The value of Net Zero Energy Renovations

Tim Jonathan
Graduation Report
April 2016
### Personal:

<table>
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<tr>
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</thead>
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<th>Delft University of Technology</th>
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<td>Architecture and the Build Environment</td>
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<tr>
<td><strong>Master Track</strong></td>
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<tr>
<td><strong>1st Tutor</strong></td>
<td>Prof.Dr.ir. A.A.J.F. (Andy) van den Dobbelsteen</td>
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<tr>
<td><strong>2nd Tutor</strong></td>
<td>Prof.Dr.ir. J.D.M. (Anke) van Hal</td>
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<tr>
<td><strong>3rd Tutor</strong></td>
<td>Dr. H.M.H. (Harry) van der Heijden</td>
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<tr>
<td><strong>External Examiner</strong></td>
<td>Dr. J.J. (Jan Jacob) Trip</td>
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<tr>
<td><strong>Tutor TiSD</strong> (Technology in Sustainable Development)</td>
<td>Prof.Dr.ir. A.A.J.F. (Andy) van den Dobbelsteen</td>
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### Internship:

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<td><strong>External Mentor</strong></td>
<td>Drs. M. (Marcel) Tankink (Reimarkt - KAW)</td>
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### Date:

| **Graduation**          | April 12th 2016                   |
Introduction

The report in front of you contains the graduation research of Tim Jonathan. It is the result of two years of general research into Net Zero Energy Renovations done during a Student Competition I participated in and 1.5 years of research done during my graduation period at the TU Delft for the mastertrack Building Technology.

During the graduation process the scope of the research has changed. The first goal of the research was to create a technical innovation that would not only work technically, but would be ready to be implemented in the market. The result should not just be a design for one house. It should be a product that people can buy of the shelve. That means creating an appealing design that fits within legal boundaries, within the financial reach of homeowners, and within the diversity of houses it should be applied to. This first goal resulted in a research into a collection of subjects that could form a graduation project on its own.

Being forced by my tutors to make decisions I had to let go some less relevant studies and continued with a more focussed research into the financial aspects of implementing technological innovations. Still, the goal is to create a design for a renovation product. In order to do so the goal of the research is to define the value of a Net Zero Energy Renovation. The outcome of this research, together with all other background information I have collected, will form a decision framework: a general methodology for the renovation of terraced houses.

The research is done under supervision of four mentors. I want to thank them for their help and input in the research.

- Andy van den Dobbelsteen as primary mentor for my graduation for his help on this research and report. But besides that, maybe in the first place, for his work as primary faculty advisor and coach throughout the Prêt-à-Loger project, which is the basis and main inspiration for this (graduation) research and many others (in the past and to come).
- Anke van Hal for her feedback and research advise.
- Harry van der Heijden, for teaching me the financial principles I needed, the basics about the housing market and for his efforts to turn my plans into a scientifically correct research framework and research.
- Marcel Tankink, for making it possible to continue development on the Prêt-à-Loger concept in a professional way with professional parties and with all the resources available at Reimarkt.

Besides my supervisors I want to thank the following people:

- Jan Jacob Trip for chairing the graduation presentations as external examiner.
- The Prêt-à-Loger team for inspiring and collaboration on a great project and lifetime achievement.
- Harry Boumeester for his help on the calculation of marketsize in SPSS.
- Josien Kruizinga with which I have not only worked together during the Prêt-à-Loger competition but also during the startup phase of DENNIS and now as colleague at Reimarkt for her help, not just concerning content of the research but also in advising me on the structure of the research.
- I want to thank Reimar von Meding for his input on the Prêt-à-Loger design that is still being worked on at Reimarkt.
- Thomas Dekker for his input and information about financing at Rabobank.
- Peter de Jong for his help with defining formulas and parameters for my model.
- The colleagues and partners at Reimarkt that are working hard on the first realisation of a Prêt-à-Loger inspired concept in practice.
- My parents for their help and dedication throughout my (student) life.
- Debbie for proofreading the final report.
- Last but not least, Martine, my wife who has been supporting me throughout my studies.

Tim Jonathan,
April 2016
Abstract

There are more and more smart technological solutions on the market for the Net Zero Energy Refurbishment of the current building stock. The Delft University of Technology developed a Net Zero Energy Renovation (NZER) concept as part of the Solar Decathlon Europe 2014 competition: Prêt-à-Loger. Many other NZER concepts are developed within Energiesprong, an initiative of the Dutch Government.

Despite the easy and fast applicability, the financial aspect is one of the barriers for large-scale implementation. This thesis addresses the financial benefits of Net Zero Energy Renovations that can activate the investment on NZERs. The main product is an online tool that calculates the value of inserted NZERs based on these benefits. The goal of this tool is twofold: to activate concept-, product-developers and builders to design renovation products that add (financial) value, and to make the market aware of the financial value that an NZER can create.

Furthermore a research is done into the ability to pay based on borrowing capacity for owners of terraced houses between 1946 and 1979 in the Netherlands, and an overview is given of NZER concepts that are build until now. The thesis also presents a conceptual decision framework; a step-by-step approach that people who want to renovate their terraced house or designers who want to design such a renovation can use.

Finally a design is presented that is inspired on the Prêt-à-Loger design and improved with help of the calculation model and decision framework.
List of definitions: This research requires a thorough and clear explanation of the different definitions. To be able to read fast through this report this chapter will list all definitions with their meanings and explanations or references to explanations in the report.

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<td>Broad Stroomversnelling</td>
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<td>Community of parties that want to address development of Net Zero Energy Renovations.</td>
<td><a href="http://www.stroomversnellingkoopwoningen.nl/de-brede-stroomversnelling/">http://www.stroomversnellingkoopwoningen.nl/de-brede-stroomversnelling/</a></td>
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<td>gebouwgebonden</td>
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<td>Direct costs</td>
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<td>Cost that directly can be linked to a certain investment</td>
<td></td>
<td>Directe kosten</td>
<td></td>
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<td>Discount Rate</td>
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<td>Interest rate that is used to define the Net Present Value</td>
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<td>Disconteringsvoet</td>
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</tr>
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<td>Discounted cashflow</td>
<td>DCF</td>
<td>A valuation method used to estimate the attractiveness of an investment opportunity</td>
<td><a href="http://www.investopedia.com/terms/d/dcf.asp">http://www.investopedia.com/terms/d/dcf.asp</a></td>
<td>Verdisconteerde kasstroom</td>
<td></td>
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<tr>
<td>Energiesprong</td>
<td></td>
<td>Innovation program of Platform31 to boost Energy neutral Buildings</td>
<td><a href="http://energiesprong.nl/over-ons/wat-is-het/">http://energiesprong.nl/over-ons/wat-is-het/</a></td>
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<td>Energy performance Compensation</td>
<td></td>
<td>A monthly compensation that a landlord can charge to a tenant when the energyproduction and energysaving measures make the house into an NZER (NOM)</td>
<td><a href="http://energieindex.nl/resources/epv">http://energieindex.nl/resources/epv</a></td>
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<td>Fixed-rate mortgage</td>
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<td>A mortgage with a fixed (monthly) payment</td>
<td><a href="https://en.wikipedia.org/wiki/Fixed-rate_mortgage">https://en.wikipedia.org/wiki/Fixed-rate_mortgage</a></td>
<td>Annuitleenhypotheek</td>
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<td>Framework</td>
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<td>A set of ideas or facts that provide support for something</td>
<td></td>
<td>Kader</td>
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<td>Housing Association</td>
<td></td>
<td>Private, non-profit making organisations that provide low-cost “social housing” for people in need of a home</td>
<td><a href="https://en.wikipedia.org/wiki/Housing_association">https://en.wikipedia.org/wiki/Housing_association</a></td>
<td>Woningcorporatie</td>
<td></td>
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<tr>
<td>Indirect costs</td>
<td></td>
<td>Cost that cannot be linked directly to a certain investment</td>
<td></td>
<td>Indirecte kosten</td>
<td></td>
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<td>Internal Rate of Return</td>
<td>IRR</td>
<td>A discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero.</td>
<td><a href="http://www.investopedia.com/terms/irr.asp">http://www.investopedia.com/terms/irr.asp</a></td>
<td>Interne opbrengstvoet</td>
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<td>Longer Establishment concept</td>
<td></td>
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<td>Market Value</td>
<td></td>
<td>The price that one would be willing to pay</td>
<td><a href="https://en.wikipedia.org/wiki/Market_value">https://en.wikipedia.org/wiki/Market_value</a></td>
<td>Marktwarde</td>
<td></td>
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<td>Ministerial arrangement mortgage credit</td>
<td></td>
<td>A common itemized deduction that allows homeowners to deduct the interest they pay on any loan used to build, purchase or make improvements upon their residence.</td>
<td><a href="http://www.belastingdienst.nl/wps/wcm/connect/bildcontentnl/belastingdienst/private/woning/ux_hypotheek_of_lening/verplicht_aflossen_voor_renteaftrek_vanaf_2013/verplicht_aflossen_voor_renteaftrek_vanaf_2013">http://www.belastingdienst.nl/wps/wcm/connect/bildcontentnl/belastingdienst/private/woning/ux_hypotheek_of_lening/verplicht_aflossen_voor_renteaftrek_vanaf_2013/verplicht_aflossen_voor_renteaftrek_vanaf_2013</a></td>
<td>Ministeriële regeling hypothecair krediet</td>
<td>Hypotheekrenteaftrek</td>
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<td>Multi Annual Maintenance Plan</td>
<td></td>
<td></td>
<td></td>
<td>Meervlakten onderhouds plan</td>
<td>MJOP</td>
</tr>
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<td>Net Present Value</td>
<td>NPV</td>
<td>Difference between the present value of cash inflows and the present value of cash outflows.</td>
<td><a href="http://www.investopedia.com/terms/n/npv.asp">http://www.investopedia.com/terms/n/npv.asp</a></td>
<td>Netto contante waarde</td>
<td>-</td>
</tr>
<tr>
<td>Net Zero Energy (Renovation)</td>
<td>NZER</td>
<td>A renovation that results in a home that will turn the energy bill for an average user to zero.</td>
<td><a href="http://www.stroomversnellingkoopwoningen.nl/wp-content/uploads/Handrekening_voorwaarden_NOM_SVKOOPPlots_V-jan2015.pdf">http://www.stroomversnellingkoopwoningen.nl/wp-content/uploads/Handrekening_voorwaarden_NOM_SVKOOPPlots_V-jan2015.pdf</a></td>
<td>Nul op de Meter (renovatie)</td>
<td>NOM</td>
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<td>Netto Value of Renovation</td>
<td></td>
<td>All cost benefits added together</td>
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<td>Owner-occupier / private owner</td>
<td></td>
<td>A Homeownership in which the homeowner inhabits the house he / she owns.</td>
<td>Section 3.4.1</td>
<td>Eigenaars-bewoner</td>
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<tr>
<td>Payback period</td>
<td>PMT</td>
<td>The length of time required to recover the cost of an investment</td>
<td>Section 3.3.3</td>
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<td>Periodic Payment</td>
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<td>Periodic Payment for an annuity investment</td>
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<td>Periodieke betaling</td>
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<td>Photovoltaic panels</td>
<td>PV's</td>
<td>Panels wit cells that convert energy from the sun into a flow of electrons.</td>
<td><a href="https://en.wikipedia.org/wiki/Photovoltaics">https://en.wikipedia.org/wiki/Photovoltaics</a></td>
<td>Zonnepanelen</td>
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<td>Principal</td>
<td></td>
<td>The amount borrowed or the amount still owed on a loan, separate from interest.</td>
<td><a href="http://www.investopedia.com/terms/p/principal.asp">http://www.investopedia.com/terms/p/principal.asp</a></td>
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<th>Abbreviation (Dutch)</th>
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<td>Rowhouse / terraced house / linked house</td>
<td></td>
<td>Referring to a style of medium-density housing that originated in Europe in the 16th century, where a row of identical or mirror-image houses share side walls.</td>
<td><a href="https://en.wikipedia.org/wiki/Terraced_house">https://en.wikipedia.org/wiki/Terraced_house</a></td>
<td>Rijtjeshuis</td>
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<td>Saving Energy concept</td>
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<td>Smart and Bioclimatic Design</td>
<td>S&amp;BCD</td>
<td>A design approach that deploys local characteristics into the design of buildings and urban plans.</td>
<td><a href="http://www.irbnet.de/daten/condad/CIB15911.pdf">http://www.irbnet.de/daten/condad/CIB15911.pdf</a></td>
<td>Smart and Bioclimatic Design</td>
<td></td>
</tr>
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<td>Stroomversnelling</td>
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<td>A network of innovative builders, suppliers, associations, municipalities, financiers, grid operators and others working together to make NZE renovations and new buildings possible</td>
<td><a href="http://stroomversnelling.nl/over-stroomversnelling/stroomversnelling/wat-is-stroomversnelling/">http://stroomversnelling.nl/over-stroomversnelling/stroomversnelling/wat-is-stroomversnelling/</a></td>
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<td>Stroomversnelling Huur</td>
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<td>An initiative to support NZER in the public sector</td>
<td><a href="http://stroomversnelling.nl/initiatief/stroomversnelling-huur/">http://stroomversnelling.nl/initiatief/stroomversnelling-huur/</a></td>
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<tr>
<td>Stroomversnelling Koop</td>
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<td>A national initiative to support NZER in the private sector</td>
<td><a href="http://www.stroomversnellingkoopwoningen.nl/wat/">http://www.stroomversnellingkoopwoningen.nl/wat/</a></td>
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<td>Terraced House</td>
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<td>See &quot;Rowhouse&quot;</td>
<td></td>
<td></td>
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<tr>
<td>Total Cost of Ownership</td>
<td>TCO</td>
<td>A financial estimate intended to help buyers and owners determine the direct and indirect costs of a product or system.</td>
<td><a href="https://en.wikipedia.org/wiki/Total_cost_of_ownership">https://en.wikipedia.org/wiki/Total_cost_of_ownership</a></td>
<td>Total Cost of Ownership</td>
<td>TCO</td>
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<td>Underwater mortgage</td>
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<td>A mortgage for a property that has less value than the remaining mortgage debt.</td>
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<td></td>
<td>gebruikgebonden</td>
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<td>Vacancy Rate</td>
<td></td>
<td>The percentage per year that a house is empty. Related to “huurdervingsreservering”</td>
<td>Section 3.1.4</td>
<td>Leegstand</td>
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| WoON12 research                   |                        | A periodic research done by the ministry of internal affairs and kingdom relations and the CBS, 70,000 people are interviewed about their living situation, livings costs and plans            | https://www.rijksoverheid.nl/actueel/nieuws/2013/04/11/woon-2012-meer-mensen-willen-Verhuizen | Woononderzoek Nederland 2012 | WoON12}
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   Deal de Stroomversnelling Koopwoningen 29 september
   Deal Stroomversnelling Huurwoningen: 111.000 huurwoningen
   ONS HUIS VERDIEN HET
   Lokaal alle lichten op groen
   Huis vol Energie
   Hoogspringers: 1000+, nul op de rekening
   Woonlastenexperiment
   Energielinq, de kennishub van Energiesprong
   10.000 euro voor Nul-op-de-meter prestatiecontract
   Renovatiewinkels
   Slim en Snel
   Woningrenovatie 80%
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1.1. Personal background

In the last decades we have become more and more aware of the impact of global warming on ecological and global environmental change. Extinction of species, decline of harvests, rising water levels etc. have long-term effects that we are not even aware of yet (Minnesma, 2015). The necessity of reducing greenhouse-gas emissions is a self-evident truth that should affect every step we take when designing. My wish and goal for this research and design is to contribute to this reduction and continue a movement that I started during my study when attending the Solar Decathlon.

1.1.1. Prêt-à-Loger

For the past 3 years I have been working with different aspects of sustainable renovation of terraced houses. In the first place as partnership- and construction-manager in the Solar Decathlon Europe 2014 (SDE2014) competition in which the team from Delft University of Technology (TU Delft) proposed an energy neutral renovation of a Dutch terraced house, contrasting with the new build houses of the other universities in the competition. A fifth of the Dutch housing stock consists of 1946-1975 terraced houses; Houses with a high energy bill, suffering from moisture problems and lacking space. On the other hand these houses have certain qualities that are recognised by their inhabitants. They are a typically Dutch typology that most of the Dutch inhabitants have lived in. (van den Dobbelsteen, Jonathan, & Kruizinga, 2015)

The team took a real house as a case study; the house of one of the team-members’ father and grandfather. Every house could have been copied to achieve a technical basis to work from. This house, however, provided the usage data, like experiences and pictures during the 50 years of lifetime. This way, the opinion of the user could be taken into account in the design process. The case study was taken as a basis for a renovation in which homeowners can stay in the house and are disturbed as little as possible. Therefore we chose the name Prêt-à-Loger, ready to live in.

The renovation itself consists of a skin around the house and some internal measures. The Smart and Bioclimatic design (van den Dobbelsteen, 2014) makes sure that local circumstances are optimally used. Roof-, cavity- and crawl space insulation and a mechanical ventilation system with heat recovery and Phase Changing Materials in combination with the skin make the house energy neutral. A smart domotica system controls all installations in the house and gives feedback to the user. The skin itself fulfils different functions at different places. Basically, it can be divided into three elements: The North side (post) insulation, the North-side green roof with Solatubes to improve daylight access and the South-side greenhouse structure. The insulation, heat recovery and green roof are mainly to reduce energy losses through the facades, but the most important part is the greenhouse. This is a smart structure that harvests the energy from the sun to produce electricity, hot water, warm air and even vegetables, while at the same time providing extra space for the dweller. In spring and autumn, the greenhouse can be used as a living space, during winter as a winter garden and in summer it becomes the covered terrace towards the garden. All year round rainwater will be collected for toilet flushing and watering of the garden. The garden and street are even redesigned to create sustainable community spaces, make urban farming possible and upgrade the overall value of the neighbourhood.

Fig.1 Prêt-à-Loger Prototype during the Solar Decathlon Europe 2014 in Versailles, France. Source: Prêt-à-Loger

Fig.2 Prêt-à-Loger logo. Source: Prêt-à-Loger

Fig.3 Climate scheme winter Prêt-à-Loger. Source: Prêt-à-Loger

Fig.4 Impression of implementation of Prêt-à-Loger on a bigger scale. Source: Prêt-à-Loger
We won five prices during the competition: a first price for sustainability, based on the teams complete and thorough perspective on sustainability and the translation into all aspects of the competition. Other prices are a first price for communication and social awareness, a second for energy efficiency, a second for construction management & safety and an overall third place. Last year another price was won: The Student Inspiration Award of the TU Delft, a prize for TU Delft students or alumni who have inspired other students with their work. After the competition the house was rebuilt at the TU Delft campus to serve as demonstration model for sustainable renovation and as research and education object.

From the moment that the house has been rebuild I have been student assistant to organise all events in and about Prêt-à-Loger, provide maintenance on the systems and give tours, presentations and workshops about the project. Over the past 1,5 years, this has given me the unique opportunity to be in the house and experience in real life what it is to live in a net zero energy home, what it is to maintain it and what the reactions are from visitors.

1.1.2. Startup
After the competition I have made an attempt to make the Prêt-à-Loger concept into a marketable product with four other students in the startup DENNIS Positive Living. With this startup we have participated in the deal Stroomversnelling Koop in which 175 parties (local and national governments, banks, housing associations, local and national government, Energiesprong, etc.). One of the companies I’ve been in contact with is Reimarkt. Reimarkt, a start-up by KAW architects and foundation KUUB, is a renovation store with several shops, where homeowners (private owners and housing associations) can buy of the shelf energy saving renovations for terraced houses. The one-stop-shop concept with physical stores works very well, since homeowners have one contact for all their questions and requests. Part of the concept is that after a renovation is done, Reimarkt converts (some of) the houses into Pop-up stores to give neighbours the opportunity to experience the renovation on a house similar to theirs (Figure 5).

A next product that Reimarkt wants to develop is the Net Zero Energy Renovation. With Prêt-à-Loger and the start-up I have worked on exactly that. Therefore Josien Kruizinga (former Design Manager of Prêt-à-Loger) and I have approached Reimarkt to continue working on that. Part of my graduation research will be done as internship at Reimarkt. The design phase will be part of a Reimarkt pilot phase that we have set up at Reimarkt with several companies, municipalities, housing associations and homeowners.

The development of net zero energy renovation concepts seems to be a struggle for everyone and my goal is to develop my knowledge about this market further in order to come up with a concept that is really viable and that can be sold in the Reimarkt stores. The process of achieving that can be found in this report.

1.2. Problem statement
1.2.1. Energy Policy in the Netherlands
The Dutch government has implemented a policy for energy use reduction since the energy crisis of the seventies. The Netherlands Environmental Assessment Agency (Planbureau voor de Leefomgeving) has evaluated this policy in order to come up with improvements to meet existing targets (Vringer, van Middelkoop, & Hoogervorst, 2016). Vringer et al. (2016) conclude that the energy use reduction in the build environment is not going fast enough: the expected reduction from 2008-2020 (with 82 petajoule) results in a total of 521 petajoule but should be 507 petajoule. CO2 levels are expected to lower to 24,7 megaton by 2020 but should be lowered to 22,5 megaton. Amongst
other things, they further conclude the following points:

- In order to meet the targets, especially improvements in the existing building stock are necessary, mainly because the volume of new build houses is limited in the Netherlands.

- Possibilities to increase energy savings in the existing building stock are to focus on "continuity and predictability of policy strategies, understanding that refurbishments are emotionally charged and understanding that financial considerations are important but not always decisive”.

- For privately owned houses, energy improvements are progressing steadily. Owner-occupiers improve their homes step by step. However, to meet targets, more binding policies are necessary.

- Housing associations are willing to improve their building stock, but face challenges in financing the renovations and support from their tenants.

- Current energy saving policy is vulnerable for changes in energy prices because financial advantages are less when energy prices decrease.

These points form the context of my research and are important to keep in mind.

1.2.2. Four drivers for implementation of new technology

Since a few years, a new initiative to research and showcase sustainable innovation exists at the Delft University of Technology. The Green Village, which is also home to the Prêt-à-Loger prototype, wants to “create a sustainable, lively and entrepreneurial environment where one can discover, learn and show how to solve society’s urgent challenges” (Van Wijk, 2013). In one of the requests for funding of The Green Village, Weishut (2015) explains that four drivers are needed to implement new technology into the market: Technology & Systems, a Business Model, Legislation and Market appreciation (Figure 6).

“Weishut explains that without market appreciation a successful introduction of “potential paradigm-shifting innovation” cannot happen. He also explains that often new technology is not anticipated in current legislation. It is clear that ‘paradigm-changing co-creation goes beyond what we usually mean by co-creation’; all of the four drivers are important.

Weishut (2015) also describes that it is not hard for tech startups to come up with innovating technologies or the accessory business model. Even regulations are not the main barrier for being successful. Often it is the most difficult to make the technology visible for the potential market (F. Moran, 2011). The market appreciation is then the main barrier.

In some examples we also see that legislation can be a barrier. Uber and Airbnb are examples of companies that are trying to implement new technology into the market. In both of the cases you see that the Technology, Business Model or even Market appreciation are not the limiting factor, but Legislation. Giebels (2014) explains that “legislation is grafted on existing, conventional technologies and is therefore not able to adapt to innovation”. In these cases, in order to deal with innovation, new legislation has to be made.

All in all we can maybe state that in general, for new technology, the driver Technology is always present. For the other three drivers, Business model, Legislation, or Market appreciation, it might be the case that one is missing, which results in the fact that “a potential paradigm-shifting technology won’t be fully exploited” (Weishut, 2015). I believe that this is also the case for Net Zero Energy Renovations (NZER) in the Netherlands.

Net Zero Energy Renovation (NZER) concepts in the Netherlands

Over the last three years, while doing the Prêt-à-Loger project, startup and internship, I have been closely involved in another paradigm-shifting innovation: The Net Zero Energy Renovation (NZER).

Since a few years, the government in the Netherlands tries to encourage the development of so-called “Nul-op-de-meter” (net zero energy) renovation concepts for terraced houses. The Energiesprong (elaborate explanation in section 2.3.1) proposes a target price for those renovations of €45,000.- for a complete net zero energy renovation concept for a rowhouse in the private sector (Energiesprong, 2014a). Based on current construction methods, this price is hard to achieve and most builders doing a pilot now are getting a subsidy (En-
ergiesprong, 2014b) and still do not manage to create a revenue out of the project. The cost of the pilots are still estimated to be around €70,000.- (Finance Ideas, 2015). However, it should be noted that costs for NZERs are decreasing and further up-scaling of the technology which is expected to contribute to lowering costs is not yet happening.

Concerning the four drivers that are needed to implement the new technology that The Green Village describes, we can say the following about the Energiesprong case.

- Since the Energiesprong is a top-down initiative, most of the legislation is present to make nul-op-de-meter renovations possible, and different government parties are working on policy to make saving energy even more attractive (Vringer et al., 2016).

- Technically it is possible to create net zero energy renovations, as is shown by the many pilots that are build so far (Energiesprong) and by the Prêt-à-Loger project of the TU Delft. Of course, this does not mean that technology is not a barrier. The four drivers necessary for the implementation of new technology in the market (1.2.2) are interconnected, and different technology could influence price, user satisfaction or could better fit current legislation.

- The market demand is another complex aspect in the implementation of NZERs. Back in 2014, Van Welzen (2014) did a market research on potential customers for NZER, showing a percentage of 33%. On the other hand, Homemates.nl, a platform that mainly focuses on social aspects as a success factor for sustainable renovation, addresses the homeowner and emphasises the necessity of incorporating and considering the emotional side in major sustainable projects (Tissink, 2014). Van Welzen (2014) shows that there is already a certain market for the NZER product, but at the same time consciously considering emotions and wishes of inhabitants is a crucial factor in the up-scaling and success of the NZER product.

- Concerning the business model: the cost of the concepts / technology is higher than the target price used by the Energiesprong. Based on this, it seems that the current Net Zero Energy Renovations are not feasible.

Of course, the implementation of NZER in the market has many different aspects and could benefit from further research and development in all four drivers (Figure 6). However, previously mentioned points clearly show that especially the market demand and the business model require extra attention. Time prevents me from looking into both aspects. Therefore I have decided to focus on one driver only, and dedicate this research to the business model and feasibility of NZERs. This mainly has to do with my personal preference and the fact that during the Prêt-à-Loger project we have focussed a lot on technology and market appreciation and with a lesser extend on feasibility and I would like to learn more about that. The consequence for this research is that I will not address barriers for other drivers and just focus on financial factors.

I understand, like Vringer et al. (2016) also concluded, that financial considerations are important but not always decisive. Research into the three other drivers: Technology, Legislation, and Market demand are as important as research into Feasibility. A business model can not exist without these.

1.2.3. Cost versus Benefits
In this report I assume that in the case of net zero energy renovations, an investment is attractive for the owner-occupier only when that investment is lower then the benefits that this investment generates in the sense of direct and indirect revenues. So, we can say that the target price of a renovation should be lower than, or at least equal to the cost benefits in order for it to be attractive. This means that being able to quantify cost benefits is very important and I will therefore spend a large part of my research on this topic (chapter 3).

This also means that current concepts aren’t necessarily too expensive. In the case of the Energiesprong there are four options: (1.) The cost of the technology is too high and can be reduced to match the target price. (2.) The benefits of the renovations are not estimated correctly and the target price could be higher, (3.) a combination of option 1 and 2 or (4.) the investment for net zero energy renovations is really higher then the benefits, and NZERs are therefore unfeasible.

1.3. Research goal
To be able to develop a successful product, I think that designers should take into account all four drivers of implementation of technology
(Section 1.2.1) from the very beginning of designing. However, based on the problem and my preference described above, this research will focus mainly on the **business plan (costs)** and **defining the financial value of NZERs** since this seems to be one of the barriers for the net zero energy renovations. Also, this research will stay confined to the terraced houses build between 1946-1979 in the Netherlands.

During my experience with Prêt-à-Loger and the startup, I have learned a lot about designing and building net zero energy renovations and the process around it. The process of learning and experiencing has taken some years and my goal is therefore to structure these learning points together with learning points from other case studies that I will encounter during the research into a clear step-by-step approach, so that people who want to renovate their terraced house, or designers who want to design such a renovation, have a clear **framework** on how to do so. The decision framework will provide a basic knowledge to build on and prevent them from having to do the same research. Because of time limits, this framework will be largely based on my experience and only partly on research. This means the product will not be comprehensive and complete, but a starting point and a literal framework in which further research can take place.

Therefore, the goal of my research is to (1.) define the benefits of a net zero energy renovation and express that in costs and (2.) provide a framework for the design of net zero energy renovations based on costs and learning points. To test the framework I will run an improved Prêt-à-Loger inspired design through it. The result should be a design for an NZER that is viable. The benefits of the renovation expressed in cost can be used as the target price for the renovation. This target can be compared with the actual cost.

### 1.4. Research Question

The overall goal of this research is to create a net zero energy renovation based on cost bene-
fits. It seems that the relation between benefits and investment for these renovations is not in balance: until now the investment of NZER pilots are higher than the supposed benefits, as estimated by Energiesprong, and expressed by the target of €45,000.-.

Also based on section 1.2.3, this means that it is important to know what the benefits of an NZER are and what the costs of the technology should be to achieve NZER.

The question that should be researched is therefore: What are the cost benefits for Net Zero Energy Renovations in the Netherlands and how can they influence design decisions? Only financial aspects will be taken into account when answering this question. Because of the scope and type of houses discussed in the problem statement, the research will focus on Dutch terraced houses.

1.5. Approach & Methodology

1.5.1. Approach
The approach for my research is influenced by my assumption in section 1.2.2 that current renovation concepts are not feasible. The research design can be found in the scheme in Figure 8. From this scheme you can see that in order to answer the research question, the research is divided in four themes and subquestions. These questions will be answered using different methods, resulting in different products.

1.5.2. Themes
The four themes I will deal with in the research are (1.) Net Zero Energy Renovations, (2.) Value, (3.) Costs, and (4.) Learning points. All of these themes are accompanied by a subquestion.

1.5.3. Subquestions
(1.) What are the costs of current Net Zero Energy Concepts? (2.) Which aspects determine the value of NZERs?, (3.) What should an NZER cost? and (4.) What can we learn from current concepts, experience, and existing research?

Question 1 will be answered by making an overview of all Zero Energy pilots that are done so far. Of those pilots I will make a reasoned selection of case studies (based on approach, whether or not it is a renovation, the design-elements, and the degree of energy savings). For this selection I will make an analysis of the costs which will result in a cost ratio per product group.

Question 2 will result in an overview of cost benefits.

To answer question 3, a calculation model is made based on the overview of question 2. The outcome of this calculation model, (together with the result of question 1) will result in a target cost for the design.

The target, together with the outcome of question 4, will be translated into a decision framework that will help set up a preliminary design. This preliminary design will form the basis for the Final Design. In the reflection the costs of this final design can be compared to the target cost that resulted from the calculation model.

This comparison will tell whether the design is attractive or too expensive: if the costs are equal to or lower than the target, it means that the design of the NZER is attractive, but if the costs are higher than the target, it means that the design is too expensive (Figure 7).

1.5.4. Methodology
Case study research, Literature study, and Research by design are the methods that I will use to answer the research question and create the different products of Figure 8.

The first way to achieve the research goal is studying the concepts that are currently build in order to learn from them. A lot of the concepts build right now are a result of the Energiesprong. Some of the concepts developed within this program will be looked at to reflect on the costs.

Another reference project will be the Prêt-à-Loger project. This project is done from a technical and market demand point of view, (almost) without looking at current boundaries of legislation or financial structures. Therefore, this project will be especially helpful to reflect on technology.

Literature Study
A lot of literature can be found on all of the different subjects. A list of literature that is used can be found in chapter 8.

Research by Design
Another method that is used is research by design. According to Research (EAAE/AEEA Research Charter, 2016), the definition of Research by Design is the following:

“In architecture, design is the essential feature. Any kind of inquiry in which design is a substantial part of the research process is referred to as research by design.

In research by design, the architectural design process forms a pathway through which new insights, knowledge, practices or products come into being. It generates critical inquiry through design work. Therefore research results are obtained by, and consistent with experience in practice.”

The preliminary design will result in more questions or solutions forming a pathway through which new insights, knowledge, practices or products will be gained.
1.5.5. Products
A list of the products belonging to the research framework and the goal of these products can be found in the next subchapter (1.6).

1.6. Products
The goal of the research is to create a product. But the process of researching will create several products as well. The first product needed is an overview of existing zero energy terraced house pilots. The second research product is an overview of cost benefits. The third product is a calculation (model) to determine the value of a net zero renovation. The fourth is a decision framework that will form the basis for the preliminary design. All of these products will result in a final technical design.

1.6.1. Overview of existing rowhouse pilots
All of the Zero Energy Concepts, both renovations and new-build that I encounter during my research, will be documented in this overview. As much information as possible about the pilots or concepts will be added.

1.6.2. Overview of cost benefits
This overview will list all factors of a net zero energy renovation that define value for the homeowner. Examples of such factors are Energy Savings, Value Increase of property, Changed maintenance costs, etc.

1.6.3. Calculation (model) for value of net zero energy renovation
This model will look at all the factors described in the previous paragraph and show how these factors relate to each other.

1.6.4. Decision Framework
During my experience with Prêt-à-Loger and the startup I have learned a lot about designing and building net zero energy renovations and the process around it. The process of learning and experiencing has taken some years and my goal is to structure these learning points together with learning points from other case studies that I will encounter during the research into a clear step-by-step approach that people who want to renovate their terraced house or designers who want to design such a renovation can use. This step-by-step approach will form a decision framework. The framework will provide basic knowledge to build on and prevent them from having to do the same research.

To make the decision framework work for as many people and as many different houses as possible, it should be as general as possible.

In short, we can say that the framework is a general methodology for renovation of terraced houses based on my experience with net zero energy renovations, based on the case studies, and based on all other research or background information I encounter.

1.6.5. Preliminary Design
The decision framework will form the starting point for the redesign of the Prêt-à-Loger renovation. This design is made in collaboration with the Reimarkt consortium.

1.6.6. Final Technical Design
The most interesting product group to elaborate on from a Building Technology perspective is the installations and how they function within the climate design of the renovation. This is what I have worked on in the final design.

1.7. Planning
The scheme of Figure 9 shows the planning I have used during my graduation. The first 6 months consist of my graduation in which research would be done, a preliminary renovation design would be made, and a final design for a specific element would be constructed. My graduation is combined with an internship with the goal to use the results of the research and the preliminary design to develop a product that could be sold on a large scale. The planning has been delayed a bit due to the amount of research that had to be done, but the result is a product that can be found in chapter 5.
1.8. Relevance
The research as described in this report is relevant in different aspects. Both society and science can benefit from it. The research can also be seen in a larger framework of ongoing research.

1.8.1. Societal Relevance
A large part of the Dutch housing stock (1.4 million terraced houses) have a large energy consumption causing an unnecessary financial burden on homeowners as well as a burden on our environment. Housing associations also have to deal with the fact that the high living costs (rent + energy) makes hiring these houses unattractive to their customers. Solving the demand for net zero energy renovations will solve these problems (Prêt-à-Loger, 2014). This demand for net zero energy renovations is not only found in the Netherlands but in more countries in Northwestern Europe with terraced houses like Germany, Great Britain, Belgium and parts of France.

1.8.2. Scientific Relevance
In recent years, there has been a growing interest in NZERs (partially thanks to the Energiesprong), and as described in the problem statement of subchapter 1.2 there are still important aspects that require extra attention: Market appreciation and the business model. The focus of this research will be on the business model. The model that will be created to calculate the value of (Net Zero) Energy Renovations is something new and something that can contribute to the awareness and knowledge of NZERs. Understanding the financial value of a certain renovation is the basis of product development and price definition.

1.8.3. Practical Relevance
The research that I will be doing will partly be done as an internship in collaboration with Reimarkt. The way in which my research can be used by Reimarkt shows the practical relevance.

My work at Reimarkt roughly consists of two parts. First, the work on the technical design of the Nicer Home concept, and secondly, the work on the financial value of NZERs. The practical relevance of the technical design is that with this design a concept can be developed that can be sold in the Reimarkt stores. The relevance of the calculation model for financial value can be found in the proposition towards clients and especially housing associations. With the model, Reimarkt can show what the value is of the different concepts that they offer. This gives housing associations the opportunity to create a complete TCO calculation, and make decisions based on the complete picture.

1.8.4. Link to ongoing research
This research is embedded in the research programme of Green Building Innovation of the Department of Architectural Engineering + Technology. Green Building Innovation focuses on urgent societal challenges for the built environment, in particular ‘carbon neutrality’, ‘circularity’ and ‘adaptivity’ (to climate change and dynamic boundary conditions of user and environment).

Energy transition of the built environment is an urgent theme, and most research projects focus on new construction, whereas the greatest challenge lies in adjusting the already existing building stock. Within GBI, several research projects have been conducted to support the energy transformation and renovation of existing buildings, such as REAP (City of Rotterdam), Leidraad Energetische Stedenbouw (City of Amsterdam), City-zen (EU FP7), and recent heritage-based studies, such as Beyond the Current. The Prêt-à-Loger project for the Solar De-
1.9. Information sources
The four subjects of my literature study (sub-chapter 1.5, Fig. 8) are partly based on interviews with parties involved with the development, research, or monitoring of the subjects, or parts of it. The parties I have consulted during research (besides my mentors) are listed in Figure 10.

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<td>Harry Bourneester</td>
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<td>The Green Village (TGV)</td>
<td>Jaron Weishut</td>
<td>Director TGV</td>
<td>consulted</td>
</tr>
</tbody>
</table>

Fig.10 Information sources I have consulted. (own illustration)
2. Research Background

2.1. Scope
The scope of this research is limited to the (1.) renovation of (2.) terraced houses in (3.) the Netherlands build between (4.) 1946-1979. There are a few reasons for this.

1. The discussion about whether we should demolish or renovate is something that is getting less and less attention in the building sector. André Thomsen (2009) explains that from a sustainability point of view, life cycle extension is often a better solution than demolition.

2 & 4. The choice of typology has to do with the nature of the case studies. The Prêt-à-Loger project has confined itself to the postwar terraced houses, since this is the most common typology in the Netherlands with the highest energy reduction potential.

3. The reason for limiting the research to the Netherlands has to do with the following. Some casestudies that I have selected are part of the Energiesprong. In consequence to this government initiative, a lot of attention is given to Net Zero Energy in the Netherlands, resulting in pilots, adapted legislation, and interested homeowners and housing associations. Altogether, this creates an environment in which a lot of interesting developments can take place. More about Energiesprong and the reaction of Urgenda on this can be read in subchapter 2.3.

2.2. Market

2.2.1. Target groups
One important aspect of product development is knowing your target groups. A lot of research has been done by several parties into the difference between target groups for energy saving measures and the value of (research into) this differentiations for housing research (Ouwehand & Doff, 2011). One of the most renowned is the Mentality model of Motivaction. Contrary to traditional divisions where people are divided based on socio-demographic and socio-economic variables, Motivaction divides people based on attitude to life (Lampert & Schoemaker, 2016). According to their model, the Netherlands knows eight different lifestyle categories which can be found in Figure 11 and 12. The advantage of this model is that people are grouped based on their social classes, not on their age, gender, education, or income, resulting in a better explanation and understanding of behaviour (Lampert & Schoemaker, 2016).

2.2.2. Target groups Reimarkt
Since I will be doing this research as part of my internship at Reimarkt, I will use a division of target groups for my research that is used by Reimarkt with the advantage that the outcome can be used directly for Reimarkt product development. Similar to the Mentality model of Motivaction, this Reimarkt division is not based on socio-demographic or socio-economic variables but on the goal of the homeowner with the renovation.

At Reimarkt, 4 different types of inhabitants are distinguished based on their goal for the renovation (Figure 13). This division mainly has to do with the marketing strategy and how to approach possible clients, not so much with the product (Reimarkt.nl, 2014). It can still be the case the product that is sold in the end is the same for all target groups.

In this research I use this differentiation of target groups to come to a more precise calculation of the netto value of a renovation. The reason for that is the value of a renovation is dependent on what an owner wants with it.

<table>
<thead>
<tr>
<th>Lifestyle category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional citizens</td>
<td>Moralist, conscientious and status-quo-minded middle class that stick to traditions and material possessions.</td>
</tr>
<tr>
<td>New conservatives</td>
<td>Liberal/conservative upper social class that is all in favor of technological development, and opposes social and cultural innovation.</td>
</tr>
<tr>
<td>Modern citizens</td>
<td>Conformist status-minded middle class that strives for a balance between tradition and modern values such as consumerism and hedonism.</td>
</tr>
<tr>
<td>Leisure group</td>
<td>Impulsive and passive consumer whose main aim is to have a carefree, pleasant and comfortable life.</td>
</tr>
<tr>
<td>Cosmopolitans</td>
<td>Open and critical cosmopolitan citizens who integrate values such as fulfillment and experience with modern values such as social success, materialism and hedonism.</td>
</tr>
<tr>
<td>Upwardly mobile</td>
<td>Career-minded individualists with a definite fascination for social status, new technology, risks and excitement.</td>
</tr>
<tr>
<td>Post Materialists</td>
<td>Idealists with a critical view of the social structure who want to develop themselves and who take position against social injustice and stand for the environment.</td>
</tr>
<tr>
<td>Post-modern hedonists</td>
<td>Pioneers of the experience culture, in which experimentation and breaking with moral and social conventions are goals in themselves.</td>
</tr>
</tbody>
</table>

Fig. 11 The Mentality model of Motivaction shows 8 different lifestyle categories. (Explanation in Figure 12) Source: Motivaction.nl

Fig. 12 Explanation of the eight lifestyle categories as distinguished in Motivactions Mentality model. Source: Ouwehand & Doff, 2011
The types that are described are (1.) The inhabitant who wants to save energy in order to save money. (2.) The inhabitant who wants to have a nicer home. (3.) The inhabitant who wants to have a bigger house. And (4.) The (older) inhabitant who wants to remain living in his home longer.

1. Energy Saving (Energie besparen)
This group's main goal is to save energy. A financial motivation underlies this goal. This means that short payback times and low investments play a large role. The group consists of starters or homeowners with a lower budget. Sustainability is important but shouldn't cost a fortune.

2. Nicer Home (Mooier wonen)
The main objective for a renovation of this group is to keep enjoying their homes. These homeowners are non-starters or starters that have lived in this house for a while, but either way do not plan to move any time soon. The renovation is mainly focused on implementing their personal wishes but if it will also provide extra comfort, a lower energy consumption and a contribution to a sustainable world that is an extra appurtenance. However, investments in sustainable measures should earn itself back over time.

3. Bigger House (Groter wonen)
This group is similar to the previous with this difference that extra space is a requirement. Expansion of the family or a different use of the house are typical reasons for the renovation.

4. Longer Establishment (Langer wonen)
This last group consists of two types of people. Elderly homeowners, both singles or couples that experience inconveniences of their age, but cannot or do not want to move to an elderly care home. And all other disabled people that fall under the Dutch Young Disabled Persons Act (Wajong). Both groups are supported with an unemployment benefit and sometimes support from local government or municipalities.

There are a few remarks to the use of the target group division of Reimarkt. The division is with 4 classes rougher than the division of Motivaction which, with 8 classes and 39 subclasses, is better suitable for research. The advantage of using the Reimarkt division is that this division is based on the goal for the renovation whereas Motivaction looks at the lifestyle categories. Practically this means that we can directly link a target group to a certain product. In case of the Motivaction division it might as well be that customers of the same social class want a different product.

Another remark is that the Reimarkt target groups are mixed rational and emotional classes. Target group 1, 3 and 4 have completely rational goals whereas target group 2 has an emotional “goal”: a Nicer Home. The result is that when we are talking about an emotional goal we can not expect customers to take rational decisions. This is a point that shows the complexity of the topic and should be kept in mind while reading the further research.

2.2.3. Size of the market
The problem statement states that “current net zero energy renovations are not feasible”. One of the lessons learned from the process research (appendix IV) is that we need to develop renovation products. (The development of products will help lower the cost since the renovations will not be addressed as single project.) However, a condition to create products is to have a potential market that is large enough.

In this subchapter I will therefore research the ability to pay based on borrowing capacity for owners of terraced houses between 1946 and 1979 in the Netherlands. It would be interesting to know the percentage of people that can finance an NZER.

The research is done in collaboration with the OTB Research Institute and is based on information obtained from the Woon Onderzoek Nederland 2012 (WoON2012) (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2013). The information in this research is personal and confidential. I will therefore only present the syntax and output, not the data itself.
Description of the operationalisation

The output that I have generated gives an indication of the size of the market related to the price of the product. Since the WoON 2012 is a sample test and since the price of the product is not yet very accurate to predict I have divided the output of the research in groups of €10,000.-. That way we’ll be able to predict how large the market will be if the renovation will be €10,000.-, if the renovation will be €20,000.-, etc.

The first syntax (Figure 14) shows that from the WoON2012 only the respondents are selected with A. an independent house (NL: zelfstandige woning), B. an owner occupied house (NL: koopwoning), C. a terraced house and D. a house built between 1645 and 1979. For those respondents the following variables are taken: brutohh (income), waarwon (value of the house), restschuld (remaining mortgage debt), LTI (loan to income).
For the following variables some simplifications and modifications have been done:

The LTI is simplified by multiplying the income with 4.5. In reality this number will be higher for the higher income groups and lower for lower income groups.

The assumption is done that maxbesteed = maxfinanc-restschuld. This is a worst-case scenario considering that savings in savingmortgages can not be taken into account and a best-case scenario assuming that a homeowner will take a new mortgage and invest it all in a renovation. However, this is inherent to the calculation that we do: calculating the maximum cost for a renovation.

The LTI is actualised for 2015 since the data is from 2012 and inflation has to be taken into account. The LTI15 is the LTI*0.977 based on data from CBS, Statline (2016) (Figure 16).

The value of houses is actualised for 2015 since the data is from WoON 2012. According to CBS (CBS Statline, 2016) (Figure 17) values of houses have decreased to 91.5%.

In the final step the maxbesteed is divided in 22 classes: <€0.- (mortgage is higher than property value), €0.- - €200,000.- in steps of €10,000.-, and >€200,000.-. Then the size of the groups is determined, resulting in a percentage. This percentage is the percentage of people that can afford a certain amount of money, the percentages of all classes above are added.

### 2.2.4. Conclusion

The result of the research is the table of Figure 19. It shows the 22 categories with the corresponding percentages. The estimated cost of an NZER of €70,000.- (Finance Ideas, 2015) would correspond with class 15: €60-70k (Figure 19) showing that at least 74.9% of all private owners of terraced houses 1946-1979 in the Netherlands would be able to finance this renovation with a new mortgage!

Similarly, if we fast forward to subchapter 3.4 and fill in the values of the renovations for the target group of “Nicer Home” of ±€77,000.-, assuming that the cost of the renovation would equal the value, this would show a potential market of 72.5%.
The first reaction that I received when I showed this numbers to some people working in the field of sustainable renovation were that these numbers seem too positive. One of the arguments was that one third of all private houses have underwater mortgages as is calculated by CBS (Pouwels-Urlings & Nieuweboer, 2014) which means that the 10.1% (Figure 19, class 22) I calculated is already too low. However, I think that there are a few possible explanations for this apparent discrepancy.

- In the first place the numbers of CBS about the percentage of households with underwater mortgages are an approximation as well. Not all banks have provided information about the mortgages they have given. And even banks do not always know all details about the mortgage they provide, for instance in case of a life insurance mortgage where information about the height of the savings mortgage (NL: spaarhypotheek) is only known by the insurance company. From this point of view the outcome of my research will probably be even more positive in reality.

- The calculation of CBS does not necessarily prove my outcome to be wrong since we are discussing a different selection of houses. Whereas CBS takes into account all private houses in the Netherlands I only considered the terraced houses build between 1946 and 1979. This means that there are also more homeowners in this selection with a longer occupancy duration which means they have bought their houses before the crisis and have experienced a longer price increase then decrease. From Figure 20 (CBS Statline, 2016) you can read that the price-index of private houses in 2015 is equal to 2004. This means that home owners in WoON12 (the numbers are actualised for 2015) that have bought their houses before 2004 are probably not under water. Also because they have a longer occupancy rate they have paid of a larger part of their mortgage resulting in a lower mortgage debt.

All in all we can conclude that the calculation for the market size is always an approximation, even though all values I’ve taken into account are the worst case scenario. The numbers that came out can now be used to calculate the potential market. However, these numbers have to be used carefully. Whatever a homeowner can afford is not equal to whatever a homeowner wants to afford. This willingness to pay (Van den Berg, 2015) has everything to do with the nature and specifications of the renovation.
2.3. Case Study

In the last few years a lot of net zero energy houses are built. Partly as renovations of existing houses stimulated by the Energiesprong or Urgenda and partly new-build. The different pilots have different approaches, different goals and different costs. But they have in common that all designs are improving the energy balance of the house. Most of them are a combination of renovation and net zero energy, some of them only a renovation and some of them only net zero energy.

The goal of this subchapter is to outline the framework in which NZER are happening and give insight in some initiatives. The information gathered in this chapter will also provide the necessary cost information that will be used in subchapter 3.5 to create the cost ratio.

2.3.1. Energiesprong

The Energiesprong is an innovation program of Platform31 in which the goal is to create a large market demand and supply for buildings without an energy bill in the Netherlands (Energiesprong, 2015). Because of its succes Energiesprong is extending so that Net Zero Energy Refurbishments will become an international reality with Transition Zero in the UK, France and The Netherlands (Energiesprong, 2014c).

Within the Energiesprong different initiatives take place. The ones that are relevant for this research are the ones related to terraced houses; Stroomversnelling Koop (Buy) and Stroomversnelling Huur (Rent). From 2015 these will be merged into the Brede (Broad) Stroomversnelling. An explanation of these and more (less relevant) initiatives can be found in appendix I.

The Stroomversnelling Huur Deal as described by the Energiesprong (Energiesprong)

“Energiesprong brokered a deal between housing associations and builders to refurbish 111,000 houses to Net Zero Energy (E=0) levels in the Netherlands. E=0 means, annually a house does not consume more energy for heating, hot water, lights and appliances than it produces. The refurbishments are financed of the energy cost savings; a refurbishment is executed within 10 days and comes with a 30-year energy performance warranty from the builder.

The approach is based on organizing massive demand for a Net Zero Energy (E=0) refurbishment proposition, making financiers and governments tune their financing offerings and regulations towards this product and challenging the construction sector to start an ambitious innovation process to deliver the proposition. The massive demand, the security that there will be financing and an enabling regulatory environment de-risks the innovation investment –based on developing an industrialized product- for the builders. Currently, Energiesprong is progressing into bringing these solutions to the private homeowner sector through a recent deal with 175 parties (including local and national governments, banks, real estate surveyors and builders) to align the market conditions for this housing segment.”

Businessplan Stroomversnelling Koop

The Stroomversnelling states that the ideal price of a net zero energy renovation is €45,000.-. They arrive at this number by using the €175.- average energy bill of inhabitants of terraced houses between 1950 and 1980 to pay of a mortgage over a period of 30 years.

With this price the cost for the separate elements of the renovation should be as can be seen in Figure 21 (Hasselaar, 2014) But all the cost overviews of the pilots I have collected show that none of the concepts reach this price yet. I believe that this is mainly because cost is usually taken as a main criteria by builders to decide which renovation measures will be taken. This can also be read from the fact that most concepts have similar approaches: almost all renovation concepts consist of post-insulation, heat pump, ventilation heat recovery system, PV’s and sometimes minor additional measures.

2.3.2. Urgenda

Urgenda is an organisation with the goal to make the Netherlands more sustainable. They do this with a clear action plan. One of their themes are energy neutral houses and within this theme they have a focus on the heating of houses without fossil fuels.

In their brochure “Ons huis energieneutraal!” Urgenda (2015) shows that average houses can be made energy neutral with an investment of €35,000.- “the average amount an average Dutch family spends on energy in 15 years.”

![Fig.22 Screenshot from Urgenda Brochure. “This €35,000.- is the amount an average Dutch family spends on energy in 15 years.” Source: Urgenda](image)

In my opinion the work that Urgenda does is very important, however, the point with “their” renovations is that they just focus on the energy use and payback period of 15 years. The complete energy consumption of the house (gas and electricity) will be supported by new installations that are chosen based on their cost/kWh.
In practice this means that the Urgenda renovations make purely use of new installations.

From the perspective of Trias Energetica developed at the TU Delft (Duijvestein, 1996) the way to approach a (renovation) design would be to first reduce the consumption of the house before looking into production (Figure 23). In practice this would mean that the first steps of a “good” renovation would be to focus on insulation, air-tightness and heat-recovery before investing in PV-panels, heatpumps and other installations.

The result is that Urgenda’s zero energy renovations are cheaper on paper, but reality is that the lifetime of installations is usually up to 15 years which means that the investment of €35,000.- will need to be done every 15 years. Concepts that are developed with the more passive approach of Trias Energetica however, consist for a large cost percentage out of passive measures (insulation) that will need less maintenance and have a larger life-expectancy then active measures (installations) and are therefore more cost-efficient in the long-term.

Prêt-à-Loger, also described in subchapter 1.1 is one of the examples that are developed with this New Steps design approach. Among the most important features are thermal insulation, an efficient PCM stabilised ventilation-system and a smart solar glasshouse (van den Dobbelsteen et al., 2015). This example shows best the approach that I would consider as the ultimate goal for a renovation in this research.
would be best to only select the representative renovations to base the cost ratio on. This would mean that for instance new build houses, renovations done by Urgenda or renovations that are not completely net zero energy would be left out.

On the other hand it turns out to be hard to get cost information about pilot projects, for most builders this is confidential information. Therefore I will make a selection of relevant product groups. This will give the possibility to use all cost information that I have to create an approximation of the “ideal” cost ratio.

For now I have gathered cost information from the Prêt-à-Loger project and several Reimarkt projects. But with more information the approximation of the ideal cost ratio would become more accurate.

### 2.3.6. Cost of current concepts

Cost specifications of the pilots that are done are not available. However, the prices for complete concepts are collected by the website Woonconcepten.nl, an initiative of Energiesprong. I have collected the prices of all concepts that are renovations, that are NZE and that sown a price. This gives quite a good impression of the cost of the current concepts.

Figure 27 shows that the average price of these concepts exceeds €75,000.--.

As a remark it should be said that only one of these concepts has been build. This means that all other costs are not proven in practice. The concept that is build in practice is the Activehouse concept of €130,000.--!

#### 2.3.7. Conclusions

Around 30 different pilots are analysed, but especially for these pilots cost information is hard to acquire. In general it would be interesting for further research to analyse the process, actual price of the different pilots, the different technologies used, the user satisfaction and market demand and the business model behind the concept. By knowing this it would be possible to do a SWOT analysis and make more statements concerning the current NZER market.

From the costs of the concepts from Woonconcepten.nl (Figure 27) it shows that the average cost of the concepts is still 67% higher than the target price of €45,000.--.

For the further research I will only use the available cost information.
2.4. Financial Principles
This subchapter will explain the financial principles I make use of in the research.

2.4.1. Net Present Value.
In this research I will make use of the Net Present Value method a lot. The explanation below is captured from Investopedia (http://www.investopedia.com/terms/n/npv.asp).

"Net Present Value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of a projected investment or project."

The following is the formula for calculating NPV:

\[
NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0
\]

where

- \(C_t\) = net cash inflow during the period \(t\)
- \(C_0\) = total initial investment costs
- \(r\) = discount rate, and
- \(T\) = number of time periods

A positive net present value indicates that the projected earnings generated by a project or investment (in present dollars) exceeds the anticipated costs (also in present dollars). Generally, an investment with a positive NPV will be a profitable one and one with a negative NPV will result in a net loss. This concept is the basis for the Net Present Value Rule, which dictates that the only investments that should be made are those with positive NPV values."

2.4.2. Present Value
The explanation below is captured from Investopedia (http://www.investopedia.com/terms/p/presentvalue.asp).

"The current worth of a future sum of money or stream of cash flows given a specified rate of return. Future cash flows are discounted at the discount rate, and the higher the discount rate, the lower the present value of the future cash flows. Determining the appropriate discount rate is the key to properly valuing future cash flows, whether they be earnings or obligations.

Also referred to as "discounted value."

The PV formula in excel would be:

\[
T=(a)/((1+i)^n-1))
\]

2.4.3. Future Value
The explanation below is captured from Investopedia (http://www.investopedia.com/terms/f/futurevalue.asp).

"The value of an asset or cash at a specified date in the future that is equivalent in value to a specified sum today. There are two ways to calculate FV:

1) For an asset with simple annual interest: = Original Investment x (1+(interest rate*number of years))

2) For an asset with interest compounded annually: = Original Investment x ((1+interest rate)^number of years)"

2.4.4. 106% LTV
The LTV for normal mortgages is currently 102% and will be reduced to 101% in 2017 and finally 100% in 2018. For Net Zero Energy renovations this percentage will stay 106%. (Blokh, 2015) Ministerial arrangement mortgage credit.

2.4.5. Ministerial Arrangement Mortgage Credit
The ministerial arrangement mortgage credit is a rule that states that the financial burden of a mortgage can be €9,000.- higher for houses with a A++ energy label (EPC 0,6) and €27,000.- for net zero energy renovations with a energy performance guarantee (Section 2.4.10) of at least ten years for homeowners with an income of €33,000.- (Dijsselbloem, 2015).

2.4.6. Energysavers Loan (Energiebespaarlening)
The energysaversloan is the loan that residents can get (besides their mortgage) to invest in energy savings measures. This loan can vary from €2,500.- to finance energy savings measures. Other interesting loans or subsidies are provided by SVn (https://www.svn.nl). Different subsidies are provided by SVn depending on location and municipality.

2.4.7. Other rules and subsidies
The Energiebespaarlening (https://www.ikinvesteerslim.nl/energiebespaarlening) is a loan between €2,500.- and €25,000.- to finance energy savings measures. Other interesting loans or subsidies are provided by SVn depending on location and municipality.

2.4.8. Subsidy by municipalities
In the pilot phase of the Stroomversnelling some of the municipalities are giving a subsidy of €15,000.- to encourage Stroomversnelling projects in their municipality.

2.4.9. Energy Performance Compensation (Energieprestatievergoeding (EPV))
The Energy performance Compensations is a rule about the extra "rent" that housing associations can ask from their tenants. This EPV is calculated based on the specifications of the renovation (Coen & Stutvoet, 2015).

2.4.10. Energy Performance Guarantee (Energieprestatiegarantie (EPG))
The EPG is a guarantee for the functional performance of a house(system) (Coen & Stutvoet, 2015a).
3. Target cost for Net Zero Energy Renovations (NZER)

This chapter is dedicated to answering the question what the target cost of an NZER should be. As described in the problem statement (Subchapter 1.2) I assume that in the case of net zero energy renovations an investment is attractive for the owner / inhabitant when that investment is lower then the benefits that this investment generates in the sense of direct and indirect revenues, and as long as they can afford (finance) the investment. (The size of the potential market is investigated in section 2.2.3 to verify this.)

An overview of the direct and indirect cost benefits of the renovation is given in the first subchapter (3.1). The second subchapter (3.2) justifies the size of certain variables that I will use in my model. Subchapter 3.3 explains which formula’s I used behind the model and subchapter 3.4 shows the model itself, with it’s conclusions. Finally, subchapter 3.5 discusses how the investment of different product groups of an NZER that I extracted from the overview (section 2.3.5) should be adapted to match the cost benefits.

3.1. Overview of Cost Benefits

As a homeowner there are a lot of reasons to renovate your house. Some of those reasons are practical, to make better use of space or increase comfort, others have to do with keeping the house up to date and following trends and other reasons are to improve home value or reduce living cost. (André Thomsen, 2002) In this subchapter we will look at all the benefits of a renovation that can be expressed in cost. Specifically related to the Dutch situation. For different homeowners, different aspects will be valued. To make things easier I will differentiate those aspects interesting for private homeowners, and those aspects relevant for housing associations.

3.1.1. Energy Savings

The savings on energy is one of the moneyflows that can be used to pay for the renovation. This moneyflow is extensively looked at by the Ergiesprong (Section 2.1.1) and is relevant for both private owners and housing associations.

The homeowner of the rowhouse that we take into account in this research has an average energy bill of €175.- per month. If the design of the renovation reduces the energy use of the house, these savings can be expressed in cost.

3.1.2. Property Value

Another relevant factor that can be expressed in cost is the increase of property value. The actual taxation is of course depending on the type of renovation and the specific setting of the house but can be estimated using previous valuations or by comparing the renovation to comparable interventions or by having the designed renovations evaluated by an actual broker.

This increase of value is potentially driven by various aspects. Usually increased surface area and aesthetic aspects are main drivers (Taylor, 2014). For net zero energy refurbishments the value increase will also originate in part from the energy savings and changed maintenance requirements. Particularly in respect to components needing maintenance or periodic replacement to keep performance up to a required level, such as ventilation systems, heat pumps or PV panels, the value increase should be calculated carefully. Unlike more permanent components such as insulation, the value of these components is expressed in a reduced energy bill. In the calculation for property value the influence of these components will therefore be neglected.

The increase of property value forms a potential option of realising the renovation through refinancing the house, as long as the income of the homeowner is sufficient. To make this even more attractive Dutch banks are allowed to provide a loan to value (LTV) of 106% for NZER opposed to a 102% LTV for normal mortgages (Blok, 2015).

3.1.3. Maintenance

The difference in maintenance cost between before and after renovation can be expressed in cost. For private owners this is not always a cost that is taken into account when deciding about a renovation. This means that educating private owners about the benefits of a renovation in the sense of reduced maintenance cost can positively affect the businesscase for NZERs. For housing associations maintenance is usually already a standard expense that is calculated in their business models.

What I mean by maintenance in the calculation model are all actions that are necessary to guarantee the performance of the house over the course of the payback period. This has to do with the EPG of section 2.4.9 and can imply that not just actual maintenance is meant, but also replacement of systems or installations if necessary.

3.1.4. Vacancy rate (housing associations)

The reservation that housing associations make for houses that are temporarily not rented is expressed in a loss of rental booking. Exact numbers about vacancy rates are not available but in general it can be said that houses with a better energy label will sell (and probably rent) faster (TIAS, 2015).
3.1.5. Increase of Rent (housing associations)
If a house has a better energy label, bigger surface or lower energy bill, this can be expressed in an increase of rent. This increase is a direct benefit created by the renovation.

3.1.6. EPV (Energy Performance Compensation) (housing associations)
If a house has a better energy performance, this can be expressed in an EPV. The EPV is a rule that allows housing associations to ask their tenants for a certain compensation for the investment they do in the reduction of the energy bill that would normally be paid to an energy service company.
3.2. The size of the different variables

In this subchapter I explain how I arrived to certain values that I used in the calculation model. I will describe those values for the second target group, Nicer Home, since the NZER product for this group is representative for the Prêt-à-Loger concept that I have worked on at Reimarkt in the last months.

3.2.1. Energy Savings

The savings on energy is one of the moneyflows that can be used to pay for the renovation. This moneyflow is extensively looked at by the Energiesprong (Section 2.3.1). The variables used by Energiesprong are:

- Energy bill: €175.-/month
- Paybacktime: 30 years
- Interest percentage: 3.2%
- Energy bills savings: 100%

In my model I will use the same values. The Energy bill of €175.- is an average for owners of post-war terraced houses, The payback time of 30 years and the interest rate of 3.2% are normal values for a fixed-rate mortgage in the Netherlands at the moment (Rabobank, 2016). The energy bill savings need to be 100% for a net zero energy house.

3.2.2. Property Value

Another factor to look at for the financial model is the increase of property value. The actual taxation is of course depending on the type of renovation but can be estimated using former taxations of by having the designed renovations evaluated by an actual broker. (This last step will be done in a later stadium, for now I work with assumptions).

Property Value increase: €37,000.-

This value for value increase is based on a small research that is done about Prêt-à-Loger by the Stroomversnelling. Ten different brokers virtually validated the concept on a house in the Voorhovevestraat in Apeldoorn. The average estimation shows a value increase of €37,000.- (Figure 28).

3.2.3. Maintenance

New installations like PV-panels, heat exchangers and heatpumps will introduce new maintenance costs; these installations have to be replaced or maintained periodically. On the other hand the renovation itself makes up for overdue maintenance. A smart design in combination with the right choice of materials can reduce the cost of general maintenance even more.

General maintenance

The cost for general maintenance differs per housing association and per house. For private owners it’s hard to get a grip on the numbers even though some sources claim a number of €300 - 400.- per month (Vereniging Eigen Huis, 2016) (Figure 29). For now I base this number on a research from TriaCon (2015) which can be found in appendix III. To be able to make a rough estimation I have converted all maintenance elements to 14 year cycles.

General maintenance cost without renovation per 14 years: €8,487.-
General maintenance cost with renovation per 14 years: €6,465.-

Another important factor is the expected cost development for general maintenance. Based on information of CBS Statline (2016) I assume a development of 1% per year on top of inflation (estimated at 2% / year).

Cost development general maintenance: 3% per year

PV maintenance

The cost for PV maintenance is based on cost information from Zonnecomfort (appendix III.II), one of the partnering companies of Reimarkt in the development of the NZER pilot.

Maintenance cost PV per 25 years: €14,673.-

Cost development is still something that needs to be researched, but should be expected to be lower then inflation. For now, based on research from the U.S. government (Feldman et al., 2014) on historical price development of PV I use the -4% parameter. Even though predicting price developments in the future is hard Feldman et al. (2014) seem to agree that prices will still drop significantly.

Cost development PV maintenance: -4% per year

Installation maintenance

The cost for installation maintenance is based on cost information from ITHO Daalderop (ap-
Appendix III.III), one of the partnering companies of Reimarkt in the development of the NZER pilot.

Maintenance cost installations per 25 years: €8,924.-

Cost development is still something that needs to be researched, but should be expected to be lower than inflation. In the model I make an assumption for cost development of -1% per year. This number is not based on literature since as far as I know research hasn’t been done yet. But the assumption is done based on the expectations of professionals in the field that expect the prices to keep dropping in the future. (De Architect, 2015)

Cost development installations maintenance: -1% per year

3.2.4. Vacancy Rate
Housing associations often take into account in their business plan that a part of their building stock will be vacant for a certain time a year. Metselaar (1990) explains the methodology in which renovation of vacant post-war houses should reduce the vacancy rate. Similarly in one of the case studies (Figure 30) high quality renovations are used to reduce retrenchment in areas experiencing population shrinkage (Consortium Zorgeloos wonen Ulft, 2012). If we can assume that the houses have a lower vacancy rate after a renovation this means that housing associations get a higher income.

Reduced vacancy rate: 1%

One of the housing associations that Reimarkt works with handles a reservation for loss of rental booking of 2%. This is meant to cover all lost revenues due to vacancy of the house. Since there is no literature about a reduced vacancy rate after renovation I assume a reduction to 1% after renovation of the house. Because of the goal of Stroomversnelling to renovate houses within 10 days the vacancy caused by the renovation will be neglected.

3.2.5. Rent Increase
The rent increase in the Netherlands is bound to a point system (https://www.rijksoverheid.nl/onderwerpen/verhuurwoning/rent/scoring). It also has to do with the “liberal-
3.3. Formula's

The profitability of a projected investment or project can be calculated using the Net Present Value Method. This method calculates the difference between present value of cash inflows and the present value of cash outflows (www.investopedia.com). In this research the main objective is to calculate the value of the NZER. Since the different in- and outflows differ in time we have to correct for inflation and price increases. We do that by using the NPV method to calculate the sum of the present value of cash inflows of an NZER since this represents the value of the NZER. The investment (the sum of the present value of cash outflows) of an NZER design can then be compared to this value. If the net present value is zero or higher, the investment is attractive.

In this subchapter I will describe how the present value of the cash outflows are calculated.

The calculation of market size (Section 2.2.3) is directly related to this because the final outcome of the research (what the renovation should cost) is input for the market size calculation.

In the calculation I am not taking into account the gross/net traject. This would make the calculation too complex. What I can say is that considering tax would always affect the value of the renovation in a positive way. This means that the actual value of an NZER can be even higher than the outcome of the calculation shows.

3.3.1. Energy Savings

In my financial model I am using the following formula to calculate the maximum height of the loan.¹

\[ T = PV(i, n, (\% \times a), 0, 0) \]

\[ T = \text{loan} \]

\[ \% = \text{percentage of energy bill savings} \]

\[ a = \text{annuity (height of energy bill)} \]

\[ i = \text{interest (/ month)} \]

\[ n = \text{number of periods (months)} \]

An example can be found in Figure 31. The formula would then look like this:

\[ -PV(0.2060\%, 360, (100\% \times €175), 0, 0) = €44,455.00 \]

In this formula I have not incorporated the energy cost increase since there’s not one unambiguous vision about what to expect.

3.3.2. Property Value

The increase of property value can be seen as a way to finance the renovation with a new mortgage, if the income of the homeowner is high enough.

3.3.3. Maintenance

The benefits of a renovation for the maintenance aspect is calculated as a difference in cost without and with the renovation. The cost are simplified to three groups: General maintenance like painting and repairs, maintenance on PV and maintenance on installations. For the three groups it’s important to know the interval in which the maintenance should be done and when the last maintenance has occurred. Other relevant factors are the expected inflation per year, the expected building cost increase per year, the interest percentage of the mortgage

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¹ see section 2.4.2 for explanation of the PV formula.
that is done to finance the renovation (assuming that the maintenance is financed by a mortgage) and of course the cost of the maintenance with and without a renovation.

The explanation of the calculation will be done by means of an example (Figure 32). First the model checks how many maintenances are done within the payback period. The assumption is done that within the renovation all work of a general maintenance is covered. The first maintenance without renovation will therefore start at year 0 and the first maintenance with renovation at year 14 (after 1 interval). In this example without a renovation 3 maintenances would be required within the payback period.

The model then calculates the sum of the maintenance costs by adding the present value (PV) of the cost of maintenance #1, #2 and #3. The PV for the different maintenances are calculated as can be seen in the marked area of the example. First the future value (FV) of the renovation in year 14 would be calculated:

\[-FV(3\%,14,0,18000,0)=\text{€27,226.62}\]

The 3% building cost increase per year means that an assumption is done that building cost will rise 1% more than inflation over the years. After that the payment per year is calculated for a mortgage in year 14. The assumption is done that the payback time of that mortgage is equal to the interval so that the mortgage is paid off when the next maintenance is required. The payment (PMT) per year is:

\[-PMT(2.5\%,14,\text{€27,226.62},0,0)=-\text{€2,328.87}\]

In the next step the PV of a mortgage with a PMT of €2,328.87 in year 14 is calculated:

\[-PV(2\%,14,\text{€2,328.87},0,0)=-\text{€28,193.88}\]

Finally the PV of this PV value will be calculated considering inflation:

\[-PV(2\%,14,0,-\text{€28,193.88},0)=-\text{€21,367.44}\]

The sum of the maintenance cost without renovation is €64,501.56 as can be seen in the marked area of the example. The sum of the maintenance cost with a renovation is calculated the same way. In this example you can see that the maintenance cost over a 30 year period after renovation will be €31,378.94 cheaper.

3.3.5. Rent Increase

Figure 34 shows an example of the calculation for the possible loan based on rent increase. Also for this calculation the present value formula is used:

\[-PV(0.04273\%,300,\text{€2,328.87},0,0)=\text{€3,378.05}\]

In this calculation the assumption is done that rent increase will be corrected for inflation over time.

3.3.6. EPV

The calculation for the EPV is based on literature from the Energiesprong (Coen & Stutvoet, 2015b). The outcome of this calculation shows a certain EPV / month. The assumption is done that the EPV will be corrected for inflation. This number is then used as the annuity in the present value formula as can be seen in the example in Figure 35.

\[-PV(0.4273\%,480,140,0,0)=-\text{€28,531.35}\]

2 see section 2.4.3 for explanation of the FV formula.
3.3.7. Sales
To calculate the final price for the homeowner, we take into account the “investment in next step” This investment has to do with the Dynamic Living. If a customer buys the “step 1. Energy savings” version he or she will pay for the fact that this renovations consists out of no-regret measures. These no-regret measures make sure that if the customer ever wants to upgrade to a Zero Energy renovation, he wouldn’t lose money on the fact that elements that are installed in step 1. Energy savings have to be removed in order to take the next step.

The financial model also shows the amount of VAT and profit that should be considered. The “investment in next step” is added, tax and profit are extracted from the value of the renovation, leaving the maximum netto cost price for the renovation.

3.3.8. Mortgage
The maximum mortgage is calculated according to a normal annuity mortgage. Added to the financial model are the “Ministerie regeling hypothecair krediet” and the “106%” rule (Sub-chapter 2.4). Both introduced to encourage net zero energy renovations.

3.3.9. Additional rules and regulations
This can be found in subchapter 2.4

Fig.36 Example of calculation model for cost benefits of a Net Zero Energy Renovation for different target groups and with a differentiation in public and private houses. The final model can be found through this link and in appendix IV. (own illustration)
3.4. The calculation model
The previous three subchapters come together in an excel model that I created. The final model can be found through this link. A screenshot is shown in Figure 36.

In this subchapter I will look closer at the model that I created and explain the functioning and the benefits. Finally I will explain the conclusions that can be drawn from the model.

3.4.1. Functioning of the model
In the excel a division can be seen. Horizontally the four target groups of section 2.2.2 can be found. All four are divided in a calculation for owner-occupiers and housing associations. Vertically the document is divided in three parts. Every calculation is split up in a calculation of the netto value of a renovation (based on the cost benefits described in subchapter 3.1: Energy Savings, Property Value, Maintenance, Vacancy rate, Rent Increase and EPV), a calculation for sales and a mortgage check.

3.4.2. Benefits of the model
The model was created to calculate the value of a renovation in the first place. Because all of the calculations in the model are based on variable inputs, the benefits of the model are much bigger. The model can be used for the following purposes:

1. General calculation of the financial value of any renovation based on averages, existing research or estimations. Especially focussed on energy saving renovations.

2. Custom calculations of the benefits of a certain renovation on an individual level. The personal situation and wishes of homeowners can be modelled to achieve a personal advise.

3. Designers can get design input from using the model. The design can be optimised to improve the most important variables and increase the financial value of a (renovation) design.

4. The financing possibilities of a homeowner can be calculated on a personal level. It might be interesting for builders / renovationshops to check this before going into the process with a customer.

3.4.3. Conclusions of the model
By adjusting certain parameters of the model I have already learned some important lessons. Based on the financial value of renovations we can conclude or note the following:

- The financial value of energy savings as shown in the model (calculated similarly by Stroomversnelling) does not take into account development of energy prices. Rising prices over a 30 year timespan can influence this value significantly. The outcome should therefore always been considered carefully.

- The property value differences caused by the renovations are still a bit uncertain. In a following research it would be interesting to look into which design elements can influence appraisal. Knowing which elements improve value could influence design decisions. An overview could be made by interviewing brokers.

- Reduced maintenance cost determine a large part of the value of a renovation. Also considering an increased building/maintenance cost in the future (Section 3.2.3), being able to reduce maintenance cost by making a smart design can create value, Especially in case of recurring interventions with a short interval.

- Cost development of PV and installations should be examined. Being able to express the expected cost reduction of PV and installations would provide a more accurate calculation. The model shows that this factors are very important. For example: a price drop of 5% per year would make a €11,500.- difference.

- Exact maintenance cost before and after renovation should be researched on a more general level. The numbers I use now are based on one research. The average maintenance cost for a rowhouse can differ from these numbers.

- Vacancy rate reduction caused by renovations is not researched yet.

- The calculation for EPV is not (completely) related to the fact that a house is Net Zero Energy. The regulation is primarily judging the energy use per square meter, hereby stimulating reduction of energy use before production. This is completely in line with the Trias Energetica (Section 2.3.2).

- The value of the renovation with the parameters as described in subchapter 3.2 shows an outcome for the “Nicer Home” renovation for private owners of ±€77,000.-. This means that the €45,000.- that the Stroomversnelling uses is less then 60% of the total financial value of a renovation.

- The outcome of the model shows what the financial value of the renovation is. However, it should be said that whatever the outcome is, it does not guarantee that the product that is calculated with the model will be sold. In the end the value of the house or the savings on energy are not the only reasons for a homeowner to do a renovation. (Source: experience in Reimarkt and En-
Getting to know which reasons, products or design elements do influence the decision making is of great value for the product development. The graduation research of Derek van de Berg (2015) could give insight in that.

- From the mortgage check it is clear that homeowners should only be considered potential clients when their mortgage debt is significantly lower than the value of their house. The value increase of the house is not enough to finance the costs of a renovation. Also the ministerial arrangement that makes it possible to do an additional loan of €27,000.- for NZER (Section 2.4.5) is not enough to finance the costs. An option would be to do a downpayment for a large part of the mortgage by using savings or a loan other than the mortgage. Another solution would lie with the government to increase the ministerial arrangement mortgage credit or to subsidise the development in another way until the cost of NZERs drop. This would speed up the adoption of sustainable renovations.
3.5. "Ideal" cost ratio product groups

This subchapter explains the product groups, their mutual relationships and what these relationships ideally would be.

3.5.1. Cost ratio

The idea of this subchapter was to create an ideal cost ratio per product group based on a selection of case studies that I would define in section 2.3.5. This selection should be made based on design / idea similarities with the Prêt-à-Loger concept. The Urgenda renovations for instance would not suit this description because of their “all installation” approach (Section 2.3.2). Energiesprong would already better suit the Trias Energetica or New Steps Strategy approach (Subchapter 2.3).

This is why I have contacted multiple sources in the NZER business to get a hold on some cost overviews of pilots that are done within the Energiesprong. Among those sources are different professionals within Energiesprong, my startup coach from Stroomversnelling and former student colleagues who are working at construction companies. All without any success.

The model I have created is therefore only based on three sources: The target of Stroomversnelling (2014b), the cost overview of Prêt-à-Loger (2014) as created for the Solar Decathlon and a cost overview of current (B label) Reimarkt renovations. This means that in theory the model could be more accurate. Still it can be used to calculate the cost ratio.

The division of product groups is based on a division Reimarkt uses (Figure 37) but slightly adapted. To define the “ideal” cost ratio for the Reimark renovation the average cost for every product group is calculated using the three sources. This average cost is also expressed as percentage of the total average resulting in a cost ratio. Of course, the different interventions are not completely representative for the Reimarkt - Nicer Home NZER. Based on the design aspects of this design the prices are corrected resulting in a corrected cost ratio. (How this is done can be read in the next section.)

This corrected cost ratio forms the basis for the targetprices of the different productgroups. The value of the renovation from the table in Figure 36 is inserted in the red cell. In this example the value of the Nicer Home (private) is inserted. This value is then divided based on the ideal cost ratio. The outcome for this example can be found in Figure 38.

3.5.2. Improved cost ratio

The corrections I have made are based on the final design as described in chapter 5. Just the interventions that are comparable with the interventions that we do in the renovation design are considered.
3.5.3. Budget of the Reimarkt - “Mooier Wonen” renovation.

At Reimarkt we are working hard to realise a net zero energy pilot inspired on the Prêt-à-Loger concept: “Mooier Wonen”. With different companies a new preliminary design (Chapter 5) and corresponding budget is produced (Figure 39). The budget shows all the costs that the different partners make. I have translated all these costs into cost per product group to be able to compare the costs with the target of Figure 38. The comparison can be found in Figure 40.

Similar to example described in section 3.5.1, I have inserted the value of the renovation into the red cell. In this case the value of target group 2: Nicer Home is taken: €71,223.23 since this represents best the design of the Reimarkt - "Mooier Wonen" NZER. It is obvious that this target price is not achieved with the budget of Figure 39. The current cost is still 17% higher than the target.

3.5.4. Conclusions

Overall cost renovation

About the overall cost of the renovation compared with the target we can say the following:

- The budget is created based on a preliminary design. Some of the items still have to be adjusted.
- The new Reimarkt - "Mooier Wonen" design will be a first pilot. It is normal that pilot projects will be more expensive in the start phase.

Cost of product groups

About the target prices for the different product groups (Figure 38) it is harder to draw conclusions. Since I have collected cost information for just three sources the outcome of this table should be used with care. Updating the table with more cost information would make the outcome more reliable. However, there are already some conclusions that we can draw from this table:

- The division of the total cost over the different product groups is not very accurate. For quite some products the cost that are described include both material and process cost. Making a distinction between those two is therefore not always possible. This means that the process cost are expected to be higher in reality, all other material cost to be lower. The consequence is that it will not be possible to draw conclusions from the difference in cost for the different product groups.
- Since the numbers are based on real (traditional) pilots we can say that the total price is

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Fig.39 Budget of the Reimarkt - "Mooier Wonen" NZER without profit. Source data: Reimarkt (own illustration)
The value of Net Zero Energy Renovations

Related to the cost distribution over the product groups of the Reimarkt - "Mooier Wonen" concept, we can say the following:

- The cost of the building process is 43% of the total renovation cost. This strengthens my presumption that the building industry should change. A lot of potential to reduce the cost lie in this change (Appendix IV).

- The next big group is again installations. A lot of potential to bring down the cost lies in this product group as well.

- What stands out in the overview of figure 40 is that the cost of sales for the Reimarkt - "Mooier Wonen” pilot is €0.-. This has to do with...
with the agreement that all the cost of sales, including profit will be covered by the consortium. The consequence is that the cost of the renovation including these costs would be even higher.
4. Framework

4.1. Explanation Framework
During the Prêt-à-Loger project, as well as during the development of the startup, my internship at Reimarkt and during my graduation research I have learned different things about the development, technologies, design, construction and deconstruction of net zero energy renovations. All these learning points form a background knowledge that a designer will make use of while designing. It would cost another graduation research to prove and substantiate these learning points. That is why I will mention them without reasoning why.

The list of points will also form a basis for the design. At Reimarkt we have worked on a further development of an NZER concept during the last 6 months. The result is in the first place based on the Prêt-à-Loger concept but also partially based on the findings of this research and the learning points. The learning points will explain the development and design of the product that can be found in chapter 5.

The learning points can also be valuable for anyone that wants to go into the process of renovating his/her house or into designing NZER. That is why I have created a set-up for decision framework with all the aspects of an NZER that should be taken into account that I could think of. The presented framework is not tested and therefore not final. It’s partly based on research but also on assumptions and experience. This means that it can be that elements are missing or that the presented order of elements is not correct.

4.2. Learning points

4.2.1. Learning points based on other concepts
Renovation concepts that are build till now are also pilots. All of those pilots have learning points that I could take into account when designing.

Regarding Finance:
- All of the renovations are above the proposed €45,000.- of the Energiesprong. However, prices have been gradually reduced over the past years and up-scaling of the concepts hasn’t happened yet. This means that eventually these prices could be reached.
- Usually cost is taken as a criteria to decide which renovation measures will be taken. My assumption is that the Energiesprong Businessplan as described in section 2.3.1 is responsible for that.

Regarding Aesthetics:
- Regarding the pilots developed within Energiesprong we can say that most of the focus has been on technology and cost and to a lesser extend on aesthetics. However, the question is if aesthetics are decisive for homeowners that are looking to buy a renovation.

Regarding Technology:
- Almost all renovations consist of the following components: post-insulation, heat pump, ventilation heat recovery system, PV’s and sometimes minor additional measures.
- The location of new installations is an issue.
• Inside insulation is sometimes used, decreasing the surface area.

• Some renovations are complete sets of measures including things like douchetimer, water saving showerheads, stand-by killers, lighting with movement sensors, LED, hot-fill connections and domotica systems. However, most of them give the impression to be a collection of measures put together without actually working together.

4.2.2. Learning points based on experience
While doing the Prêt-à-Loger project I have learned a lot. These learning points, positive and negative are valuable when designing.

• The glasshouse is one of the expensive parts. We should research a shape in which cost can be reduced but the climate effect will remain. (Figure 41)

• An addition like a greenhouse is something that customers have to experience. I have noticed that visitors of the Prêt-à-Loger prototype are always enthusiastic about the greenhouse when they are inside. This does not say that greenhouses are undoubtedly the best solution. (See section 4.2.3)

“A lot of times, people don’t know what they want until you show it to them.”
-Steve Jobs-

4.2.3. Learning points based on other research
All the research I have done into aspects of Zero Energy Design, even though I have not elaborated all of it in the report, will be taken into account.

• In the nineties several sustainable neighbourhoods are build with greenhouse-homes. In many of the cases there have been problems with these houses in the sense that homeowners have been knocking out walls between house and greenhouse/conservatory to make use of the extra space all year round. This undermined the intended energy savings making the energy consumption of the house even worse.

• At Reimarkt we distinguish different target groups. There’s not just one NZER customer. By handling different marketing strategies we will be able to address more customers and serve more customers.

• The value of energy savings measure is not taken into account in current valuations (Dekker, 2014). Informing customers about this value could positively influence the businesscase for NZER.
4.3. Decision Framework

As described there are different motivations for people to decide to do an energy reduction renovation. Doing a renovation can often become an intense event. After someone has decided to do a renovation, it would be good to know which decisions should be made. Based on my experience I have created a decision framework. This framework can serve as a guide to structure all major focus points both for homeowners and designers. That is why the framework is divided in two main parts: process and design.

However, also the design-framework might be interesting for homeowners when deciding about which interventions to do.

4.3.1. Process

1. Goal
What is the goal of the homeowner for the renovation (besides reduction of energy use)?

1. Energy Savings: I just want to lower my energy bill with the lowest investment. (Figure 42)
2. Nicer home: I want to enjoy living in my home more, I want more comfort and luxury and I want to live a more sustainable lifestyle. (Figure 42)
3. Bigger house: I would like a bigger house with more space for me and my family. This expansion will be a perfect moment to also address maintenance and update my house to current standards. (Figure 42)
4. Longer establishment: I enjoy living in my house but my age or handicap make it hard for me to climb stairs, use the bathroom and be independent. A ground floor only home would solve these problems. (Figure 42)

5. Additional measures: One of the above but I have specific wishes too.
   a. Sustainability:
      • Rainwater use
      • Food production
      • Domotica
      • Solatube
      • Specific material use
      • Appliances
      • Lighting
      • Waste Separation
   b. Kitchen
   c. Bathroom
   d. Toilet
   e. Safety/Security:
      • Locks
      • Smoke detection
      • CO Alarm

2. Benefits
What are the benefits of the renovation for me? Writing these benefits down can help me in the decision making.

1. Emotional: these benefits will be different for anyone but could include things like sustainability.
2. Financial: All benefits that I can express in numbers.

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3 1-4 based on the division of target groups by Reimarkt as described in section 2.2.2
a. Related to the investment: which subsidies can I use
b. Exploitation:
   • Mortgage: what does my income allow? Do I need savings to finance the renovation?
   • Energy: What are my gains on energy savings?
   • How will the renovation influence my maintenance expenses?
   • How will the renovation influence my tax expenses?
c. Property value: What will the renovation do with the value of the house?
d. What can I afford? (related to mortgage)
e. What am I willing to pay for?

3. Permits
Some renovations require permits. What should you consider?

1. Do I need a permit?
   a. How much time does it take to get it?
   b. What are the cost for the permit?
   c. What are my options if the permit is denied?

4. Practical
Considering the following points can help you manage your expectations about the renovation.

1. How long will the renovation take?

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Fig.43 Visual representation of the Framework: Process. (own illustration)

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4 The financial model of chapter 3 can be used to calculate this.
4.3.2. Design
For designers and architects of Net Zero Energy Renovations it is important to know the motivations and personal wishes of the homeowner as described in the previous section. This is the first step in the Design-framework that will be described in this section. Part 4-6 of this section are based on the New Steps Strategy described by Van den Dobbelsteen (2008).

1. Analyse
What should I know before I can set up a design brief and start designing?
1. What are the wishes of the homeowner? (related to section 4.3.1)
2. What are the technical (im)possibilities for the renovation? (The Design-framework will list these possibilities)
3. What are the possibilities for the specific location with regard to size, orientation, previous interventions and regulations?
4. What are the target costs of the renovation (based on the Process-Framework and the Calculation model of chapter 3)?

2. Legislation
What are rules I should take into account while designing?
1. Building code: What are rules addresses by the building code concerning renovations?
2. Permits: What are possibilities to build without a permit?

3. Performance
What is the goal for the performance of the building? This can be elaborated in the design brief. The following points can be considered.

1. Size: In case of an extension: what will the size be?
2. Energy: What energy sources will be used? (mainly concerning the use of natural gas) And what should the energy demand of the house be?
3. Water: What should the water use of the house be?
4. Which materials will be used? (or better: which will not?)
5. Additional: Which other points concerning performance should be determined?
6. Cost: All of the points mentioned above should be considered taking into account the cost.

4. Reduce
What are the possibilities for reduction in the renovation design?
1. Natural gas: According to the NSS of Van den Dobbelsteen (2008) no fossil fuels should be used. Gas use should be reduced to zero. Possibilities to produce heat without natural gas are described in step 6: Produce.
2. Electricity: What are the possibilities to reduce electricity use?
   a. Heating: What are the possibilities to reduce electricity use for heating?
      • Insulation
         ✴ Wall: Cavity insulation or Post insulation
         ✴ Floor: with crawlspace:
      • Soil insulation: Pearls, Chips, Foil or Shells
      • Floor insulation: PUR or Tonzon
      ✦ Without crawlspace: Bluedeck
      ✶ Roof
      • Windows / doors / glass: well insulated windows doors and glass.
      • Draft Proofing
      • Ventilation: Heat recovery
   b. Cooling: What are the possibilities to reduce electricity use for cooling?
      • Insulation
      • Glass coating
      • Shading
      • Green Roof
      • Ventilation
         ✶ Heat recovery
         ✶ PCM
         ✶ Ground duct
         ✶ VRU icw Heat pump
   c. Ventilation: What are the possibilities to reduce electricity use for ventilation?
      • Use as much as possible natural ventilation
   d. Lighting: What are the possibilities to reduce electricity use for lighting?
• Use daylight as much as possible
  ✴ Bigger windows
  ✴ Solatube
• LED lighting
• Movement sensors to switch off lights after inactivity.
e. Appliances: What are the possibilities to reduce electricity use for appliances?
  • Use A+++ appliances
  • Use hot fill appliances
f. Domotica: Domotica can switch off appliances, reduce heat demand by tracking occupancy and heat locally, activate shading and giving insight in energy use.

3. Water: What are the possibilities to reduce water use?
  a. Use of water saving appliances
  b. Use water saving shower heads and shower timers
  c. Rotating taps
  d. Use of rainwater for toilet and garden

4. Materials What are the possibilities to reduce material use?
  a. smart design

5. Reuse
What are the possibilities for reuse of waste streams?
1. Waste water:
  a. grey water use for toilet and garden
2. Waste Heat
  a. HRU: a heat recovery unit can reuse heat to heat fresh air
  b. shower HRU: cold water can be heated using warm waste water

3. Organic waste
  a. Compost
  b. Biogas

4. Domestic waste
  a. Glass: should be reused outside the house
  b. Plastic: should be reused outside the house
  c. Paper: should be reused outside the house

5. Waste materials: should be reused outside the house

6. Excess electricity
  a. Battery: excess electricity can be stored for later use in a battery.
  b. H2: Hydrogen can be produced for transport or storage and later use.
  c. Heat: excess electricity can be used for additional heating when required.
  d. Transport: excess electricity can be used for transport with electric vehicles.

6. Produce
What are the possibilities for production of sources?
1. Electricity: What are the possibilities to produce electricity?
  a. Solar PV: PV panels can produce electricity
  b. Wind: Windmills can produce electricity
2. Heat: What are the possibilities to produce heat?
  a. Greenhouse: A greenhouse will produce warm air
  b. Solar Boiler: A solar boiler will produce warm water
  c. Heat Pump: A heat pump will produce warm water using the following sources:
    • Soil
    • Air
    • Water
3. Water: What are the possibilities to produce water?
  a. Rainwater can be collected
4. Food: Food can be produced in the garden (or even on the facade or roof) or in a greenhouse.

The value of Net Zero Energy Renovations
Research: Decision Framework
The value of Net Zero Energy Renovations

Research: Decision Framework

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4.4. Conclusions
The list of learning points is not a complete overview. I have only described the points that have influenced the design significantly.

The decision framework that can be found in figure 43 and 44 is not only based on these learning points but mostly on the experience I have gained while doing the Prêt-à-Loger project. Anyway it can be a helpful tool for anyone that wants to reduce energy costs or for designers that want to design an energy conscious renovation.

4.4.1. Considering homeowners
For homeowners that want to reduce energy it is important to know what the consequences are for every step they do in the renovation. Every choice for a certain step has a certain consequence, both performance- as cost-wise.

These performances and cost consequences are different in every situation, and it would be interesting to calculate the investment versus cost reduction for every measure. This relationship could help to make a decision about the order of the measures to take. However, it is important to look at all these relationships with a long term perspective. As we have seen from the example of Urgenda (Section 2.3.2) certain measures may seem interesting and cost effective, but this is only true on the short term.

If the decisions for measures are taken with a long term perspective this will automatically result in a an approach that complies with the New Steps Strategy (van den Dobbelsteen, 2008): Cost wise it would be more interesting to invest in the reduction measures before investing in production measures. This mainly has to do with the lifetime of insulation versus installations.

4.4.2. Considering designers
For designers the same conclusions apply as described in the previous section.

For homeowners the main influence they can have on value of a renovation lies in the energy reduction. For designers there are additional focus points that lie in the value increase of the property and reduction of maintenance.

A renovation always influences the value of a house. Knowing which design elements influence this value could be interesting while designing. Also taking into account maintenance cost of the design can create additional value. The choice for installations or materials could depend on the requirements for maintenance.
5. Design

During the startup, as well as during my work as student assistant and during my internship at Reimarkt I have been working on further development of the Prêt-à-Loger design. This chapter shows the result of this development with the design of the Nicer Home concept, developed at Reimarkt. (The decision framework is used for this design)

5.1. Preliminary Design

The planning and organisation of the overall design is done under supervision of the Reimarkt concept development team, which was initially formed by Josien and me. (Josien has been Prêt-à-Loger Design Manager as well as my startup colleague). Later the concept development team has been expanded with 4-5 other colleagues that are now working on the design, marketing and organisation of the collaboration with external companies.

I can say that the result that is described in this chapter is the result of this collaboration over a period of almost 5 months in which we have organised biweekly pressurecookers in which we have tackled all different design- and practical problems. My role has mainly been in the climate design focussed on creating an integrated installationbox product and setting the financial goals for the pilot and following products.

5.1.1. Description of the Design

The design can be found in Figure 46 - 49. As can be seen the Prêt-à-Loger concept is still preserved, however, a few things are changed. The most important changes are the shape of the greenhouse: The greenhouse is lowered half a meter so that it only reaches the gutter. The buffer capacity of the greenhouse is lowered, but the advantage is related in the cost: the steel structure is much lighter, the expensive glass panels in the greenhouse can be replaced with normal PV panels on the roof of the house and the folding doors are replaced with sliding doors. Another important change is the location of the installations. One of the learning points (Section 4.2.1) from the current concepts was that the location of installations is always an issue for the inhabitant because it takes up space and produces noise. By placing the installations between the foundation of the greenhouse in the backyard, all those problems are solved. All piping and cables go through the new prefabricated facade and roof so that all rooms are ventilated through the skin (Figure 47). The advan-
The value of Net Zero Energy Renovations

The advantage is that this makes the design independent from the layout of the house, which is what we want with for a product. The installations itself are accessible through a hatch in the greenhouse floor and heavy installations can be lifted out with a lifting jack to make maintenance even easier.

The other changes are related to the insulation of the house. In the original Prêt-à-Loger concept the North facade was insulated using post insulation and the South, underneath the greenhouse, was insulated with cavity insulation. In the improved design also the South Facade is insulated with high performing post-insulation. This has to do with the fact that we experienced that the greenhouse could become as cold as outside temperature if there’s no sun to heat it up. Besides that we wanted the Reimarkt renovation to be net zero energy without greenhouse as well so that the concept can be transformed to fit the other target groups (Section 2.2.2).

Figure 48 shows the different options for the cladding of the front facade.

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Fig. 49 Preliminary Design of the Prêt-à-Loger inspired “Nicer Home” concept developed at Reimarkt. Source: Reimarkt
5.2. Final Design

My initial idea was to create a final technical design since in the end I am doing a Building Technology master. The topic of my graduation however, has kept shifting to the financial side since this turned up to contain the biggest challenges. At Reimarkt I have worked on the technical design of the installations but not to the extend that I would usually do. This also means that the initial ideas for the technical design are mine, but the elaboration is done by Reimarkt colleagues.

5.2.1. Concept

The result of the technical design research is mainly visible in the location of the installations. As described in section 4.2.1 the location of the new installations like heatpump, boiler, ventilation box and inverter for the PV panels are always inconvenient for the inhabitant of the house since it would take up valuable space and would produce noise. Also placing the box in front of the house like some builders are doing didn’t seem like a nice solution since it changes a lot of the image of the street (Figure 50).

Taking into account the different target groups and the different accompanying concepts (Figure 51) I figured that three out of the four concepts would require building / digging activities in the backyard to place a foundation for the extension. The foundation, placed around the perimeter of the extension would create a space that could possibly provide a space for installations outside the house, without taking up any living space.

The location of the different installations within the foundation have not been defined by me. I have created the boundary conditions for the location by means of a zoning plan (Figure 52), by describing the different mutual relations between the different installations, the house and the greenhouse (Figure 53) and by describing the climate diagrams (Figure 54). This zoning plan and description of relations is used by the Reimarkt consortium to create a design.

5.2.2. Details

More drawings and details of the design can be found in appendix VII and VIII.
Fig. 53 Visual description of the different mutual relations between the different installations, the house and the greenhouse. (own illustration)

Fig. 54 Climate diagrams for Reimarkt - “Nicer Home” design. (own illustration)
5.3. Cost of the design

5.3.1. Cost vs target

The cost of the design is still an issue. Figure 38 shows that the current cost of the renovation concept (±€83,000.-) is still higher than the target of ±€71,000.-.

5.3.2. Cost vs price

At Reimarkt we have been working to make the Prêt-à-Loger concept into a product. This also implies a fixed price. Even if the real value differs from customer to customer.

As I described in section 3.1.3 the maintenance costs are not always an expense that is taken into account. For this reason we have argued that it would be good if the price of the renovation would be equal to the value of the renovation without the advantages of reduced maintenance cost. The result that came out of that calculation is shown in Figure 55: The value would be €69,630.-. This is the amount that we are communicating for the first pilot with potential customers (Figure 56).

Fig.56 Flyer for the Reimarkt NZER. Source: Reimarkt

The value of Net Zero Energy Renovation


<table>
<thead>
<tr>
<th>Property value</th>
<th>Targetgas 3</th>
<th>Monolaser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neto Value of renovation</td>
<td>108.5%</td>
<td>114.5%</td>
</tr>
<tr>
<td>Energy Savings</td>
<td>€792.00</td>
<td>€849.00</td>
</tr>
<tr>
<td>Energiebesparingen</td>
<td>Current energy use rate</td>
<td>€792.00</td>
</tr>
<tr>
<td>Procentuele vermindering energieconsumptie</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Bruto Savings (for inhabitants)</td>
<td>653.00</td>
<td>653.00</td>
</tr>
<tr>
<td>Netto percentage (per month) 8%</td>
<td>2.08%</td>
<td>2.08%</td>
</tr>
<tr>
<td>Possible cost saving on energy savings (Present Value)</td>
<td>€644,405.00</td>
<td>€697,590.00</td>
</tr>
<tr>
<td>Total interest</td>
<td>€71,542.00</td>
<td>€76,349.00</td>
</tr>
<tr>
<td>Total</td>
<td>€88,087.00</td>
<td>€96,929.00</td>
</tr>
<tr>
<td>Property value increase</td>
<td>€73,223.00</td>
<td>€79,200.00</td>
</tr>
<tr>
<td>Property value increase percentage (house value)</td>
<td>18.74%</td>
<td>19.76%</td>
</tr>
<tr>
<td>Property value increase percentage (renovation cost)</td>
<td>23.14%</td>
<td>24.42%</td>
</tr>
<tr>
<td>LTV percentage (100%)</td>
<td>108.5%</td>
<td>114.5%</td>
</tr>
<tr>
<td>Property value increase for LTV</td>
<td>€792.00</td>
<td>€849.00</td>
</tr>
<tr>
<td>Property value increase (year)</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Monthly increase (Periodic payment + PNI)</td>
<td>653.00</td>
<td>653.00</td>
</tr>
<tr>
<td>Possible cost saving on property value increase (LTV) (Present Value)</td>
<td>€644,405.00</td>
<td>€697,590.00</td>
</tr>
<tr>
<td>Total interest</td>
<td>€71,542.00</td>
<td>€76,349.00</td>
</tr>
<tr>
<td>Interest rate</td>
<td>4%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Total</td>
<td>€88,087.00</td>
<td>€96,929.00</td>
</tr>
</tbody>
</table>

Fig.55 Value of the renovation without maintenance aspect. (own illustration)

5.3.3. Price vs new developments

The calculation of Figure 55 is made a while ago and in the meanwhile we have gathered new insights. For instance the interest percentage of 2.5% that I used back then is quite low for 30 year mortgages. I currently found out that Energiesprong handles a 3.2% interest rate in their calculations. Changing this number decreases the value of the renovation.

Also because of the continuously changing market, we have decided to keep the price of the renovation as it is, even though new insights may change calculations.
6. Conclusions and recommendations

6.1. Introduction
In this research I have addressed the problem that current Net Zero Energy Renovations do not seem to be feasible. The statement is based on the fact that Stroomversnelling handles a target price for an NZER of €45,000.¬, and at the moment there are no renovation concepts that approach this target. In the research I strongly focus on the benefits of NZERs to answer the research question: “What are the cost benefits of Net Zero Energy Renovations in the Netherlands, and how can they influence the business model for NZER?”

6.2. Conclusions Subquestions
The literature studies together with the case study research have provided the necessary information to understand the problem and answer the research subquestions.

6.2.1. What are the costs of current Net Zero Energy Concepts?
The average costs of current NZER concepts are estimated to be around €70,000.¬ by Finance Ideas (2015). They claim that this number is based on costs that are commonly used within the Stroomversnelling.

I have tried to underpin this number with the costs of concepts that I could find on woonconcepten.nl. It is remarkable that the only renovation concept for which the costs can be concluded with certainty, because this is the only concept that has actually been built, is the concept with the highest price: €130,000.¬.

All in all, this small research shows that the average costs of the available concepts are still above €75,000.¬ (Figure 27). This is 67% higher than the Energiesprong target of €45,000.¬.

It is necessary that these prices drop, but considering that NZERs are in the pilot phase and that up-scaling has not yet happened, we can be sure that this will happen in the near future.

6.2.2. Which aspects determine the value of Net Zero Energy Renovations?
The problem statement that current NZERs are unfeasible is based on a target price set by Stroomversnelling. To nuance that statement I have researched how a target should be defined and what the target should be.

I have assumed that an NZER is attractive when the investments in this renovation are equal to, or lower than the benefits (Figure 57). This means that the target of a renovation should be defined by its value.

The value of a renovation is defined by all financial aspects that this renovations influences. This is more than just Energy Savings.

In my research I have considered the following six aspects:

- Energy Savings
- Property Value
- Maintenance costs
- Vacancy Rate
- Rent Increase
- Energy Performance Compensation

The first three apply to private homeowners, the last five to housing associations.

By looking at all the cost aspects of a renovation, it was possible to create a complete overview of the value of a certain renovation.

6.2.3. What should a Net Zero Energy Renovation cost?
I have described in the previous section that the target of a renovation should be defined by its value and the value is defined by six cost aspects. Because all of these cost aspects are influenced by different variables, I have created a calculation model. This model helps to calculate the value of a certain renovation with regards to the six cost benefits. As an example I have calculated the design that we are working on at Reimarkt. The value of this renovation is used to define the price of the concept (Subchapter 5.3).

So, the question of what an NZER should cost is not answered with one number. The calculation model can help to define the value of every (energy reducing) renovation. This value can be transformed into the price of a concept.

6.2.4. What can we learn from current concepts and existing research?
During my experience over the last three years with the Solar Decathlon competition, the start-up, the internship at Reimarkt, and my graduation, I have collected a lot of information about...
zero energy renovation. In contrast to what I had planned initially for my graduation, it turned out to be impossible to use all this information in my research. That is why I have structured all this information in a decision framework that can be used as a basis for homeowners who want to renovate their homes, or for architects who want to design a renovation.

The decision framework is also used to show the boundary conditions for the design that I have worked on at Reimarkt.

6.3. Conclusions research question
Now that we have answered the different subquestions and by taking into account the context in which the research happens, we can answer the main research question.

“What are the cost benefits of Net Zero Energy Renovations in the Netherlands and how can they influence design decisions?”

6.3.1. What are the cost benefits of NZERs in the Netherlands?
The first part of the question is already answered by the answer of subquestion 2 and 3 (Section 6.2.2 and 6.2.3). The benefit of a renovation is determined by several aspects and all of these aspects are influenced by different variables.

The example for the Prêt-à-Loger concept that I have calculated is estimated to have a value of ±€71,000.-. In general we can say that the value of a renovation is at least €45,000.- if it is NZE. This is caused by the reduced energy bill. Another large factor that influences value is the property value increase which is dependent on location, initial property value and added features. Also, maintenance costs play a role, and for housing associations vacancy rate, rent increase and energy performance compensation (EPV) play a role.

6.3.2. How can the cost benefits influence design decisions?
According to Weishut (2015), four drivers are needed to implement new technology into the market: Technology and Systems, Business model, Legislation and Market Appreciation (Figure 58). In the problem statement (Section 1.2.2), I have stated that the implementation of NZER in the market has many different aspects and could benefit from further research and development in all four drivers (Figure 58). However, I have decided to focus on one driver only and dedicate this research to the business model and feasibility of NZERs.

Even though Stroomversnelling is working on the business model, and even though we know that all NZE projects done are pilots and tests, and up-scaling of the technology has not yet happened, the research shows that there are possibilities to encourage development of NZERs even more.

At the moment, the government is stimulating the development of NZER with subsidies, legislation, and active coaching through Stroomversnelling. Jan-Willem van de Groep, program director of Stroomversnelling, states that the goal for NZER should be based on the Energybill:

“If we want to rebuild uneconomical houses into energyproducing houses on a large scale, then solutions should be available for this. Attractive renovation-propositions that are sold through one-stop-shops to homeowners. Those propositions are fully under development. However, the prices of those solutions are still too high because the building industry is still in a pioneering phase. The renovation of an average terraced house from the sixties/seventies is now still 70,000 euro. However, this price does not allow to use the energybill as financing source. With an average energybill of €175.- a loan of 45,000 euro can be financed based on a annuity mortgage. That is where the bar is set for the industry at the moment. That is how you get a renewed and comfortable house for the price of your energybill.”

- Jan Willem van de Groep, Program Director of Stroomversnelling - (van de Groep, 2014)

The reason why the target should be based on the energy bill is not explicitly mentioned, but can be traced back to two reasons:

1. The lower the costs, the bigger the market that can afford the renovation.

2. If the energy bill changes because of the renovation, and the renovation can be financed through this money flow, the homeowner will not have higher housing costs.

The first reason is obvious considering market size is always important, especially when developing products. However, the research on market size shows that market size (homeowners who can finance the Renovation) does not change so much (Section 2.2.3, Figure 19). The difference between a €45k or €70k renovation is only a 5% smaller market. Of course, the percentage of people who can finance a renovation differs from the number of people who want to buy a renovation. For these people the price will certainly play a role.
To argue against the second reason I think that just looking at the energy costs is not enough. From subquestion 2 (Section 6.2.2), I have concluded that there are 5 more cost aspects that can play a role. In the case of private home-owners a reduced maintenance cost will also create a cashflow that could be used to finance the renovation without causing the housing costs rise. The increase of property value is an income that does not create a cashflow directly, but will allow for a higher LTV when financing the renovation with a mortgage. However, by considering the total costs of ownership, the property value increase also generates value when the house is sold.

All in all, the research shows that there is a lot of potential to create additional value with a renovation. By carefully considering all the cost aspects while designing, this value can be increased.

Even when assuming that the target of the NZER should eventually be €45k, like Jan Willem van de Groep states, we are in a pioneering phase in which the NZER is still too expensive and we have to finance an unprofitable top. By stretching out the possibilities of value creation and thereby raising the target for NZERs, this unprofitable top can be financed. This will help to initiate the first pilots which will result in further development of the propositions and reduction of costs. This is especially relevant for smaller building companies that do not have the initial capital that is necessary to scale up.

The example of Electric Vehicle (EV) producer Tesla Motors perfectly illustrates a successful implementation of a new technology in the market. CEO Elon Musk explained in his presentation of the Tesla Model 3 (Musk, 2016):

“It takes multiple iterations and economy of scale to come to a great and affordable product.”

The first step in his “Masterplan” (Figure 59) was the Roadster:

“…high price and low volume, but it showed the world that you could make a compelling electric car. … before, people would think that an electric car would be slow and ugly and low range and have bad performance, and we had to break that wall”

Musk explains that even though they made few cars it had a leverage effect. It would inspire other carmakers to start EV programs themselves.

“…the goal of the Model S wasn’t to achieve awards…. …but to show the car industry, to show the world that an electric car really can be the best car.”

Later, talking about the model S and X, Musk explains:

“…both of these are very important because the revenue of the model S and X is what’s needed to develop the model 3”

“…the final step is the master plan which is a mass-market affordable car. It was only possible to do that after going through the prior steps…”

What I am showing with this research is that we are in step 1 of the “masterplan” and that the value of an NZER could (and should) be higher. This means that we should develop low volume, high quality and high priced products for the top of the market. This gives builders the possibility to ask a higher price for their concepts, making it possible for them to start development of concepts which would eventually help to speed up the cost reduction and reach that €45,000.-. The consequence might be that the market will initially be smaller because of the higher target.

An interesting target group in this pioneering phase might be homeowners who are already investing in their homes. These might be people who are in the process of relocating, and buying a house. These owners are usually already planning to invest in modifications of the house, and combining this moment with an NZER has the advantage that the house is empty and the process with brokers will not cost additional money. The same applies to homeowners who
are planning to do a renovation, build an extension to their house or do other major modifications.

The last note I would like to make is that when we are talking about “nice” products, emotional aspects start to play a role. I think we can assume that in the Tesla example, buyers of the Roadster would not talk about payback times. The same applies for the Nicer Home concept of Reimarkt.

6.4. Recommendations
In this subchapter I will describe the recommendations that I can give to different actors in the field of NZER based on the graduation research.

6.4.1. Homeowners
For homeowners it is important to look at the total picture of the renovation. The initial costs of the renovation will not tell anything about the costs of future maintenance, value of the house or reduced energy, or aspects like comfort and aesthetics.

6.4.2. Designers
For designers it is interesting to create as much value as possible with the renovation. The calculation model may help with that.

6.4.3. Banks
Banks should make information about options to finance NZER better available. An option would be to provide this information at the moment that a client comes to get a mortgage. This can help to make people aware of living costs and accelerate the transition to sustainable living.

6.4.4. Brokers
Similar to the banks, I think there are opportunities for brokers to promote NZER when clients buy a house. Besides that, it is important that brokers start to take into account all aspects of the value of a renovation when validating houses. The calculation model could help with that.

6.4.5. (Local) Government
The most important recommendation for the government is to have a critical look at the target that is presented for NZERs in the Energiesprong programs. As I have explained in section 6.3.2, lowering the bar by raising the target price for NZER would possibly give a boost to the development of NZERs.

There are a lot of other opportunities to stimulate NZER. Besides providing information, it should be possible to finance an NZER with the extra value of this renovation. Now this is already partially possible by means of the Ministerial arrangement mortgage credit of €27k. However, this might not be enough for all homeowners.

For local government the challenge lies in regulation. Making it easier to get licenses for NZERs, or allow for exceptions in the pilot phase can help development of the NZERs.

6.4.6. Renovations shops
For renovation shops like Reimarkt there is a challenge to activate all the previous actors. Possibilities lie in creating awareness among homeowners about their current living costs and what the possibilities are to get a nicer house while reducing those costs. It is important to communicate that besides the initial investment of the renovations there are more costs related to owning and living in a house than just Energy, like maintenance costs which can all be influenced by an NZER.
7. Reflection

7.1. Reflection

With regards to the results of the research and the products, there are a few notes that I want to discuss in this subchapter.

Firstly, the net zero energy renovation market in the Netherlands is a developing and therefore dynamic market. The result is that my research has become dynamic as well. New information has provided new directions to research and new insights. For example: in the last year new legislation has been developed concerning Energy Performance Compensation (EPV) and new pilots have been built as part of Stroomver-snelling. The new legislation about EPV has made me decide also to include a value assessment for housing associations in my calculation model, alongside the calculation for private owners.

My second note is that in the research I have focussed mainly on costs. This is related to the problem statement. In the research framework I have explained that from the four drivers necessary to implement new technology, only one is missing in case of the Net Zero Energy Renovations (NZER): the barrier is not a lack of technology or legislation, but a lacking business model. The result is that this research has had a strong financial emphasis, contrary to what is typical for a Building Technology graduation research. Anyway, this has provided me with an interesting perspective on the NZERs and the development of technology and innovation in general.

Concerning the research process itself I have learned a few lessons. This has to do with the fact that I have started my graduation with a desire to work on too many interesting topics. The graduation research does not allow for this. I noticed that if I wanted to dive deeper into one subject I had to let go of others. This has forced me to make decisions about what the exact topic of my research would be, but at too late a
stage. If I were able to start graduation again I would have made the decision on this topic at an earlier stage. This would have given me the opportunity to work more consistent towards a final research and products without a delay.

**7.2. Reflection on research**

During my research into the value of Net Zero Energy Renovations (NZER), I have used different methods and have created different products. The relationship between those methods and products can be found in the Research Design (Figure 60).

**7.2.1. Reflection on topic**

Because of the Prêt-à-Loger Solar Decathlon project, my desire has always been to continue in the NZER field and graduate on a related topic. The spin-off of Prêt-à-Loger in the form of a startup has helped decide on that topic. The contacts that we had with Stroomversnelling, related builders, designers, housing associations, municipalities, banks and homeowners strengthened my feeling that a clear vision on what the goal (target cost) for NZER should be, was missing and that I wanted to dive deeper into that.

The topic that I have chosen is financial. For a Building Technology graduation this is not usual. However, the financial topic is always part of a technological development and can also be a criteria and input for a technical development. This is what I have tried to achieve with my research: investigate the financial consequences of certain design decisions and use financial aspects to set boundary conditions for the design. More information about current concepts like cost overviews could have made these boundaries more defined.

The choice for the financial emphasis has given me a new perspective on the subject and has given me the opportunity to explore new fields while still working on the zero energy renovations. I feel that I have learned a lot about the financial side of the net zero energy market and the development of technology and innovation in general.

**7.2.2. Reflection on research framework**

The research framework has helped me to structure my research. It helped me to see which products would fit where in the bigger picture, and which products would contribute to the goal of the research and to answering the research question. Over the course of the graduation the framework has been adapted several times, mostly to reduce the amount of work. I think that the final framework clearly shows what the structure of the research is and which products will logically come out of it.

**7.2.3. Reflection on process and planning**

The planning in the research framework shows that I initially planned to finish graduation in January. This has been delayed a bit, partly because I had some struggles in finding the right research topic in the beginning. After P2 however the process has been quite smooth.

After I decided on the topic, I also applied at Reimarkt for the internship. This gave me the opportunity to access necessary information about costs of renovation products and get to know the struggles and problems as well as opportunities of NZERs. (Based on these problems and opportunities I have written the chapter about building opportunities for Reimarkt in Appendix V)

The internship at Reimarkt has changed me in the sense that I understand more and more that the crux of the NZER market does not lie in technology or the design only. A lot of effort and time goes into managing the process around that. An example is that it takes time to talk with municipalities to get them to judge a renovation design apart from its context. If this is possible, homeowners do not need to apply for a permit when they buy the Reimarkt renovation. Another example is to get partners to understand the necessity to think in products and not in projects. Also, getting housing associations to understand the necessity of doing pilots for product development has taken its time.

**7.2.4. Reflection on wider social context**

The application of NZER in general is possible on a large scale. Besides 4 million terraced houses in the Netherlands, there are significant numbers in Belgium, France, Germany and the UK for which these renovations could be a solution in order to to convert the building stock in a more sustainable one.

**7.3. Reflection on product**

In this subchapter I will reflect on the products that I have created. The relationship between the products and research can be found in Figure 60.

**7.3.1. Overview of Net Zero Energy Pilots**

The first product I have created is an overview of Net Zero Energy pilots in the Netherlands. This overview has not been as useful as I had hoped in the beginning. The idea was to collect all information about these pilots to create a background for the research but also a database with information. This last part did not happen. When I decided to focus on the financial aspects of NZER, this turned out to be the hardest information to find. So, the analysis of the costs that I planned to make was limited to just two projects. More information would have made it possible for instance to make more statements about the cost ratio of product groups (as described in subchapter 3.5).
7.3.2. Cost benefits
The second product I created is the overview of all cost benefits that are influential for the value of a renovation. Initially, I focussed on the aspects for the private market only. (The cost aspects that are relevant for this market are energy savings, increased property value and reduced maintenance costs.) But because the largest market for Reimarkt consists of housing associations and their tenants, I have eventually included aspects for the public market as well, as this would make the calculation model (Section 7.3.3) directly usable for Reimarkt propositions. (The cost aspects that are relevant for housing associations are rent increase, vacancy rate, and energy performance compensation). All together, this has resulted in what I think is a complete overview of value aspects for renovations.

7.3.3. Calculation model
The product that I believe has the most potential for market use is the value calculation model. The model can be found online by clicking the following link:

Value calculation model for (NZER)’s.
Initially I used the excel to calculate the value of an NZER. But because of the many variables in the formulas, the calculation became a model that can be used to calculate the value of all renovations. It can be a useful tool for housing associations as well as homeowners and designers / renovation shops like Reimarkt.

Since the market appreciation is not taken into account, I think that the calculation model works best if the renovation that is inserted is a renovation that is asked for by the client. Only then we can say for sure that market appreciation of the NZER is not a problem. If product developers were to use the model to calculate the value of a new renovation product, they should be sure that the market would appreciate that product. Only then the calculation model will work. In case of a renovation product that can be bought of the shelf, the real value depends on the client and his / her wishes.

In the calculation model I have made some assumptions, for instance considering cost development of PV and maintenance, or considering reduced vacancy rate of terraced houses after renovation. The outcome of the model should therefore always been considered carefully.

The only aspect that is currently still missing in the model is a gross net calculation that takes into account mortgage interest tax relief (NL: hypotheekrenteaftrek). Including this in the model would show that the value of a renovation for private owners is even higher.

### 7.3.4. Decision Framework
The decision framework is a tool for homeowners who want to renovate their homes and for designers who want to design a renovation. With the framework I have tried to address all aspects that should be taken into account when designing an NZER with their different options. As I have explained in the research framework (Section 1.6.4) and subchapter 4.1, the presented framework is not tested and therefore not final. It is partly based on research but also on assumptions and experience. This means that it could be the case that elements are missing or that the presented order of elements is incorrect.

At the moment, the decision framework is just a scheme. The exact application of the framework is a recommendation for further research. Making it into a tool would make it more usable.

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**Fig.61 Planning: Focus and development points for the coming pilots. Source: Reimarkt**
7.3.5. Design
The design I have worked on at Reimarkt is based on the Prêt-à-Loger concept that TU Delft created for the Solar Decathlon competition. The design was made with the goal in mind to win a competition, not to be affordable. The research that I have done has shown what the value of the Prêt-à-Loger concept is and what the target price for a similar renovation should be. The result is that some expensive elements of the design are removed. The most visible change is that the greenhouse has been lowered so that the part above the roof disappears. The advantage is that the span of the roof is halved and the steel construction can be much smaller. Besides that, the expensive semi-transparent PV-panels of the Prêt-à-Loger concept can be replaced with normal opaque PV panels. The semi-transparent panels become optional. The next important change lies in the installations. One of my learning points from the Prêt-à-Loger concept was that the installations are quite an obstruction since they are spread throughout the house. The solution that I presented in the design (Chapter 5), where a box with all installations in it is placed in the ground underneath the greenhouse, has the advantage that the homeowner receives extra space, but also noise problems are solved.

In the end, the costs of the Reimarkt - "Mooier Wonen" concept are still bigger than the target that I put forward. That means that development is still necessary. However, I believe that the design is a step in the right direction. A point of attention with the target is that the calculation is based on the original Prêt-à-Loger prototype. As a feedback it would be good to recheck the calculation with the parameters of the improved Reimarkt design. Since the design has changed, some parameters (for instance concerning added value of the house) might be changed also.

7.4. Recommendation for further research
Concerning the further development of the concept, the product development team has addressed that the development of many aspects of the design require more time. That is why we have made a planning for several pilots in which different aspects / product groups of the design can be elaborated and developed (Figure 61). In this development it would be good to have input from homeowners to be sure that the market will appreciate the product.

A lot of research I have not been able to do myself but would still be interesting for further research.

This research addresses the financial value of NZER. This is already complementary to the graduation research of Thomas Dekker (2014) about the influence of energy saving measures on the value of a house, and the research of Derek van de Berg (2015) into the willingness to...
pay for sustainable measures. However, there are still more investigations that can be done in the field of NZERs.

A development that I think is one of the most important aspects to make the NZER development successful, is the development of domotica for efficient control of all the new technologies in a renovated home. Another function might be to provide insight in the functioning of installations to provide homeowners with useful feedback about use of the house. The development of software and algorithms can be a means to prevent dissatisfaction with NZERs (Figure 62 and 63).

Besides that, more related to the topic of my graduation, research could be continued into the property value. The current validation methods do not take into account energy measures yet, so it would be interesting to see which measures do influence property value. For example: the valuation of Stroomversnelling of a BAM prototype shows a different value from the Prêt-à-Loger prototype: €28,700.- for BAM versus €37,000.- for Prêt-à-Loger (Figure 64).

Another recommendation for further research would be the decision framework. Finding out and listing all decisions that homeowners and designers of renovation products can make and finding out in what form this could be used best, would be another step to support the development of NZER.
8. Bibliography


• van den Dobbelsteen, A. (2014). SMART AND BIO-CLIMATIC DESIGN: AN EFFECTIVE APPROACH TO THE SUSTAINABLE USE OF RESOURCES AND DEPLOYMENT OF LOCAL QUALITIES.


The value of Net Zero Energy Renovations

Bibliography
Appendix

I. Actuele initiatieven van de Energiesprong (Energiesprong, 2015).

Deal de Stroomversnelling Koopwoningen 29 september
www.stroomversnellingkoopwoningen.nl

De Stroomversnelling Koopwoningen is een samenwerking van partijen en aanbieders die vraag en aanbod gaan creëren voor nul-op-de-meter-verbouwingen van particuliere rijwoningen uit de periode 1950 – 1980. Een samenwerking van (bouw)partijen en toeleveranciers (co-developers) die voor het aanbod zorgen enzijds en gemeenten, energiecoöperaties en wijkambassadeurs die vraag creëren anderzijds. Zij worden daarbij ondersteund door Energiesprong. Huiseigenaren zouden de kosten van hun huidige energierekening om moeten kunnen zetten in een lening voor een slimme verbouwing naar een NulopdeMeter woning. Dan krijgen zij een mooier en comfortabeler huis dat bovendien meer waard is.

Op 29 september wordt er een deal ondertekend in het bijzijn van minister Blok waarbij meer dan 100 partijen, waaronder bouwers, gemeenten en banken zich verbonden aan de opgave om op grote schaal verbouwingen naar nul-op-de-meter voor koopwoningen mogelijk te maken; 100.000 om mee te beginnen. Zie ook de NOS reportage 100.000 woningen naar energieneutraal.

In voorbereiding daarop vinden er gesprekken en overleggen plaats met gemeenten, energiecoöperaties, provincies, bouwers, toeleveranciers in de bouw, financiers en andere betrokkenen. Partijen die nog niet zijn benaderd en alsnog graag willen aanhaken, kunnen tot begin september een mail sturen naar energiesprong@platform31.nl met in de onderwerpregel ‘Interesse Deal Stroomversnelling-koopwoningen’.

Deal Stroomversnelling Huurwoningen: 111.000 huurwoningen
http://www.stroomversnelling.net/

In juni 2013 is de deal Stroomversnelling Huurwoningen gesloten om 111.000 woningen te renoveren naar nul-op-de-meter. De deal is gesloten tussen de corporaties: Portaal, Lefier, Woonwaard, Stadlander, Tiwos, Wonen Limburg en de bouwbedrijven: VollerWessels, BAM, Ballast Nedam en Dura Vermeer. Dit zijn de partijen die het voortouw nemen bij de eerste 11.000 woningen. De Stroomversnelling Huurwoningen richt zich primair op grote aantallen seriewoningen uit de jaren ’50-’70. De grote aantallen van de corporaties stellen de bouwers in staat om te investeren in een forse innovatie die nodig is om de gestelde ambitie van prijs en kwaliteit te realiseren. Met de huidige bouwprocessen is een kwaliteitsrenovatie die leidt tot woningen zonder energiekosten niet haalbaar noch betaalbaar. Door het bouwproces te industrialiseren, vergelijkbaar met de auto-industrie, kan de kwaliteit van de woning flink worden verbeterd tegen lagere kosten. Met een gemiddelde renovatieprijs van €60.000 euro komt de omvang van deze deal op ruim 6,5 miljard euro. Diverse testwoningen zijn opgeleverd. Voor meer informatie over de Stroomversnelling Huurwoningen en filmpjes en foto’s van de testwoningen zie www.stroomversnelling.net

ONS HUIS VERDIENT HET
http://www.onshuisverdienthet.nl

Via de campagne ONS HUIS VERDIENT HET, onderdeel van Stroomversnelling Koop, geeft Energiesprong huiseigenaren massaal de kans om te laten weten dat zij energieneutraal willen wonen. Hoe meer steunbetuigingen, des te beter. Het televisieprogramma ‘Ons huis verdient het’ op RTL4 is hier ook onderdeel van.

OVER ONS

ONS HUIS VERDIENT HET
Via de campagne Ons Huis Verdient Het geeft Energiesprong in 2014 huiseigenaren massaal de kans om te laten weten dat zij energieneutraal willen wonen. Bijna 4.000 mensen steunden de actie. Op 29 september 2014 tekenden banken, bouwers, garantie-instituten, makelaar-taxateurs, gemeenten, provincies, energiecoöperaties en nog vele anderen de Deal Stroomversnelling Koopwoningen. Dat is heel goed nieuws, want na een pilotfase zijn vanaf 2016 die renovaties te koop! Een Upgrade naar een comfortabel huis dat z’n eigen energie opwekt, binnen 10 werkdagen met gelijkblijvende woonlasten. Energiesprong werkt samen met partijen die hier ook in geloven: collega’s, vrienden, maatschappelijke organisaties, gemeenten, provincies, belangenverenigingen, bouwers, banken etc.

ONS HUIS VERDIENT HET TV

Lokaal alle lichten op groen
http://www.lokaalallelichtenopgroen.nl

Zes gemeenten zijn kwartiermaker om in hun gemeente met bouwpartijen en financiers lokaal alle lichten op groen te zetten voor minstens 20 particuliere rijwoningen uit de periode 1950 – 1980. Een samenwerking van (bouw)partijen en toeleveranciers (co-developers) die voor het aanbod zorgen enerzijds en gemeenten, energiecoöperaties en wijkambassadeurs die vraag creëren anderzijds. Zij worden daarbij ondersteund door Energiesprong, partijen die hier ook in geloven: collega’s, vrienden, maatschappelijke organisaties, gemeenten, provincies, energiecoöperaties en nog vele anderen de Deal Stroomversnelling Koopwoningen. Dat is heel goed nieuws, want na een pilotfase zijn vanaf 2016 die renovaties te koop! Een Upgrade naar een comfortabel huis dat z’n eigen energie opwekt, binnen 10 werkdagen met gelijkblijvende woonlasten. Energiesprong werkt samen met partijen die hier ook in geloven: collega’s, vrienden, maatschappelijke organisaties, gemeenten, provincies, belangenverenigingen, bouwers, banken etc.

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SEV stelt 6 x maximaal 250.000 euro ter beschikking, in te zetten voor procesondersteuning lokale experimenten.

Oproep tot 1 oktober 2011
Tol 1 oktober 2011 hadden gemeenten tijd te reageren op de oproep Lokaal alle lichten op groen. Onze vraag was: Als u gaat zoeken, vindt u dan binnen uw gemeente minimaal 20 eigenaar-bewoners die hun woning naar energieneutraal willen verbouwen? En hoe zit het met de professionele partijen rond die eigenaren? De makelaars, financiers, aan-nemers, architecten, installateurs, leveranciers en adviseurs? Denkt u dat u alle partijen rond de tafel kunt krijgen om mee te doen in een project om gezamenlijk een sprong te maken in duurzaam bouwen? Bent u zelf bereid om regels te vernieuwen om zeer energiezuinig wonen te stimuleren?

Informatiebijeenkomst
Op 7 september werd tijdens een drukbezochte informatiebijeenkomst uitgegaan gegeven aan de oproep van Energiesprong. Er was volop ruimte voor het stellen van vragen. Bekijk de presentatie.

Veel belangstelling

Zes gemeenten geselecteerd
De jury selecteerde in totaal zes gemeenten die de beste plannen hebben. In het juryrapport leest u hun motivatie.


Energiesprong gaat met kennis en coaching in deze zes gemeenten lokaal alle lichten op groen krijgen voor de eigenaar-bewoners die hun nek uitsteken. En de successen vervolgens kopieren in andere gemeenten.

Voordeel voor alle gemeenten
Door in deze zes gemeenten het traject te ondersteunen waarin minimaal 20 eigenaar-bewoners worden geholpen bij het energieneutraal renoveren van hun woning wordt praktijkervaring opgedaan. Belemmeringen in regelgeving, technische oplossingen en financieringsmogelijkheden worden door de coalitie herkend en structureel weggenomen voor volgende renovaties. De ervaringen worden gedeeld met andere geïnteresseerde woningeigenaren, lokale en regionale aan-nemers, energieadviseurs etc. Zo komen tegelijkertijd vraag en aanbod in een stroomversnelling. En dit is het doel van Lokaal alle lichten op groen: verbeter de marktcondities voor energieneutraal renoveren!

Verder heeft Energiesprong ook mogelijkheden om met landelijk opererende partijen zoals brancherabattenorganisaties en de Rijksoverheid lokale blokkades te bespreken en oplossingen te zoeken. We monitoren de voortgang van het experiment, brengen relevante expertise in en geven extra publiciteit aan de projecten, omdat we graag willen dat de beweging die met dit project binnen gemeentegrenzen op gang wordt gebracht, uitstraalt naar andere gemeenten.

Waarom doen we dit?
Energiesprong is een initiatief dat beoogt hoge energie-ambities in de gebouwde omgeving te versterken en op grote schaal toegepast te krijgen binnen Nederland. Daarvoor ondernemen we diverse activiteiten, waaronder dit project op gemeentelijk niveau waarin we zowel vraag als aanbod een impuls willen geven.

Energiesprong stelt in dit deelprogramma de koplopers onder de eigenaar-bewoners centraal. Door voor hen de weg te banen komt er letterlijk veel energie vrij. We hebben ons de vraag gesteld hoe we zoveel mogelijk lichten op groen kunnen krijgen. We hebben deze activiteit binnen Energiesprong ‘Lokaal alle lichten op groen’ genoemd.

Voor Energiesprong is dit project een experiment om beweging te creëren en te leren wat er moet gebeuren om eigenaar-bewoners hun eigen ambities te laten realiseren. We beseffen daarbij dat energie niet het enige motief is voor woningverbetering. Zo kan worden meegelift met een andere aanleiding, zoals het levensloopbestendig maken van een woning. De koppeling met ‘reguliere’ woningverbeteringen kan de marktontwikkeling van energieneutraal renoveren alleen maar helpen. Voor ons is daarbij het ambitieniveau qua energiebesparing een belangrijke maatstaf voor ondersteuning, evenals de intentie van de lokale partijen om dit initiatief gezamenlijk tot een succes te maken.

Huis vol Energie
https://www.huisvolenergie.nl

Huis vol Energie.nl is een community van particuliere woningeigenaren die de ambitie hebben hun huis energieneutraal te (ver-) bouwen. Het online platform ondersteunt een groeiende groep mensen met energiezuinige ambities om elkaar te ontmoeten en ervaringen met elkaar te delen. Voor en door deze Energiepioniers worden onder meer bijeenkomsten, huisbezoeken en workshops georganiseerd. Op de site plaatsen pioniers energiezuinige woningen en is inzichtelijk welke energierelateerde maatregelen ze hebben toegepast.

Hoogspringers: 1000+, nul op de rekening
http://energiesprong.nl/hoogspringers/

Vier steden renoveren per stad binnen vijf jaar meer dan 1.000 corporatiewoningen naar nul-op-de-meter. De vier Hoogspringer steden (Tilburg, Amersfoort, Utrecht en Groningen) zien in dat door samenwerking tussen gemeente, corporaties en bouwers, verantwoord mooie renovatieprojecten en woningen kunnen worden opgeleverd. Energiesprong helpt gemeenten en corporaties hierbij door onder meer haar kennis en netwerk te delen en procesbegeleiding aan te bieden.

Woonlastenexperiment
http://energiesprong.nl/blog/woonlastenexperiment/

Samen met de G32 werken we aan een aanpak om woonlasten in de toekomst betaalbaar te houden. We kijken naar het hele plaatje; niet alleen huur/hypotheek en energielasten, maar ook bijvoorbeeld gemeentelijke belastingen, waterschapslasten, (zorg) verzekeringen, OZB en riolrechten. Het doel is een aanpak te ontwikkelen waarin de woonlasten niet met meer dan inflatie toenemen, met medewerking van onder meer huurdersverenigingen, netbeheerders, banken, waterschappen, gemeenten en corporaties. In totaal worden daartoe in vijf gemeenten experimenten opgezet om te onderzoeken wat er lokaal mogelijk is.

Energielijn, de kennishub van Energiesprong
http://energie4l.nl

Energielijn.nl is een verzamelplaats van kennis en ervaring rondom energieneutraal bouwen, opgedaan tijdens de verschillende trajecten en experimenten van Energiesprong. De website is gevuld met concepten, projecten, informatie over vernieuwende processen, prestatiecontracten, ervaringen, etc. Daarnaast is alle kennis gekoppeld aan een expert met wie contact kunt opnemen kan worden als men meer wil weten over bijvoorbeeld een bepaald project, specifieke technische kennis, een presentatie of subsidieaanvraag.
10.000 euro voor Nul-op-de-meter prestatiecontract
http://energiesprong.nl/blog/10-000-euro-voor-gegarandeerd-nul-op-de-meter-in-contract-2/

De prestatie nul-op-de-meter wordt door verschillende nieuwbouwpartijen toegezegd. Er zijn echter nog weinig tot geen contracten tussen aanbieders van concepten en kopers die zo’n belofte ook duidelijk vastleggen. Bovendien is de monitoring van het energieverbruik nog niet genoeg uitontwikkeld en juist hiermee is vast te stellen of de beloofde prestatie waargemaakt wordt. Energiesprong verwacht dat de behoefte aan een prestatiecontract groter zal worden en riep daarom op om projecten in te dienen, gericht op de totstandkoming van prestatiecontracten.

Renovatiewinkels
http://energiesprong.nl/blog/renovatiewinkels/

Naar de winkel en een kant en klare renovatie aanschaffen om je huis naar energieneutraal te laten verbouwen: het kan binnenkort! In Amersfoort timmert men onder de noemer van 033energie al langer aan de weg en zijn bouwstudenten betrokken bij het ontwerp van de renovatiewinkel. In 2014 gaat dat op minimaal zes andere plekken in Nederland ook lukken. 26 inzenders dienden hun plannen in voor de oproep die Energiesprong deed voor retailconcepten.

Slim en Snel
http://www.slim-en-snel.nl


Woningrenovatie 80%
http://energiesprong.nl/woningrenovatie/

Onder de titel Woningrenovatie 80% deed Energiesprong in 2012 een oproep op zoek naar renovatieprojecten van minstens 30 woningen op hoog energieambitienniveau, namelijk 80% energiebesparing. De geselecteerde projecten – met publiekprivate consortia bestaande uit vragers en (een combinatie van) aanbieders van energiezuinige gebouwconcepten aangevuld met een lokale overheid – zijn gestart in 2013.
II. Adaptability

BOUNDARY CONDITIONS - APPLICABILITY

Terraced houses
Dimensional characteristics

- Roof length ca. 4,5-6m
- First height: roof 2,0-2,7m; floor: 2,0-2,7m
- Garden depth = 1,4
- Dwelling depth = 7,5-3,0m

Diverse additions

- Dormers
- Extensions
- Balconies
- Overhangs

Energetic improvements

- Solar panels
- Aluminium
- Insulation
- Installations
- Steel
- Green roof
- Bricks
- Insulation

Customizing renovation elements on household level

- Difficult to customize
- Partly customizable
- Relatively easily customizable

Boundary: fixed roof length for sp

1. Angle determined by slope existing; unit height and width adapts to fluid.
2. Height determined by gl width and gl roof length; height adapts to fluid.
3. Boundary for same purpose as glass.

POSSIBLE SOLUTIONS - APPLICABILITY

Glass house
Overview conditions

- Roof
- Facade
- Existing roof slope
- Fixed

Dealing with width - roof

- Realigning walls parallel: 5.50m
- Differences caused by positions
- Reusable customised windows parallel
- Glass panels need to be adaptable in length

Dealing with height & slope & depth

- Some aspects fixed and some adaptable, either to fit the existing or to deal with renovation elements slope, height, depth, roof length
- Same principle would work for the front facade and side facade

Source: DENNIS Positive Living
Dak heeft houtconstructie met als basis poren of gordingen en versimpelde spanten voor grote overspanning. Vanaf ca.1965 geprefabriceerd.

Vloeren tot 1955 hoofdzakelijk van hout. Daarna instm brand veiligheid vooral systeemvloeren, zowel prefab als in het werk gestorte vloeren.

Begane grondvloer tot 1950 nog vaak van hout met steenachtig materiaal in smalle beuk. Daarna hoofdzakelijk toepassing systeemvloeren.

Bouwmuren bijna altijd massief uitgevoerd met stapelbouw kalkzandsteen of betonblokken of elementbouw met beton. Soms getrouw of combinatie.


Indeling (gevel en plattegrond)
- Constructietypologie verticale delen
- Constructietypologie horizontale delen
- Hoofdzakelijke overspanning

Vanaf 1965 naast inmetselkozijnen ook vaak pui-elementen met open en dichte delen. Deze hebben geen dragende of stabiliserende functie.

Tot 1965 standaardisatie kozijnen en vervanging gemetselde lasten door prefab beton, gewapend metselwerk of staal-koudebruggen.

Vanaf ca. 1965 met systeemvloeren naast doorzonooring ook één-beukige woningen. Hierdoor meer verhoudingsvariatie en tuinkamertypologie.


Van 1965 naast inmetselkozijnen ook vaak pui-elementen met open en dichte delen. Deze hebben geen dragende of stabiliserende functie.

Tot 1965 standaardisatie kozijnen en vervanging gemetselde lasten door prefab beton, gewapend metselwerk of staal-koudebruggen.

Source: Reimarkt
### III. Maintenance

#### III.1. Example maintenance plan for 16 1960s terraced houses.

**Source: Reimark**
### Example cost PV installation

<table>
<thead>
<tr>
<th>Position</th>
<th>Artikelnum</th>
<th>Bezeichnung</th>
<th>Anzahl</th>
<th>Verpackung</th>
<th>Einheit</th>
<th>Preis</th>
<th>Marge %</th>
<th>Consumente</th>
<th>project totaal</th>
<th>zonder marge</th>
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<tbody>
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<td>18</td>
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</table>

Source: Reimarkt
### Example cost Installations

#### Appendix

**Source:** Reimarkt

---

### Overzicht kale kostprijs (excl BTW en winstmarge)

<table>
<thead>
<tr>
<th>Kosten materiaal</th>
<th>Kosten</th>
<th>Kosten assemblage in fabriek</th>
<th>Kosten transport</th>
<th>Kosten montage op bouwplaats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Categorie</td>
<td>Kosten</td>
<td>Categorie</td>
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<td>Zec Module</td>
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<td></td>
<td>Geluiddempers</td>
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<tr>
<td></td>
<td>Voorraadvat tbv tapwater (150L)</td>
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<td></td>
<td>Revestigingsset voorraadvat</td>
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<td></td>
<td>Buitenveger</td>
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<td></td>
<td>Buffervat (50L)</td>
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<tr>
<td></td>
<td>Schaarlift tbv installatie</td>
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<td>in woning</td>
<td>MFT Thermostaat</td>
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<td></td>
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<td>RFT ventilatiediening</td>
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<td>Spidar monitoring</td>
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<tr>
<td>Totaal</td>
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<td>€ 6,048,25</td>
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<td>€ 1,520,00</td>
</tr>
</tbody>
</table>

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### Waar en hoe zou het goedkoper kunnen en waar en waarom niet? (rood=nieu, groen =wel)

<table>
<thead>
<tr>
<th>Kosten materiaal</th>
<th>Kosten assemblage in fabriek</th>
<th>Kosten transport</th>
<th>Kosten montage op bouwplaats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Categorie</td>
<td>Toelichting</td>
<td>Categorie</td>
</tr>
</tbody>
</table>

Betref indicatieve kostenopgave, definitieve kostenopgave kan plaats vinden aan de hand van Pilotproject.

Betref investeringskosten aan voorankt. Er zal zeker ook naar TCO model over periode (nader te bepalen) van 25-40 jaar gekeken moeten worden.

Optioneel kan nieuw te ontwikkelen VRU (€ 500,-) worden opgenomen om warmte las te regenereren naar bron.

Subsidie mogelijkheid WPU 3 = € 2800

Om arbeid op de bouwplaats te minimaliseren zullen alle opwekers in een prefab samenstelling worden samengebouwd en geleverd.

Opwekking voor verwarming en eventuele koeling worden gerealiseerd door een warmtepomp met bodembron.

Afghoosysteem zijn bestaande radiatoren.

Ventilatie zal worden uitgevoerd thru centrale WTW zonder zonering.

Monitoring vindt plaats door Spider monitoringsplatform.
## IV. Financial model

### Table: Calculation Result

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Value</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>Total energy bill savings</td>
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<tr>
<td>Total energy bill cost increase</td>
<td>€3,274.10</td>
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<tr>
<td>Total renovation cost</td>
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<td></td>
</tr>
<tr>
<td>Total potential loan recovery</td>
<td>€6,455.00</td>
<td></td>
</tr>
<tr>
<td>Total renovation cost plus energy bill savings</td>
<td>€1,183.67</td>
<td></td>
</tr>
<tr>
<td>Total renovation cost plus energy bill increase</td>
<td>€9,937.25</td>
<td></td>
</tr>
<tr>
<td>Total renovation cost plus energy bill savings</td>
<td>€6,455.00</td>
<td></td>
</tr>
<tr>
<td>Total renovation cost plus energy bill increase</td>
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<tr>
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<tr>
<td>Total renovation cost plus energy bill savings</td>
<td>€1,183.67</td>
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</table>
V. Building process

One of the assumptions generally done is that the building industry (in the Netherlands) is not innovative. This could be one of the reasons that also the business model behind the net zero energy renovation as proposed by the Energiesprong is not ready or even existing yet. An innovative renovation should therefore also reconsider the way we’ve organised our building processes. Industrialisation, 3D printing, 3D measurements and other new, smart technologies could change that process.

V.I. Current situation

The building sector as it is structured now is very linear. That way the product development is far away from the user. The result (and problem) with this model is that the demand from the users will not always return to the producer because there are a lot of parties between the customer and the real producer of the technologies.

The result is that the producers of new technologies are often trying to innovate by optimising their current technology.

In general we can say that the current building industry thinks in projects, not products.

V.II. Ideal Building Process

In an ideal building process, innovation would be demand oriented. That would mean that product development would stand closer to the customer. Innovation wouldn’t only imply optimisation of technology by increasing efficiency etc. But much more it would mean listening to the customers and adapting technologies to fit their needs.

An example could be the continuous desire of an installation company to improve the coefficient of performance (COP) of a heatpump to increase sales of this heatpump. The problem with this heatpump for the customer however is not necessarily the COP, but more the shape of the boiler. Changing this shape so that it would fit under neath a staircase or a pitched roof could solve this problem.

V.III. Reimarkt situation

At Reimarkt we have the wish to sell products to our customers. The only problem is that the products that we think the customers want to buy are not always available. That is why Reimarkt has its “product development” team. Not so much to develop new technologies, but rather to return the demand of the customer to the producer and develop new products together. An important focus point in this is to ask the question to the right party. For building companies the contactpoint for installations would usually be wholesalers (groothandels) that wouldn’t be developing the products themselves. For the product development team of Reimarkt it is therefore important to only work with the producers that are doing product development themselves.

V.IV. Proposed Building Process

In the scheme on the next page I’ve proposed a new structure for the product development with Reimarkt. What is important are the following points:

- Reimarkt concept has its own product development department
- Local stores are selling Reimarkt products
- The product development works with two types of producers: Group 1 are producers with products that do not need further development. They will be chosen based on product (vision). Group 2 are the producers that will become part of the development team. With a 10% adaptation their products can...
become part of Reimarkt concepts and sold in the stores.

- The user is closer to the development.
- The builder is not producer, assembler and installer any more. Production will be done at a fixed location. Local builders will install products on site.

- Feedback from customers, local Reimarkt shops and local builders will form input for the product development.

The expectation at Reimarkt is that if our initial investment for product development is high the building price will drop more than in a traditional product development process. (Figure ?)
VI. Reimarkt topics

**No-regret en productlijn**
Overzicht elementen, pakketten & producten en no-regret relatie

**Toelichting**
1. **Overzichtelijk & simpel naar de klant:** elementen, pakketten & totaal producten.
2. **No-regret stasgewijs:** centraal staat dat iedereen moet kunnen doorbouwen naar duurzaam wonen in zijn eigen tempo (element stappen, pakketstappen of in één keer), met zo min mogelijk kapitaal vernietiging, materiaal vernietiging en demotivatie. Hierbij proberen we de voorinvestering in een volgende stap zo laag mogelijk te houden: zo min mogelijk betalen voor wat je nu nog niet gebruikt/wil.
3. **No-regret uitwisselbaar:** de uitbouwproducten (p-à-l en dynamisch wonen) zijn no-regret uitwisselbaar. Dat wil zeggen dat je de een kan weghalen om de ander te plaatsen. Streven is om dit te kunnen doen zonder meerkosten voor demontage (dit zou kunnen door circulaire gedachte en hergebruik) en dan het ‘gewone’ bedrag betalen voor de nieuwe uitbouw. Deze uitwisselaarheid moet mogelijk zijn, maar hoeft niet geoptimaliseerd. Mensen kopen p-à-l niet omdat het uitwisselbaar is, maar omdat ze een prachtige tuinkamer willen. Het is mooi meegenomen dat deze eventueel gratis kan worden weggehaald en ze een ander product kunnen kopen, (een reden om bij Reimarkt te kopen) maar in principe kopen ze de tuinkamer met de gedachte ‘voor altijd’. Als mensen flexibiliteit en optimale aansluitbaarheid willen, dan kopen ze dynamisch wonen, waarbij mensen bij wijze van spreken elke 5 jaar anders kunnen wonen voor slechts 1000 euro inwisselkosten. Centraal staat: mensen willen wel betalen voor wat ze willen hebben (klantwaarde), maar niet voor wat ze niet hoeven. Niet iedereen hecht waarde aan optimale aansluitbaarheid.
4. **Stimuleren van grote stappen:** Centraal staat dat we met elkaar de bestaande woningvoorraad willen verduurzamen. Hiervoor is het goed als we zoveel mogelijk doen aan onze woningen, passend binnen een budget. Om grotere stappen te stimuleren, zijn elementen relatief duur, dan pakketten en producten het goedkoopst. Dit is ook realistisch, omdat het in proces en integratie veel efficiënter is om grotere stappen in één keer te zetten (dit hoeft dus niet teruggestaan naar andere marges voor Reimarkt). Om ook te stimuleren bijvoorbeeld 2 pakketten te kopen ipv 1, zonder dat dit gedefinieerd is als nieuw pakket (wordt veel te complex naar de klant!!!) kunnen we zeggen: per pakket extra = -1000 euro op de totaalarief.

Source: Reimarkt
VII. Design details Reimarkt
Nicer Home concept

Source: Reimarkt / Plegt-Vos