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 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 NZER in general
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).
The second product I created is the overview of value aspects for renovations. Initially, I focused 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.
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.

 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.

7.4. Recommendation for further research
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.