratie van zonne-energie, een voorziening voor regenwater en de voorrang voor openbaar vervoer; en
- Een grote transparantie in de wijk, door gedeelde binnenplaatsen en geen fysieke scheiding tussen percelen.

(Freiburg im Breisgau - Rieselfeld Projekt Group, 2009)

Stedenbouwkundig plan

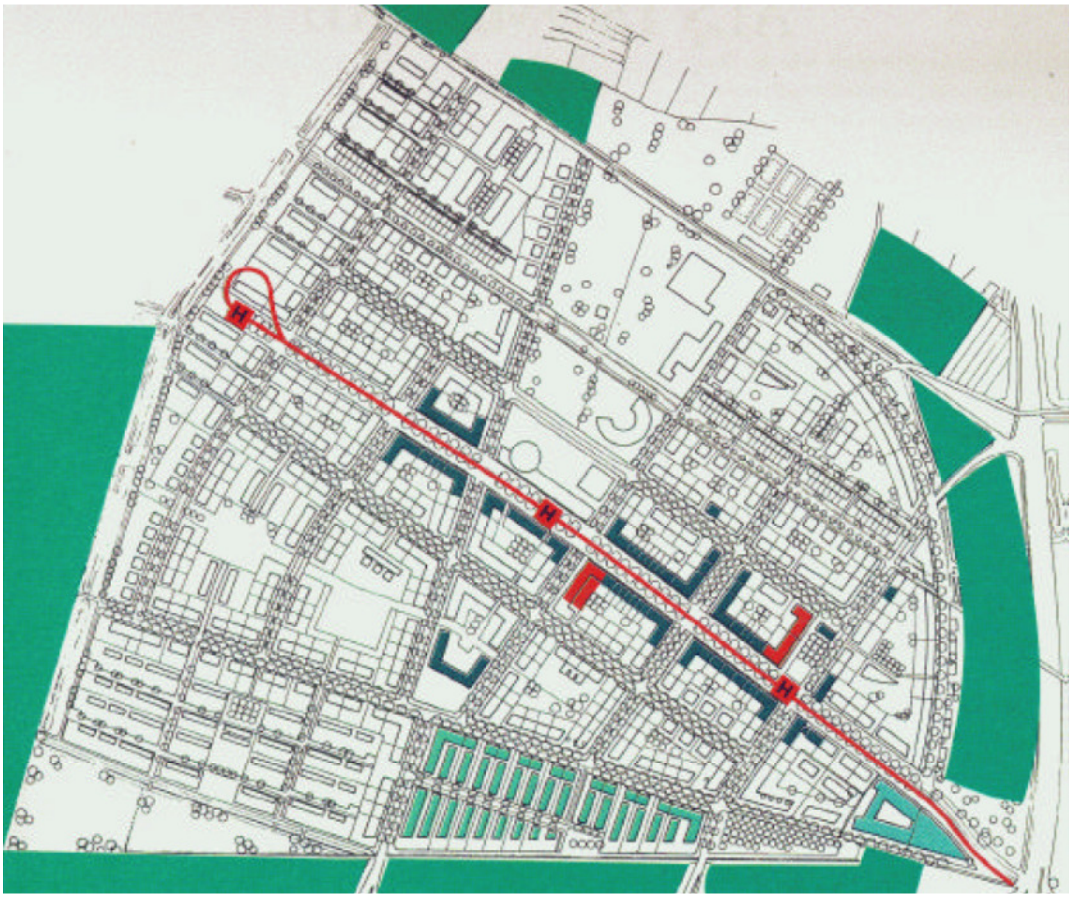
De compacte structuur van Rieselfeld wordt gekenmerkt door een randbebouwing van vijf verdiepingen tellende appartementencomplexen (figuur 2). Deze stedelijke rand is gepland langs de noordoost zijde van het gebied.

Daarnaast wordt de compactheid van het gebied gecreëerd door vier/vijf verdiepingen tellende wooncomplexen verspreid over het gebied. Vele van deze wooncomplexen zijn door middel van particulier opdrachtgeverschap gerealiseerd. Deze vorm, ook wel bouwgroepen genoemd komt vaak voor binnen het plangebied (figuur 3).

Figuur 3; particulier opdrachtgeverschap (bouwgroepen) levert een divers straatbeeld

De hoofdstaat wordt gekenmerkt door het openvaar vervoer netwerk. (Rode lint op figuur 4). Op de begane grond van de appartementencomplexen langs de hoofdstraat komen kleine supermarkten, winkels en sociale voorzieningen (aangegeven met een donker grijze kleur op figuur 4).

In het zuidelijk deel van het gebied is 1,5 ha gereserveerd voor kleine bedrijvigheid en diensten (lichtgroen in figuur 4). Dit gebied biedt potentiële werkgelegenheid voor een deel van de bewoners van Rieselfeld. Daarnaast is het plangebied voorzien van diverse publieke voorzieningen zoals een middelbare school, een basisschool, vijf kleuterscholen en een buurthuis. Na een besluit van de gemeenteraad wordt 50% van de woningen in het gebied gesubsidieerd voor sociale huisvesting.



Figuur 4; Stedenbouwkundig plan Rieselfeld

Planningsproces Rieselfeld

In 1991 ging de gemeenteraad van Freiburg akkoord met de herontwikkeling van het

Riesenfelder gebied. In hetzelfde jaar werd in samenwerking met de burgers en verschillende verenigingen binnen Freiburg een ontwerpwedstrijd uitgevoerd. De voorstellen van de drie winnende concepten werden door de stadsplanningafdeling uitgewerkt tot één stedenbouwkundig ontwerp. Na het besluit van de gemeenteraad om dit stedenbouwkundig plan goed te keuren werd in 1994 gestart met de bouwwerkzaamheden (Stadt Freiburg im Breisgau, 1992). Het laatste deelgebied van het project zou in 2010 afgerond moeten zijn.

Financiering
Voor de implementatie van het project heeft de gemeenteraad een publiekprivate samenwerking tussen de stad en ontwikkelaars opgezet in de vorm van een ontwikkelingsorganisatie. Deze organisatie is de verbindende organisatie tussen de praktische economische deskundigheid en financiële middelen van de particuliere ontwikkelaars en de inbreng van de stad Freiburg.

De ontwikkeling van het gehele project werd hoofdzakelijk gefinancierd door de verkoop van gronden (circa 115 miljoen euro) (de gronden in Rieselfeld waren eigendom van de stad Freiburg) (Freiburg im Breisgau - Rieselfeld Projekt Group, 2009)) en de ontwikkelingsvergoedingen (circa 22,5 miljoen euro), maar ook uit publieke en landelijke bijdrages (7,5 miljoen euro) in de vorm van subsidies, landbeheer en voorfinanciering. Deze inkomsten, ongeveer 145 miljoen euro, werden in een trustmaatschappij gestort. Met de opbrengsten werden de publieke voorzieningen gefinancierd, zoals openbare gebouwen (52 miljoen euro), straten en nutsvoorzieningen (35 miljoen euro), de groenvoorziening (13 miljoen euro) en planning, beheer en marketing (19 miljoen euro). De totale kosten bedroegen ongeveer 144 miljoen euro. Voor de voorfinanciering van de ontwikkeling van de publieke infrastructuur en publieke voorzieningen kreeg de ontwikkelingsorganisatie een krediet van 40 miljoen euro van de nationale bank van Baden-Wurttemberg.

De totale publieke en private investeringen voor het project bedroegen circa 1.35 miljard euro. De investeerders zijn veelal eigenaren van kleine en middelgrote ondernemingen.
(Brunisng, Möller, & Woxforth)

Inspraak van (toekomstige) bewoners
De stad besloot om het publiek vanaf het begin te informeren over het nieuwe project. De afdeling stadsplanning had vele gesprekken met verschillende groepen burgers om een idee te krijgen van de visies en (mogelijke) bezwaren van de burgers. Bovendien werd door de gemeenteraad een burgerraad met lokale vertegenwoordigers gevormd. De burgers van Freiburg konden hierdoor deelnemen aan het planningsproces van Rieselfeld. In zeven teams werd over de volgende verschillende onderwerpen gediscussieerd:

- Alternatieve woonpatronen
- Energie
- Plannen voor ouderen
- Ecologie: constructies
- Ecologie: ruimtelijke ordening
- Vervoer
- Huisvesting

Na drie maanden hebben de verschillende teams de resultaten gepresenteerd aan de gemeenteraad en de stadsplanningafdeling. De gemeenteraad heeft besloten om een aantal van de suggesties te integreren in het stedenbouwkundige plan. Deze intensieve participatie leidde uiteindelijk tot de oprichting van een burgervereniging voor Freiburg-Rieselfeld (Stadt Freiburg im Breisgau, 1997a), (Stadt Freiburg im Breisgau, 1997b).

Lessons Learned

Een aantal belangrijke zaken zijn naar voren gekomen bij de herontwikkeling van Rieselfeld:

- Illustrerend voor de ontwikkeling van Rieselfeld is de bijdrage van de (toekomstige) bewoners in het ontwikkelingsproces. De bewoners hadden veel inspraak en ook een behoorlijke mate van invloed op de totstandkoming van het project.
- De bewoners initiëren duurzame energie concepten in het gebied. De drijfkracht achter deze concepten is het collectieve gedachten tegen de toepassing van kernenergie in de regio.
- De ontwikkelingsmaatschappij geeft gronden uit aan verschillende (kleinere) projectontwikkelaars, waaronder particulier opdrachtgeverschap. Binnen Rieselfeld wordt particulier opdrachtgeverschap toegepast in een vorm van een vereniging van bewoners welke zelf de ontwikkeling van de kavel verzorgen. Om ervoor te zorgen dat deze ontwikkelingen in het gebied passen, heeft de ontwikkelingsmaatschappij duidelijke eisen gesteld aan de ontwikkelingen binnen het gebied.
- De collectieve gedachte binnen het gebied is ook terug te zien in de inrichting van de kavels. In het gebied zijn weinig omheiningen of natuurlijke afscheidingen te vinden.
- Alle duurzame energieconcepten worden door middel van private middelen gefinancierd. Een belangrijke stimulans hierin is het feed-in tarief systeem wat door de overheid is geïntroduceerd. Dit systeem zorgt ervoor dat particulieren elektriciteit terug kunnen leveren aan het net en hier een vooraf vastgestelde vergoeding voor ontvangt.

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5. Solar-Fabrik

Inleiding
Solar-Fabrik is in 1996 opgezet door de Duitse zonne-energie pionier Georg Salvamoser. Vanaf het begin richt het bedrijf zich op het beschikbaar maken van PV-modules (fotovoltaïsche of Photo-Voltaic) voor een brede markt. Het bedrijf beschrijft de volgende kenmerken:

- Solar-Fabrik werkt met een state-of-the-art fabriek met een capaciteit van 130MW/jaar, met de mogelijkheid tot uitbereiding.
- Solar-Fabrik gebruikt energie die uitsluitend wordt verkregen vanuit hernieuwbare bronnen. Sinds 1998 werkt het bedrijf via het 'zero-emmissie-principe'.
- Solar-Fabrik ontwikkelt en produceert producten in Freiburg, de 'zonne-stad'.
- Solar-Fabrik werkt nauw samen met het Fraunhofer Institute for Solar Energy Systems in Freiburg, een toonaangevende Europese instelling.

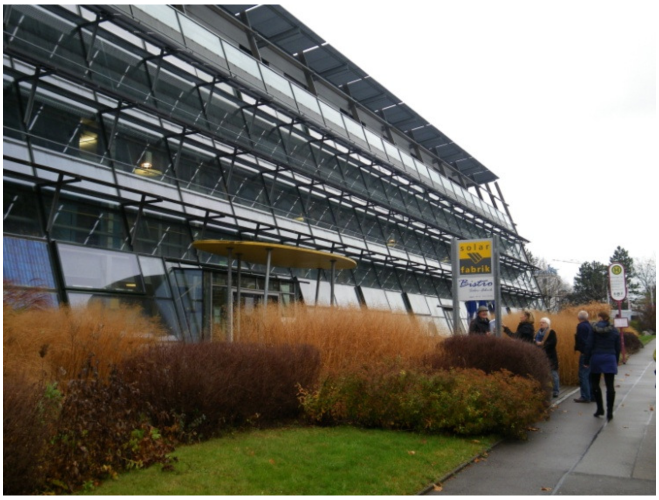
Zero-emissie fabriek
Het gebouw waar Solar-Fabrik in is gevestigd is een zero-emissie gebouw. Het gebouw beschikt over een uitgekiend energieconcept wat kan voorzien in de totale vraag naar warmte en elektriciteit met behulp van hernieuwbare energiebronnen.

Zonnearchitectuur
Het Solar-Fabrik energieconcept is gebaseerd op het uitgebreid gebruik maken van zonne-energie. Het gebouw is georiënteerd op het zuiden, en de licht hellende glazen gevel zorgt ervoor dat de laagstaande winterzon het gebouw opwarmt in de winter. Achter de gevel van het gebouw is een donkere wand geplaatst. Deze wand wordt door intredend zonlicht opgewarmd en verwarmt daarmee het gebouw. In de zomer zorgen de pv-panelen in de gevel voor een welkome schaduw, wat resulteert in een verminderde zonlicht intreding. Hierdoor wordt de binnenruimte minder opgewarmd. (Figuur 5)

Figuur 5; Interieur van de Solar-Fabrik, gekenmerkt door de schuine gevel voorzien van PV-panelen

Ventilatie
De ventilatie in het gebouw wordt verzorgd door een natuurlijk airconditioning systeem dat zowel geld als energie bespaart. Het systeem bestaat uit een aantal leidingen in de ondergrond welke de warmte van de ondergrond afgeeft aan de leidingen. De constante temperatuur van de ondergrond is ongeveer 12°C en verwarmt de verse lucht in de winter en koelt de lucht in de zomer.

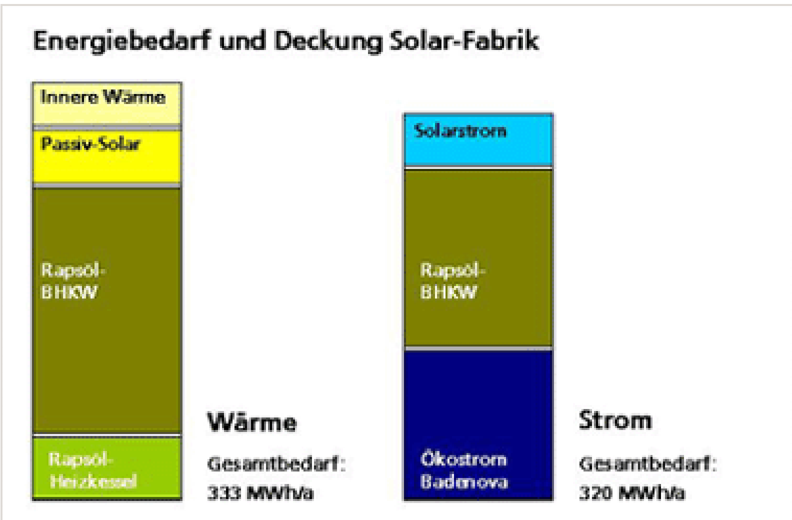
Zonne-energie systeem
Ongeveer 20% van de elektriciteit gebruikt binnen de fabriek wordt geleverd door PV-panelen met een totaal oppervlak van 575 m^2 (figuur 6). Daarnaast wordt de gevel gebruikt als voorbeeld voor de integrale toepassing van PV-panelen in een gevel van een gebouw.



Figuur 6; De schuine gevel is aan de buitenzijde voorzien van PV-panelen

Koolzaadolie in combinatie met een warmtekrachtkoppeling
De energievoorziening van het gebouw wordt aangevuld door een warmtekrachtkoppeling (WKK) gevoed met natuurlijke koolzaadolie uit de regio. Deze wordt voornamelijk in de wintermaanden gebruikt. De CO^2 die vrijkomt bij de verbranding van de koolzaadolie wordt opgenomen door de gewassen tijdens de groei. Dit resulteert in een CO^2-neutrale warmtevoorziening.

Energiebalans
Het energieconcept is zo ontwikkeld dat de energie opgewekt uit hernieuwbare energiebronnen voldoende is voor de vraag van het bedrijf (zie figuur 7). Wanneer nodig voorziet Badenova (energieleverancier in Freiburg) het bedrijf van extra groene energie.



Figuur 7; Energiebalans Solar-fabrik

(Bron: www.solar-fabrik.de)

6. **Draaiend zonnepaneel**

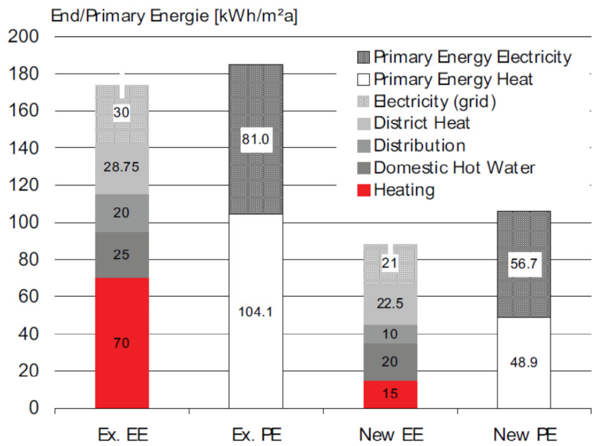
Na een bezoek aan de Solar-fabriek zette de tour zich voort bij een enorm draaiend zonnepaneel. Bijzonder aan dit zonnepaneel is, dat niet alleen de hoek waaronder het zonnepaneel zich bevindt kan variëren, maar dat het gehele paneel ook om zijn as kan draaien en op deze manier vanuit meerdere richtingen zonlicht kan opvangen. Hierdoor kan het zonnepaneel optimaal gebruik maken van al het zonlicht. Daarnaast beschikt het paneel over sensoren. Hiermee de windkracht kan worden waargenomen. Wanneer deze te sterk wordt, zakt het paneel tot een horizontale stand, waardoor zo min mogelijk wind wordt opgevangen.

Herontwikkeling sociale woonappartementen (passiefhuis)
De excursie werd vervolgd bij een appartementencomplex. Het appartementencomplex, stammend uit de jaren '70, werd op het moment van bezichtiging herontwikkeld. Bijzonder aan deze herontwikkeling is, dat het appartementencomplex wordt omgebouwd tot passiefhuis. Hierdoor kan het warmtegebruik van het complex met 80% worden verminderd. Tevens is er met de herontwikkeling van het complex extra woonruimte gecreëerd. De bewoners, een combinatie van ouderen, jongen en gezinnen, hebben geparticipeerd in het planproces. De inzet van de bewoners is onderscheiden door de Raad voor Duurzame Ontwikkeling.

Een **passiefhuis** is een zo energiezuinig mogelijke woning. Het verbruik is minder dan 15 kWh/m² bruto per jaar voor ruimteverwarming. Dit wordt bereikt door het verminderen van het warmteverlies en het maximaliseren van de warmtewinst. (Bron: Wikipedia, 2010)

De herontwikkeling tot passiefhuis bestond uit:

- Een gevelisolatie van 20 cm
- HR++ glas
- Dakisolatie van 2 x 20 cm
- Kelderplafond isolatie van 20 cm
- Luchtdichtheid van de gebouwschil
- Behuizing van de bestaande balkons, nieuwe balkons zijn thermisch gescheiden
- Thermische isolatie van kelderwanden
- Vervanging van verwarming met lage temperatuur (inlaat temperatuur van 50 °C)
- Installatie van ventilatie met warmteterugwinning
- Energiezuinige verlichting, lift, enz.
- Energiebesparende lampen en apparaten in het appartement, stand-by schakelaars, enz.
- Fotovoltaïsche panelen op het dak cast ongeveer 25 kWp



Herontwikkeling van twee appartementengebouwen RislerstraBe
Vervolgens is er een bezoek gebracht aan twee appartementengebouwen uit 1961 die recentelijk zijn gemoderniseerd. Het doel van de modernisatie was om de energienorm van

60KWh en 40KWh te bereiken. Het project werd geïnitieerd als proefproject door het Duitse Energie Agentschap (DEA), dat zich inzet voor energiebesparing in de bestaande woningbouw. DEA ontwikkelt informatie en initieert proefprojecten om invloed uit te oefenen op lange termijn (energiegerelateerde) investeringsbeslissingen van particuliere en publieke eigenaars. Hun boodschap is "*Energie sparen, Wert Gewinnen*". Technieken die onder andere zijn toegepast zijn fotovoltaïsche cellen, isolatie en hoogwaardig glas.
De doelstellingen van het proefproject waren:

- Primair: Energienorm van 40 en 60 kWh/m2 te bereiken
- Secundair: Kennisvorming over modernisering, aanzetten tot soortgelijke herontwikkeling in de regio, acceptatie van de gebruikers en eigenaren

De herontwikkeling bestond uit:

- Gevelisolatie van 20 cm
- Vloerisolatie van 26 cm
- Kelderplafondisolatie van 21 cm
- Luchtdichte deuren in huis en kelder
- Ventilatiesysteem met warmteterugwinning
- Fotovoltaïsche panelen op het dak

Waterkrachtcentrale
Freiburg staat bekend als Zonnehoofdstad van Duitsland. Maar in Freiburg wordt naast zonne-energie ook energie uit water opgewekt. De excursie eindigde dan ook met een bezoek aan twee waterkrachtcentrales.

De bezichtiging van de eerste waterkrachtcentrale was indrukwekkend. De apparatuur van het centrale kon bekeken worden in het centralegebouw. Daarnaast was het werken van de enorme waterkrachtslak (schroef), waar het water doorheen geslingerd wordt, goed zichtbaar van buitenaf. De centrale levert per jaar ongeveer 300.000 kWh op, wat gelijk staat aan het energieverbruik van circa 120 woningen. De waterkrachtcentrale is met subsidie van Innovatiefonds Badenova en het Ministerie van Landbouw tot stand gekomen. De tweede waterkrachtcentrale is gelegen naast het Badenova-stadion van Freiburg aan de rivier de Dreisam. De waterkrachtcentrale heeft de naam "de kracht van de Dreisam" gekregen. De centrale is tot stand gekomen met subsidie van het Innovatiefonds Badenova en de Gemeente Freiburg. Deze waterkrachtcentrale levert ongeveer 880.000 kWh per jaar op. In de centrale kon de Kaplan Turbine bekeken worden. Deze turbine bestaat uit een generator, propeller en tandwiel.

7. **Model District Vauban**

Het ontwikkelingstraject van het District Vauban von plaats tussen 1997 en 1999 en kan het beste worden omschreven aan de hand van een viertal onderwerpen. De volgende onderwerpen zullen daarom kort de revue passeren: Planning en Coöperatie, Consultatie en burgerparticipatie, Verkeer en Energie.

Planning en Coöperatie

De gemeente Freiburg was toentertijd de enige eigenaar van het Vauban gebied en daarom tevens verantwoordelijk voor de ontwikkeling ervan. Vanaf het begin van het ontwikkelingstraject heeft de gemeente hoog ingezet op het verbeteren van het sociale en ecologische karakter van het gebied. De gemeente heeft geprobeerd deze ambitie inhoudt te geven door in de ontwikkelingsplannen enkel nog energie zuinige nieuwbouw projecten op te nemen, het gebied aansluiting te geven aan het tramnetwerk van Freiburg, het regenwater op te vangen in de grond zodat het hergebruikt kan worden, een bepaalde sociale balans van inwoners te creëren en tenslotte haar private grond te verkopen aan veel verschillende private bouwers en ontwikkelaars zodat de toekomstige bewoners veel inspraak hadden in hoe hun leefomgeving er uit zou zien.

Met name de participatie van toekomstige gebruikers van het gebied werd als heel belangrijk gezien. De gemeente heeft samen met de toekomstige gebruikers van het gebied veelvuldig overleg momenten gehad waardoor de wensen van de toekomstige gebruikers beter in kaart gebracht konden worden. Door deze overleggen is er op het gebied van verkeer, energie, bouw en sociologie een hoop verandert ten opzichte van de oorspronkelijke plannen. Het betrekken van de toekomstige gebruikers van het gebied heeft uiteindelijk voor een hoop extra werk gezorgd, maar nog veel belangrijker ook voor meer transparantie en acceptatie van de toekomstige gebruikers en bewoners.

Consultatie en burgerparticipatie

De gemeente heeft (zoals aangegeven) al in een vroeg stadium van het ontwikkelingstraject toekomstige bewoners en huiseigenaren betrokken in het ontwikkelingstraject van het district. Met een zogenaamde ‘push’ en ‘pull’ strategie in het achterhoofd heeft de gemeente geprobeerd verder te gaan dan de oorspronkelijke ecologische eisen uit het ontwikkelingsplan. Er werd een concept van advisering bedacht met daarin een breed scala aan topics op het gebied van ecologie en sociale ontwikkeling. Deze topics zijn vervolgens tijdens bijeenkomsten en middels exposities en publicaties besproken met project ontwikkelaars, “Bouwgruppen” (soort van bouwers in Duitsland) en huiseigenaren. Door deze sessies werd het sociale aspect en het ecologische aspect dat de gemeente voor ogen had op een goede manier overgedragen.

Met name de ontwikkeling met behulp van de “bouwgruppe” en de verschillende woningeigenaren van een pand waren erg succesvol in het district. Niet alleen resulteerde deze samenwerking in een sterke reductie van de constructie kosten, maar het resulteerde ook in een stabielere leefomgeving. De toekomstige bewoners leerden elkaar in een vroeg stadium al kennen en hadden naast inbreng in hun eigen pand, ook een hoop inbreng het uiterlijk van de rest van het district.

Verkeer

Een belangrijk uitgangspunt van het project was dat het district vooral bedoeld is voor bewoners zonder auto (in Freiburg heeft op het moment 35% van de inwoners geen auto). Dit uitgangspunt heeft als belangrijke nadeel dat de mobiliteit van de toekomstige bewoners van het gebied erg onder druk komt te staan. Dat is natuurlijk geen probleem als het gebied een goede aansluiting heeft met de rest van Freiburg. De gemeente heeft dit heel serieus genomen en heeft er voor gezorgd dat het district een goede aansluiting heeft met het publieke transport netwerk van Freiburg en dat het gebied veel fietspaden heeft. Scholen, winkels en recreatie zijn allen op loopafstand te vinden. Grote gedeelten van het district zijn parkeer vrij, waardoor een hoop ruimte en dus geld wordt bespaard, omdat er geen brede grote wegen gebouwd hoeven te worden. Dat resulteert in situaties die de plaatjes hieronder het beste weergeven.

Energie

Het gebied kenmerkt zich vooral door de vele energiezuinige huizen en de vele zonnepanelen op de huizen. De energiezuinige toepassingen en de duurzame energie opwekking met behulp van zonnecellen werd met name mogelijk door een aantal subsidieprogramma's die de gemeente aanbood. Na de oplevering van de eerste 40 huizen bleek dat de 'pilot' versie van de Passieve huizen het interessants was. Om deze reden werd besloten om van de volgende bulk huizen allemaal passieve huizen te maken.

In het Oosten van Vauban is de laatste jaren Europa's grootste 'zonnewijk' gebouwd. In dit gebied zijn 210 huizen gebouwd volgens het Energie-plus concept. Het energie-plus concept wil zeggen dat de huizen meer energie opwekken dat zelf verbruiken. In Vauban zijn huizen te vinden die 3 keer zoveel energie opwekken dan dat ze zelf verbruiken. Dit is mogelijk omdat in Freiburg de subsidieregelingen ook veel beter zijn dan in Nederland. De pioniers in de wijk die bij de bouw gebruik hebben gemaakt van de subsidieregeling krijgen vanaf de bouw 20 jaar lang, voor iedere Kwh die ze terugleveren aan het net €0,54 euro (om te vergelijken; in Nederland krijg je €0,09 euro voor diezelfde terug geleverde Kwh en betaal je ongeveer €0,23 euro per Kwh). Deze immense subsidieregeling maakt de bouw van energie plus en passieve huizen natuurlijk een stuk interessanter. Daarnaast maken de huizen gebruik van allerlei technische snufjes als compleet vochtdichte muren, driedubbele beglazing, slimme ventilatiesystemen die koude lucht van buiten opwarmt met behulp van de warme lucht van binnen. Dat alles heeft er voor gezorgd dat Vauban op het moment Europa's grootste wijk is die gebaseerd is op passieve en energie plus huizen.

8. Heliotrop

In 1994 heeft de Duitse Architect en zonne engineer Rolf Disch 's werelds eerste zogenaamde Heliotroop gebouwd. Het bouwwerk is om verschillende redenen erg speciaal en uniek. Niet op de eerste plaats vanwege haar uiterlijk. Het cilindervormige veertien meter hoge bouwwerk lijkt nog het meeste op een soort reuzen paddenstoel. In Duitsland staan drie soortgelijke ontwerpen, maar het ontwerp in Freiburg was de eerste. Net als een hoop andere architecten uit Freiburg was voor Rolf Dish het afzetten tegen kernenergie de belangrijkste motivatie voor het bedenken van het ontwerp. De Heliotroop was het eerste gebouw in de wereld dat meer energie opwekt dan dat het verbruikt. Deze energie wordt daarbij volledig duurzaam en dus emissie en CO_2 vrij opgewekt. In totaal kan het huis ongeveer 5 keer zoveel energie opwekken dan dat het gebruikt.

Een belangrijke eigenschap van het huis is dat het huis op zeer efficiënte wijze energie kan opwekken. Zo is de gevel van het huis voorzien van zonnecollectoren. Het huis kan, met behulp van een kleine zuinige motor, ongeveer tot 400 graden om haar eigen as heen draaien. Met een zuinige motor wordt ook echt een zuinige motor bedoeld. De motor gebruikt namelijk minder dan een cassetterecorder die permanent aanstaat. Het voordeel van een draaiend huis is dat hiermee optimaal gebruikt gemaakt kan worden met de positie van de zon. In de lente en herfst draait het huis met haar voorkant met de zon mee. De voorkant van het huis heeft een groot oppervlak aan ramen waardoor er zeer efficiënt gebruik gemaakt kan worden van het licht inval en waardoor er gebruik gemaakt kan worden van het ontstane broeikaseffect. Daarnaast beschikt de voorkant van het huis over vacuümbuis zonnepanelen die de warmte van de zon opslaat. In de zomermaanden, wanneer de zonne-instraling zijn hoogtepunt bereikt, zorgt het draaiende mechanisme er voor dat de zon zoveel mogelijk vermeden wordt. Het huis staat dan zoveel mogelijk met haar goed geïsoleerde achterkant op de zon gepositioneerd waardoor er minder gekoeld hoeft te worden. De rest van de verwarming en koeling worden in de verschillende maanden zoveel mogelijk opgevangen door een warmtepomp.

Op het dak van het huis staan in totaal 54 vierkante meter aan monocrystalline silicium zonnecellen gepositioneerd op een plaat die via een dubbele as mee kan draaien met de zon. Deze slimme constructie resulteert in een extra opbrengst van ongeveer 30% tot 40% ten opzichte van vaste zonnepanelen. In totaal wekt het huis op jaarbasis ongeveer 9000 kWh elektriciteit. Dat betekent dus dat het huis ongeveer 5 keer zoveel energie opwekt dan dat het zelf verbruikt. Het elektriciteit overschot gaat natuurlijk niet verloren maar wordt aan de plaatselijke energieleverancier weer doorverkocht.
Maar natuurlijk is het opwekken van duurzame energie niet voldoende. De grootste winst is

te behalen met maatregelen die er voor zorgen dat er op een zuinigere en efficiëntere manier met de beschikbare energie wordt omgegaan. Uiteraard is hier in de ontwerpfase ook al rekening mee gehouden. Zo is het skelet van het huis geheel van hout gemaakt en heeft het huis overal driedubbel glas. Niet noodzakelijk elektriciteit verbruik is noodzakelijkerwijs teruggebracht tot een absoluut minimum. Zo maakt het huis gebruikt van permanent energiezuinige spaarlampen en ontbreekt er in de keuken bijvoorbeeld een vriezer. Het huis gaat ook heel vooruitstrevend om met water, Leidingwater is slechts bruikbaar als drinkwater. Voor de rest gebruikt het huis zoveel mogelijk gereinigd regenwater. Regenwater wordt op het dak opgevangen, gefilterd en tenslotte verzameld in een tank. Zodra het water in de tank wordt opgeslagen is het klaar voor huishoudelijk gebruik. Binnenhuis wordt het voornamelijk gebruikt voor allerlei schoonmaak werkzaamheden. Het water wordt niet gebruikt voor het doorspoelen van het toilet om de doodsimpele reden dat het huis gebruikt maakt van droge afvoer. De uitwerpselen worden samen met het groene keukenafval in een tank verzameld. Om er voor te zorgen dat er geen vieze lucht ontstaat wordt de materie onder lichte druk opgeslagen. In deze opslag tank krijgt de materie de tijd om te composteren wat na een paar maanden resulteert in droog compost en korrels.

9. Technische Universiteit Darmstadt

SurPLUShome – Winnaar *Solar Decathlon 2009*

Solar Decathlon

De *Energy Solar Decathlon* wordt elke twee jaar gehouden in Washington. Twintig teams mogen deelnemen aan deze wedstrijd. Hun taak is om een door zonne-energie aangedreven woning te ontwerpen en te bouwen. Een eis van de wedstrijd is dat de gebouwen kosten- en energie efficiënt zijn, maar ook esthetisch aantrekkelijk. Daarnaast mag het gebouw maximaal een oppervlakte van 70m² hebben en maximaal 5.4 meter hoog zijn. Er wordt beoordeeld op tien disciplines, waaronder uitvoerbaarheid, verhandelbaarheid en leefbaarheid van het gebouw. Interdisciplinair onderzoek is hierbij belangrijk. Het team dat het beste aantrekkingskracht voor consumenten in het ontwerp combineert met optimale energie productie en maximale efficiëntie is de winnaar van de wedstrijd.

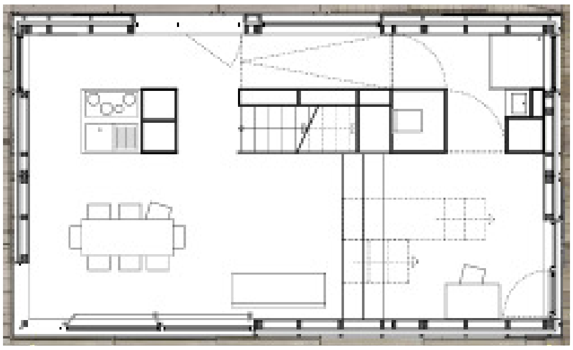
Team Germany

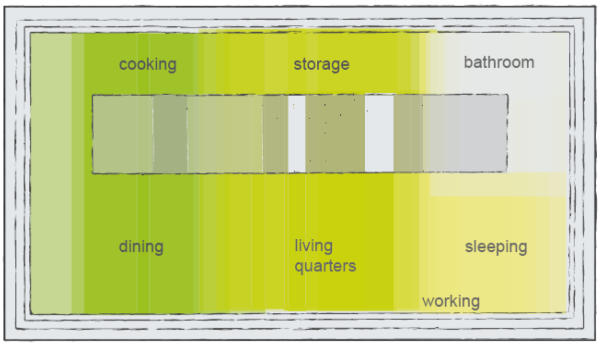
In 2007 heeft Duitsland ook de wedstrijd gewonnen, maar met een ander team dan in 2009. In dit laatste jaar bestond het team van Duitsland uit (slechts) 24 studenten. De meesten hiervan zijn architecten die studeren aan de Technische Universiteit van Darmstadt. Daarnaast hebben werktuigbouwkunde en elektrotechniek studenten geparticipeerd in het project. Ook sponsoren en vrijwilligers spelen een belangrijke rol in het proces, zoals adviseurs die hebben geholpen. Het was leerzaam hoe bijvoorbeeld voor creatieve oplossingen gekozen moest worden tijdens de samenwerking tussen architecten en elektrotechnici. Zonder ervaring zijn de studenten aan het avontuur begonnen, zowel het ontwerp als het daadwerkelijk bouwen. Dit project heeft hen veel ervaring opgeleverd. In totaal heeft het de studenten anderhalf jaar gekost om te komen tot het eindresultaat: winnen in Washington.

Kosten

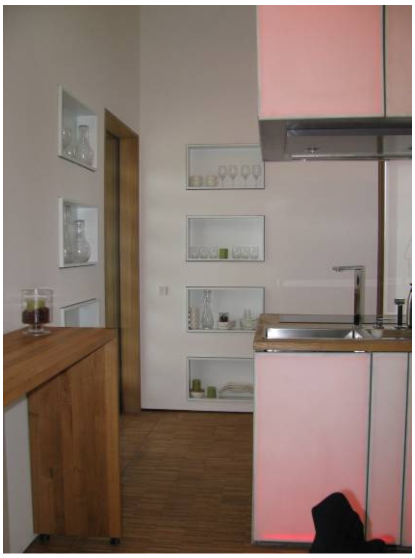
De bouwkosten voor het SurPLUShome liggen tussen $ 650.000 en $850.000. Hierbij moet gemeld worden dat dit gebouw éénmalig gebouwd is met geavanceerd technologieën. Bij massaproductie zullen de kosten drastisch afnemen. Naast deze kosten is ook nog sponsorgeld verkregen en de medewerking van verschillende bedrijven die hun ontwikkelingen hier konden testen.

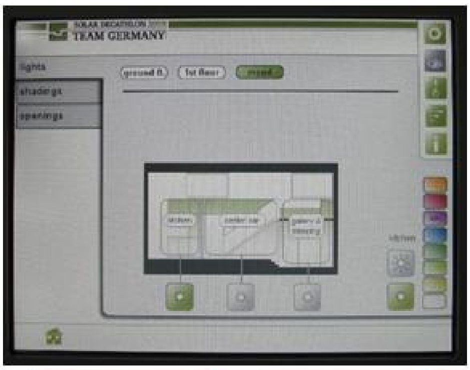
Concept
Voor deze wedstrijd is gekozen voor een één-kamer concept. Hierin zijn wel verschillende functies duidelijk ondergebracht. De architecten wilden in de kubus met twee verdiepingen zoveel mogelijk nieuwe technieken onderbrengen. Bovenaan stond het maximaliseren van de opbrengst van PV-cellen en de connectie met het elektriciteitsgrid. Daarnaast zijn *Phase Change Materials*, vacuum isolatie panelen, geautomatiseerde zonwering in de ramen, een boiler geïntegreerd in het warmtepomp system en te kiezen verlichting in het huis opgenomen. Dit alles heeft geresulteerd in het SurPLUShome met één multifunctionele ruimte.



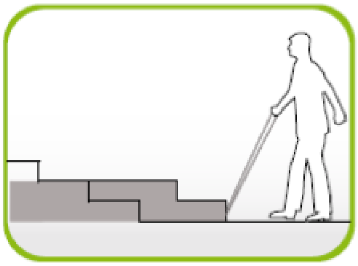
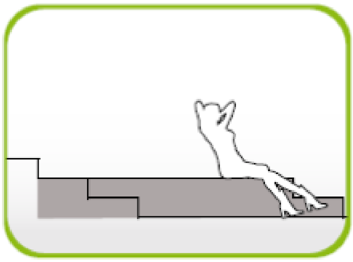
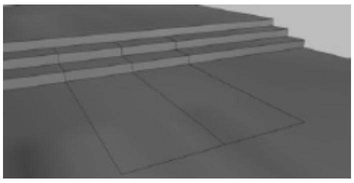


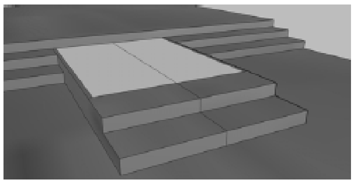
Keuken
De keuken heeft een eigen plek in het huis en heeft als functie om er te koken. In de keuken zijn verlichte deurtjes toegepast waarbij de kleuren zelf te kiezen zijn. In de deurtjes zijn led-strips verwerkt en het materiaal verspreidt de kleur over het gehele deurtje. De toepassing hiervan was mogelijk doordat sponsoren hun nieuwe materialen en technieken konden testen.



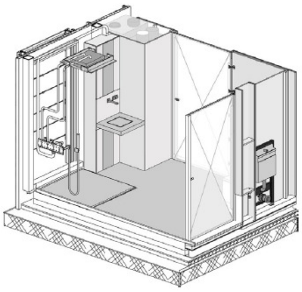
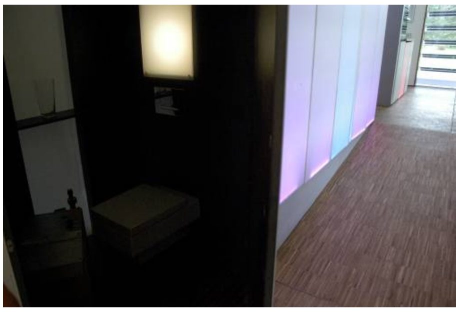


Woonkamer
De woonkamer is multifunctioneel, het kan namelijk ook gebruikt worden als kantoor op slaapvertrek. In de kleine trap zit namelijk een bed verwerkt. Daarnaast zit ook de luchtinlaat verwerkt in deze trap. Door de hoogte van het huis was het mogelijk een tweede verdieping te maken. Aangezien deze boven de woonkamer ligt, krijgt de woonkamer toch een soort van privé karakter.



Badkamer en toilet
De badkamer is open, maar kan ook afgesloten worden met behulp van panelen die om het toilet zitten. Dit betekent dat het toilet wel altijd afgesloten is. In het licht in het toilet zit direct de luchtafvoer verwerkt. Het ventilatievoud is ingesteld op $1.6h^{-1}$, maar dat kan hoger ingesteld worden. In de badkamer zit een wastafel en de douche is in het 'dak' verwerkt.

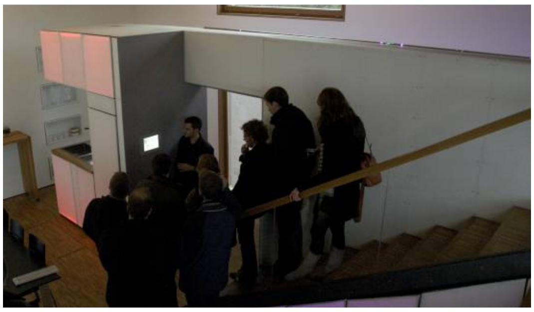




Slaapkamer
Op de eerste verdieping is de slaapkamer geplaatst. De ruimte onder het bed is gebruikt om installaties weg te werken. De trap naar de verdieping is een zeer lichtgewicht trap van slechts 37 kilo.



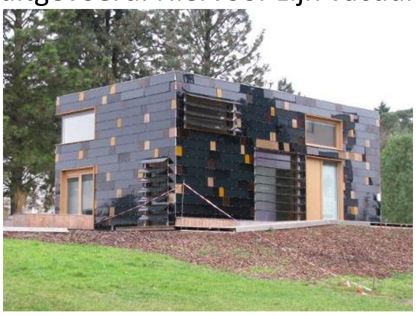
Energie

Het SurPLUShome speelt in op de actuele en verwachte ontwikkelingen omtrent de energievraag. Het vermogen van hernieuwbare energiebronnen fluctueert en is lastig te controleren. Maar wind- en zonne-energie winnen wel steeds meer terrein. Vandaar dat de huidige structuur verandert. Het SurPLUShome heeft daarom een touchscreen geïntegreerd in het gebouw. Alle systemen zijn hierop aangesloten en kunnen zelfs nog onderling communiceren. Ook is er een stoplicht op het scherm zichtbaar. Dit is gekoppeld aan het PV-cellen op de gevel. Rood staat voor consumptie is groter dan de productie. Bij geel is de consumptie ongeveer gelijk aan de productie van energie en bij groen geldt dat de productie groter is dan de consumptie. Met behulp van het stoplicht dient de bewoner geactiveerd te worden om energie verbruikers die op dat moment niet nodig zijn uit te schakelen. Op het scherm is ook te zien welke apparaten op dat moment stroom gebruiken. Op het scherm is het ook mogelijk de opbrengst van de PV-cellen is per façade te zien. Het is ook mogelijk om bijvoorbeeld apparaten enkel te laten starten als er voldoende energie door de eigen PV-cellen geproduceerd wordt. Hierdoor kan het stroomnet enorm ontlast worden. Tot slot is het mogelijk dat het systeem detecteert wanneer het beste een apparaat gestart kan worden. Een voorbeeld is dat het systeem vertelt wanneer het beste een warme douche genomen kan worden.

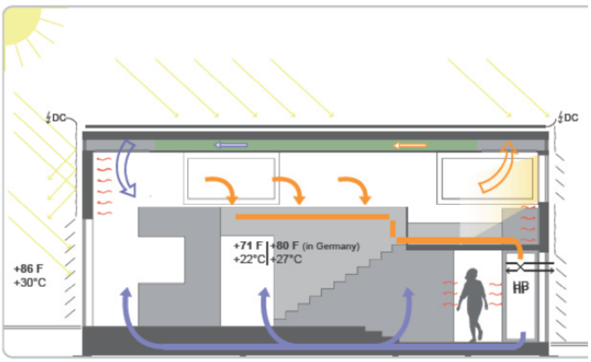

Zonne-energie façade

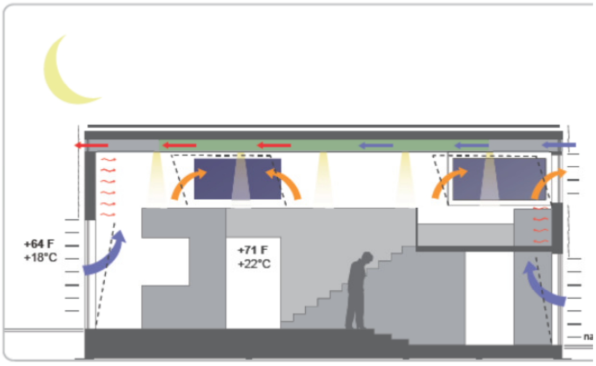
De façade van SurPLUShome is een *eye-catcher*, maar heeft daarnaast nog belangrijke functies. Naast energiewinning verzorgt de gevel ook zonwering, lichtregeling, bescherming tegen slagregen en ventilatiemogelijkheden. Voor de gevel zijn een soort tegels over elkaar heen geplaatst. Daartussen zijn ook enkele plexiglas platen aangebracht voor de afwisseling. Aangezien ruimtegebruik in het gebouw belangrijk was is de oriëntatie van de gevels niet optimaal. Daarom zijn de geveldelen beweegbaar gemaakt. De cellen volgen zelf de zon, dit hoeft dus niet ingesteld te worden. Voor de gevels zijn 250 CIGS-panelen gebruikt. CIGS staat voor Copper Indium Gallium Selenide en zijn minder efficiënt dan silicium panelen, echter ze presteren beter bij bewolkt weer. Enkele glasdelen in de gevel zijn ook nog constructief gebruikt. Deze kunnen niet bewegen. Verder is de gevel goed isolerend uitgevoerd. Hiervoor zijn vacuüm panelen gebruikt.



Klimaatdak

In de dakconstructie zijn *'Phase Change Materials'* opgenomen en deze worden gebruikt om het huis te klimatiseren. Verschillende faculteiten hebben meegeholpen en het dak bleek goed te presteren. Het is belangrijk een materiaal te kiezen dat bij de gewenste temperatuur een faseverandering ondergaat. Allereerst is bij het SurPLUShome een PCM toegepast om de thermische massa van het gebouw te verhogen, daarna is het materiaal ook al actieve sturing gebruikt. In het dak met het PCM zijn luchtkanalen opgenomen. Als bijvoorbeeld de ruimtelucht gekoeld moet worden dan kan de warme lucht door de kanalen geleid worden en de warmte overdragen aan het PCM. In de nacht wordt koudere lucht gebruikt om het PCM weer af te koelen. Het PCM moet namelijk ook weer geregenereerd worden. Het goede presteren en de toepassing van een PCM heeft vermoedelijk een belangrijke bijdrage geleverd aan de overwinning. Op het dak zijn ook 40 één-kristal silicium PV-panelen geplaatst. Samen met de panelen op de gevels leveren de PV-cellen 11.1kW. Samen produceren ze 200% van de energiebehoefte van het huis.



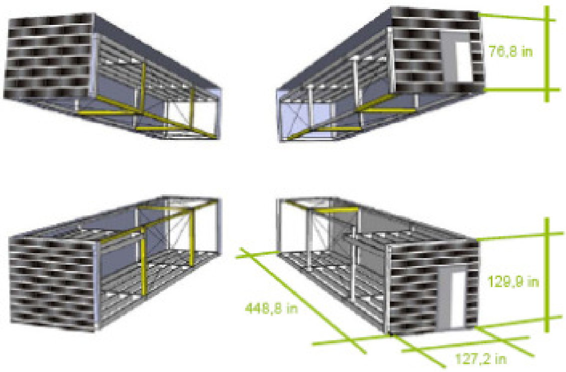


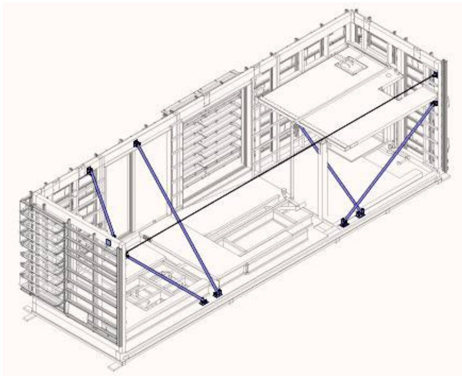
Leerpunten

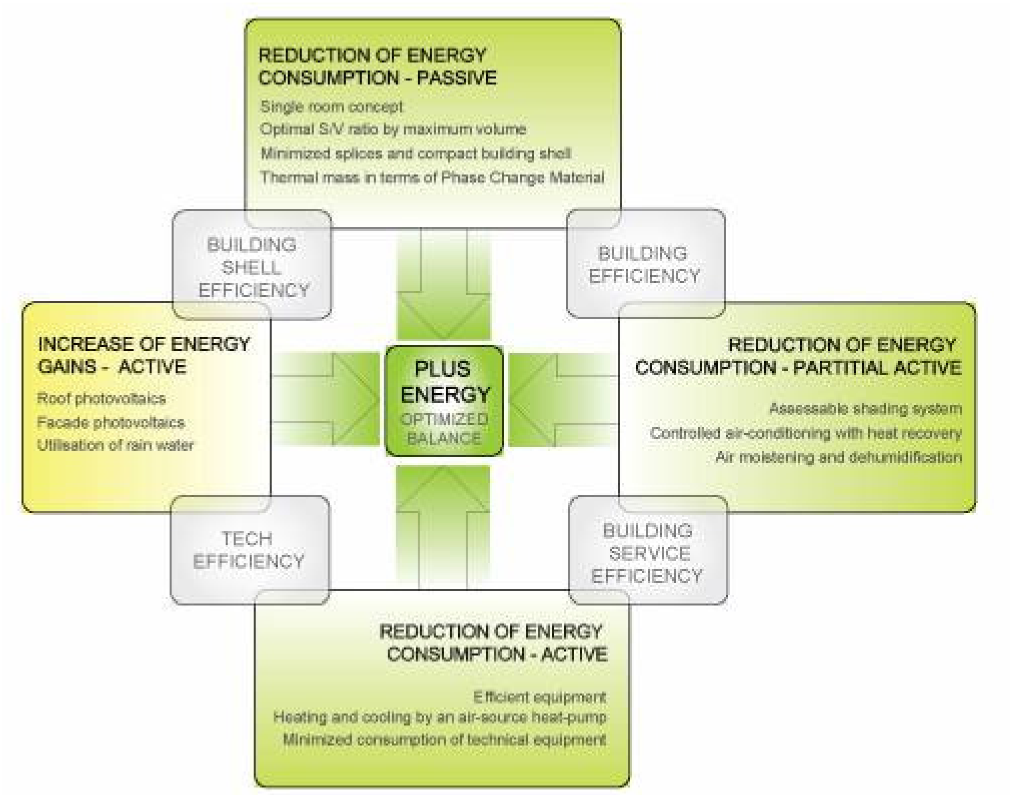
Team Germany heeft veel ervaring opgedaan tijdens deze prijsvraag. Naast samenwerken, moest dit huis ook echt gebouwd worden. Het was vooral leerzaam om iets te ontwerpen in Duitsland wat uiteindelijk in Amerika moest functioneren. Hierbij moet rekeningen gehouden worden met de daar geldende eenheden, normen en ook het weer. In Washington kan het in oktober warm en koud zijn en kan het soms ook heel hard regenen. Daarnaast moest het SurPLUShome ook vervoerd worden van Duitsland naar Washington, vandaar dat het gebouw is opgedeeld in vier modules en is het gebouwd met lichtgewicht hout. Het gebouw staat inmiddels weer in Darmstadt, maar het is duidelijk dat het veel te lijden heeft gehad van een paar keer afbreken en opbouwen.



Overige foto's/afbeeldingen







Bronnen:

- Wissenschaftsmagazin der TU Darmstadt (2010)
- http://www.solardecathlon.gov/
- http://www.solardecathlon.tu-darmstadt.de/home/home.de.jsp

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