Tendering strategy for the sustainable social housing industry

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ABSTRACT,

This thesis is about an innovation in the Dutch construction market: NoM houses. Social renting houses who are not energy efficient, are being renovated into energy neutral houses. These energy neutral houses are called NoM houses. The social renting houses belong to the social housing cooperatives. At the moment, the costs for renovating these social renting houses are still too high, however it is expected that these costs will decline in the future due to amongst others the learning effects and the application of industrialization practices in the construction market. The purpose of this thesis is to set up a tendering strategy for social housing cooperatives to reduce the costs of a NoM renovation to at least €30,000. The estimation of the cost price is done with a learning curve. After using a start price of €130,000 per NoM renovation and a learning rate of 90%, the learning curve is calculated. Take into consideration that currently the NoM renovation price floats around €60-70,000, we conclude that there is still space left for further cost reduction based solely on learning effects. Though, the learning curve tend to flatten around €40,000, which is not enough, because the market wants to go to €30,000 or even less. The remaining €10,000 of the cost reduction should thus come from economies of scale effects such as joint procurement activities and industrial construction practices. Regarding the distribution of the number of renovations over the 5 year, it can be concluded that the renovation production should start prudently with a low number of renovations and that this should be increased in an incremental and exponential way over 5 years.

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1. INTRODUCTION

``Nul op de Meter`` (NoM, which is Dutch for zero on the meter) is the concept where houses are isolated and provided with smart technologies in such a way that they are energy neutral. This is possible with an upgrade of the houses with amongst others a new façade, smart installations and an own energy generation ("Wat is Nul op de Meter?," 2017). Such adjustments on houses costs currently around €70.000. It is expected that these costs will decline substantially when it is possible to industrialize the necessary technologies, when these technologies can be applied extensively and when the construction industry can benefit more from learning effects. However, there is a lot of uncertainty how the industrialization and economics of scale should be applied in the case of the social housing industry. In the context of this paper, with a NoM renovation we are referring to a NoM upgrade applied to houses in the social housing industry in The Netherlands. There are many of these kinds of houses and the houses themselves show many similarities. This makes them great for a NoM renovation, because economies of scale and industrialization can be applied on these houses. In this thesis, we will answer the question how should the tender offer of the tendering strategy for the NoM renovations look like? To answer this question, the learning curve will be used to estimate future costs of the NoM renovation.

2. BACKGROUND INFORMATION

2.1 What is Nul op de Meter?

As already stated in the introduction of this thesis, a NoM renovation is a renovation of a house in such a way that it will be energy neutral on average. NoM is not a specific product from a single company; it is a general term for houses who are energy neutral. Thus, any type of house can be a NoM house e.g. an apartment house on the 5th floor, a suburban house or an estate house. There is also no consensus how such a NoM house looks like. Pioneering construction companies already renovated several 100 NoM houses and they differ a lot from each other: some look like aesthetic futuristic houses while others look like standard newly build houses. At the moment, it takes around 10 days to renovate a house to NoM house. Currently, a NoM renovation consists of the application of many components to the house (Roskam, 2015):

- Thermic isolation of the new peel/façade of the house
- Triple glass windows
- Isolation of the door chinks
- Solar panels
- Active ventilation systems
- Heating by means of a heat pump. This pump takes heat out of the soil under the house

An example of a NoM renovated social renting house can be seen in figure 1.

Figure 1. Example of a social renting house renovated to a NoM social renting house. On the left side, the original social renting houses can be seen (Sacon, 2016)**.**

2.2 The social housing industry

To get a better understanding of the current social housing industry, a brief explanation is given. The social housing industry is a big industry in The Netherlands. In the Netherlands, the term social housing applies specifically to rental housing subsidized by the government (Dolata, 2008). On the supply side, the housing cooperatives can be found. A housing cooperative in The Netherlands can be described as a nonprofit organization that focuses on building, managing and renting of affordable houses ("Woningcorporatie," n.d.). These housing cooperatives have a big portfolio consisting of many houses. The demand side consists of people whose wealth is not big enough to buy a house or pay the market housing rent. The housing cooperatives make available their houses for these people to rent these houses against reduced prices. These prices are lower than the market prices due to subsidies which are given by the government of The Netherlands. Here below, a schematic overview of the Dutch social housing industry without energy providers can be seen.

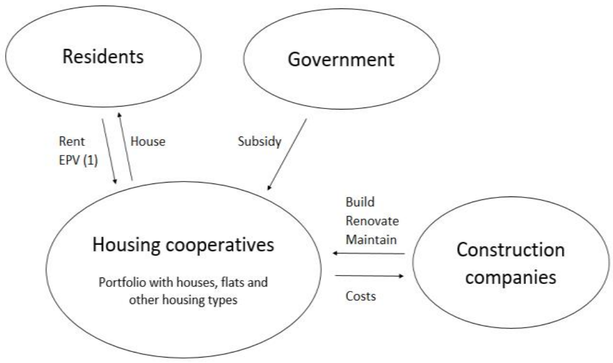

Figure 2: A schematic overview of the Dutch social housing industry without energy provider. (1) The EPV is only applicable when the house is a NoM house. More about the EPV will be explained in section 2.4.

There are many kinds of social renting houses and the houses themselves show many similarities. According to the Dutch government, 2.402.360 houses out of the 7.588.000 in The Netherlands belong to the social house cooperatives, which is around 32% of the total houses in The Netherlands ("Cijfers over Wonen en Bouwen 2016," 2016). As a result of the Second World War and the subsequent baby boom, there was a deficit of houses after the Second World War. This led to the construction of many similar housing projects in the following decades which can be seen in figure 2 (Dolata, 2008).

Figure 2. A typical social housing residence in The Netherlands.

Uniformity of the houses, a big supply of houses, EPV and social cooperatives who mostly share the same ideology make up for a favorable situation where NoM renovations can be applied. More about EPV will be explained later. The 4 previously mentioned factors allow for a massive NoM renovation project by means of the application of economies of scale applications such as industrialization of the construction industry. More about the industrialization of the construction market will be explained in section 2.3..

To renovate the houses, housing cooperatives make use of tendering processes to select suitable candidate(s) who will build and renovate the houses. The candidates are in this case the construction companies. More about tendering will be explained in section 4.1.

2.3 Industrialization of the construction market

One big driver that makes possible the NoM renovation on a big scale is the *industrialization of the construction industry*. ``Industrialized construction applies production processes and technologies from the manufacturing sector to construction in order to improve key project objectives of time, cost, quality, environment and safety``(Goh & Loosemore, 2016). This means that the components and other parts like the façade and roof are manufactured as complete as possible at a location away from the project. This is called off-site prefabrication. These components can be installed directly at the site, which are in this case the houses those are being renovated. The growth numbers of the labor productivity of the construction market are far behind that of almost all other industries in the world. The growth in productivity is actually almost zero in the last 2 decades (Energielinq, 2017). Though, huge potential is ahead to increase the labor productivity with amongst others an industrialization of the construction market.

The off-site prefabrication has several advantages. Less time is needed to install the components at the site location which results in less nuisance for the residents. Besides that, the components can be manufactured in a more efficient way due to the advantages which are present in a manufacturing system like economies of scale and automation. This results in lower renovation costs. Thereafter, (Court, Pasquire, Gibb, & Bower, 2009), (Yunus & Yang, 2011) showed that off-site prefabrication can reduce safety risks by 35% as a result of less congestion on the site and removing operations from the site to a more controlled factory environment with better working conditions. ``Off-site prefabrication has also been proposed as an effective way of reducing the negative environmental impacts of construction through reduced waste, increased reuse and recycling and reduced emissions on-site and in use`` (Goh & Loosemore, 2016). Finally, it is said that maintenance costs and construction quality are improved due to tighter managerial production control. According to a McKinsey report, it is said that total productivity in the construction sector can be boosted by 50-60% when several actions, where off-site prefabrication is (one of) the most important, are taken (van der Groep, 2016).

Because there are so many houses that should be converted to NoM houses, off-site prefabrication is a very effective and suitable way of constructing in this case.

2.4 Financial facts about the NoM renovation

In this section, some financial facts of the NoM renovation are highlighted. When looking at the costs of the NoM renovation for social renting houses, it makes sense that housing cooperatives fear the high costs of the renovation. The first NoM renovation costed around €130,000 (Stroomversnelling, 2015). At the moment, these costs declined to around €60-70,000 under ideal circumstances. With ideal circumstance it is meant that the costs are exclusive additional costs as a result of overdue maintenance, independent installed facilities (ZAV in Dutch) and other deviations which result in additional costs (Stroomversnelling, 2015). To reduce the costs, a smart solution is set up for these social housing cooperatives. Due to the fact that a NoM house is energy neutral, it has no gas and electricity costs during normal operation. These costs are normally paid by the renters of house. To spread the costs of a NoM renovation, the same amount which is normally paid for the electricity and gas bill by the renters will be paid to the social cooperatives. This is called the EPV. The EPV is thus an amount that the renter pays to the owner (the social cooperative) because of the energy neutrality of the house (Rijksoverheid, 2017). So the renters pay the same amount before the NoM renovation to the social cooperatives, which means that the renters get a more modern and energy neutral house for free or barely rising costs. The social housing cooperatives can use the money collected from the EPV to offset the NoM renovation costs. The EPV system is set up by the Dutch government and is operative since May 2016.

Instead of talking about the costs to renovate a house only, it is more valid to talk about the total cost of ownership or TCO. The TCO of the NoM renovation looks at the total cost during the operational period of the NoM renovation. This means that it also includes maintenance costs over time, but also benefits such as the value increase of the NoM houses (Chegut, Eichholtz, Holtermans, & van Marwijk, 2014). To look at the profitability the IRR is used. ``Internal rate of return (IRR) is a metric used in capital budgeting measuring the profitability of potential investments. Internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero`` ("Internal Rate Of Return - IRR," n.d.). When looking at the TCO, the internal rate of return (IRR) of an average NoM social renting house is 4.5% while a social renting house with energy label B, that is pretty energy efficient but not energy neutral at all, has an average IRR of 2.1% (Energielinq, 2017). Besides that, a NoM house has a lifespan of 40 years and a label B house has a lifespan of 25 years. So, although the investment costs of the NoM renovation costs are pretty high, the high IRR which is a result of the EPV and the longer lifespan of the NoM house makes this long-term investment attractive.

3. RESEARCH QUESTIONS AND PLAN OF APPROACH

3.1 Research questions

To make the research questions more useful in this thesis, the SMART criteria principle is used. It says that an objective should be specific, measurable, achievable, responsible and time-related (Doran, 1981).

Main research question: Which tendering strategy should housing cooperatives implement in order to decrease the price of NoM products substantially, that is to around € 30,000, in 5 years?

Sub question 1: What kind of tendering strategies are available in the context of the relevant problem?

Sub question 2: What is a learning curve and is it possible to apply the learning curve on the NoM renovation?

Sub question 3: How does an eventual learning curve of a NoM renovation looks like?

Sub question 4: How many houses are needed for a construction company to realize sufficient cost savings, that is a cost price around € 30,000?

3.2 Plan of approach

As you have already read, some background information of the problem was given. Section 3 contains the research questions and the plan of approach. This will be succeeded by the literature review & possible approach which is section 4. It will contain the current knowledge, findings about the topic and a possible approach to solve the problem. In this section, sub question 1 and the first part of sub question 2 will be answered. In section 5, the method to calculate the learning curve will be applied to the data we collected. With this learning curve, a tendering strategy can be set up. Sub question 2 and 3 will be answered in this section. This will be followed up by section 6 Results and Discussion and section 7 Conclusion. Sub questions 2, 4 and the main research question will be answered in section 6 and 7. To complete this thesis, section 8 will contain the limitations, further research and completion, followed up by the acknowledgements and references.

The thesis research is considered qualitative with some quantitative aspects. This thesis can be seen as a mix between mainly a desk research and in-depth interviews. ``Desk research is based on using previous research done by other researchers and the information that you can directly retrieve from the internet or from the library`` (van Tulder, 2012). A small part of the thesis consists of in-depth interviews. Interviews will be held with the director of Stichting Pioneering and the graduation committee member of the University of Twente, while some short telephone interviews will be conducted with big construction companies in The Netherlands. Both primary and secondary resources will be used in this thesis. Information is considered a primary resource when the information comes from the original source (van Tulder, 2012). ``Secondary source materials, then, interpret, assign value to, conjecture upon, and draw conclusions about the events reported in primary sources. These are usually in the form of published works such as journal articles or books, but may include radio or television documentaries, or conference proceedings. ``("Distinguish Between Primary and Secondary Sources: Home," n.d.). The face to face and phone call interviews are primary resources, while the other sources of information such as websites and books are secondary resources. This thesis will contain both qualitative and quantitative data. Most of the thesis will consist of the former.

The author works in cooperation with Stichting Pioneering. This foundation contributes to social issues by innovating the entrepreneurship in the construction market ("Stichting Pioneering," 2017). The foundation`s objectives are as follow:

- Strengthen the economic power of the construction related companies in Twente.
- Innovation fostering of the construction industry in the region of Twente in such a way that this industry is characterized by innovative, progressive and dynamic
- Insuring and promoting the employment in the construction industry in Twente.

This thesis will focus only on the social housing industry with single-family houses which are already build; the NoM technologies are already applied to many new build houses, because the NoM technologies are already cost-effective for new build houses. Also, not all single-family houses are considered because some houses are too new and modern while others are too old and are ready for demolition. Thereafter, this thesis focuses only on The Netherlands. However, if the results of thesis are useful, they can be partly applied in other countries.

4. LITERATURE REVIEW & POSSIBLE APPROACH

This sections begins with a literature review which will include a summary and synthesis of what is already known about the topic. This will be followed by a possible approach: what can we possibly do to solve the problem?

4.1 Tendering strategy

In order to set up a *tendering strategy*, prices of the NoM renovation should be estimated.

In this section, we will talk about tendering strategies. In 1956, Lawrence Friedman laid the foundation for tendering theory in ``A Competitive Bidding Strategy``, a paper of great importance for the development of what is commonly known as building economics (Runeson, 1996). To decide which tender strategy is the most suitable one, a tender strategy has to be explained first. The components of a tender strategies will be explained. The learning curve will be integrated in this strategy. In this strategy, I will also come up with some ideas and suggestions concerning the problem.

According to PIANOo ("Wat is een aanbestedingsstrategie?," n.d.), in a tender strategy the following will be set up:

- The size of the tender offer. In our case, this is referred to the number of houses and the total price of all these houses combined.
- The number of companies that will execute the tender. This can be 1 company, but also more companies.
- Determination of the ground lot and the description of it.
- The organization of the tender offer.
- The steps in the tender offer and how these steps are carried out. This includes among others the way of selecting and whether the tendering is going in a digital way or not.

In section 5.4, more about the tendering strategy will be discussed. To calculate the costs of the NoM renovation for the size of the tender offer, we use a learning curve. With some trial and error, we will find a suitable distribution of the NoM renovations over the 5 years and therewith we can calculate the size of the tender offer.

A suitable method to foster and improve innovation and quality of the NoM renovation, housing cooperatives can use the concept of competitive dialogue. ``The public procurement directive defines the competitive dialogue procedure as a procedure in which any economic operator may request to participate and whereby the contracting authority conducts a dialogue with the candidate admitted to that procedure, with the aim of developing one or more suitable alternatives capable of meeting its requirements, and on the basis of which the candidates chosen are invited to tender`` (Uttam, Le, & Roos, 2014). Because this thesis limits on 1 company that is involved in a tender offer, the competitive dialogue is not used. Though, it is a useful tender method that housing cooperatives can use.

Another procedure that might come in handy for housing cooperatives are innovation partnerships. ``An innovation partnership is a new procedure in the European directives 2014/24/EU and in the Aanbestedingswet 2012 (tendering law in Dutch). This procedure can be used for the procurement of products and services which are not available at the market or are not on the desired quality level yet``(“Innovatiepartnerschap,” 2017). The client, which is the housing cooperative in this case, gives the problem or the need and the construction companies propose an innovative solution. This procedure will not be considered because it is beyond the scope of this thesis.

4.2 Cost reductions over time

To estimate or calculate how the NoM renovation costs looks about in the future, the classification from the Clean Electric Power Technologies report is used. They classify four principal ways in which costs come down over time (O`Connor, 2016):

- Research and development. This leads to innovations which can make products, processes and services more efficient.
- Learning by doing or *learning effects* This is a byproduct of manufacturing and deployment.
- Economies of scale. When companies or industries are getting larger and larger, the fixed costs can be spread over a larger volume which results in lower costs.
- Learning by waiting. This is essentially just waiting for the others to innovate and then copy the innovations.

The 3 biggest drivers that reduce the costs are the economies of scale effects, learning effects and R&D effect. The learning by waiting effect is an effect that takes more time and thereafter it does not match with the Dutch entrepreneurial mindset. Research and development can have big effects on cost reductions. Off-site prefabrication, industrialization of the construction industry, lean building, 3D printing, solar panels etc. are examples that arisen from this driver. These techniques and systems are thus already invented, though they are not full time applied. When (some of) these techniques or other innovative useful techniques are getting applied, the learning effect and economies of scale effect takes place. These effects will have huge effects on the NoM renovation costs. Sometimes it is very hard to say if costs came down due to economies of scale effects or learning effects; the line between these two effects are blurry. One important difference between the two effects is that learning effects tend to happen more in the short term production and to a lesser extent in the long term production, while economies of scale effects are an outcome of long term production (Pindyck, n.d.). Although the economies of scale are extremely important to achieve cost reductions, this thesis is focusing on the learning effects. So, the three effects other than that of the learning are mainly excluded in this thesis.

4.3 Learning curves

To estimate the costs of the NoM renovations in the coming 5 years, the *learning curve* will be used. With these costs, the number of houses that should be renovated per year can be calculated. The learning curve was firstly applied by T.P. Wright in his paper in 1936 about direct labor costs in the airplane industry. Learning curves are mathematical models used to estimate efficiencies gained when an activity is repeated (Stump, n.d.). As organizations produce more of a product, unit cost of production typically decreases at a decreasing rate. This phenomenon is referred to as a learning curve, a progress curve, an experience curve, or learning by doing (Argote & Epple, 2017) In the context of this paper we are referring solely to the learning curve.

Learning curves are not used a lot in the construction industry. Still, they are suitable to be applied on this industry (Srour et al., 2009). Due to the off-site prefabrication of the NoM components, the learning curve is even more applicable because learning curves are originally intended for the manufacturing industry.

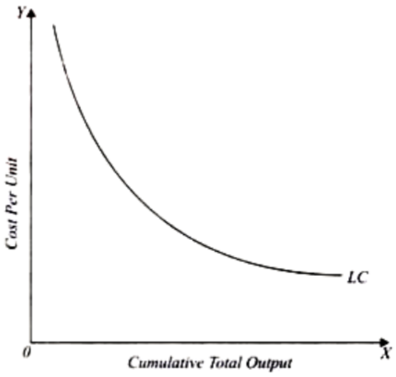

Figure 3: An example of a learning curve.

5. APPLICATION

5.1 Learning curves

There are several conditions that should be met to apply the learning curve:

- *Repetition of tasks.* If there is no repetition in the tasks, there will be no learning (Shmula, 2007) .

- *Absence of heavily customization of the product.* Slopes tend to flatten, even for a small number of units, when there are minor changes in the product configuration. When each product is heavily customized every time, learning will approach 100%. That is, no learning at all. More about the learning rate will be explained later.

- *Continuity of workers.* These should be no or little breaks in the production. Besides that, employees should not leave on a regularly basis. If many employees who work with the NoM renovation leave on a regularly basis, the learning process for new employees has to start over again ("The learning rate and learning effect," 2017).

- *The presence of manual operations.* Individuals and organizations learn from their faults and handlings. Machines not: the 5th output unit of e.g. an automated punch machine will be the same piece of iron as the 120th unit when the conditions are the same.
- *Complex operation.* If the operation is considered very simple, little or no learning will take place. Think about a job where someone must lift and move objects on a continuous basis. Although all conditions mentioned above are met, no or very little learning will take place, because the operation is considered too easy.

In section 5.2 it will be checked if these conditions are satisfied for an application on the NoM renovation.

The learning curve function is defined as follows according to Management and Accounting Web (James R, n.d.):

$$Y = aX^b$$

Where:

Y = the cumulative average cost per unit.

X = the cumulative number of units produced.

a = cost required to produce the first unit.

b = slope of the function when it is plotted on log-log paper.

b is calculated with the following formula:

$$b = \frac{\log learning\ rate}{\log 2}$$

The *learning rate* is described as a percentage. However, to take the logarithm of the learning rate, it should be denoted as a decimal instead of a percentage. The learning rate ranges between 0% and 100%. ``You might expect that a 100% slope reflects a furious rate of learning, but quite the contrary. It represents no learning at all. 0%, on the other hand, reflects a theoretically infinite rate of learning, if such a thing can be imagined.`` Still, it is possible to have a learning rate above 100% due to forgetting of the employees. Obviously, we will not include this in our thesis, because this hardly happens. In practice, human operations hardly ever achieve a learning rate higher than 70%. The effective range of industrial learning is essentially between 70% and 100% (James R, n.d.). A learning rate of e.g. 80% means that for every doubling of the units, the costs will be 80% of what they were before doubling.

How are learning rates determined? When data about the number of units and the costs/time per unit is available, it is possible to calculate the learning rate. This is done by dividing the cumulative average cost/hours per unit by the cumulative average cost/hours per unit of the previous doubling. The cumulative average cost/hours can be hound by dividing the cumulative costs/hours by the cumulative units. When there is no data available about the costs and hours, it is wise to look the learning rates of similar products.

The biggest driving factor behind the learning rate is the degree of automation of the operation. The higher the degree of automation, the higher the learning rate which results in a flatter curve. So a higher degree of automation results in a higher learning rate and thus in lower learning effects.

Representative learning rates	
Aerospace	85%
Shipbuilding	80%-85%
Machine tools (new models)	75%-85%
Electronics (repetitive)	90%-95%
Electrical wiring (repetitive)	75%-85%
Machining	90%-95%
Manual assembly + 25% Machining	80%
Manual assembly + 15% Machining	85%
Manual assembly + 10% Machining	90%
Punch press	90%-95%
Raw materials	93%-95%
Purchased parts	85%-88%
Welding (repetitive)	90%

Table 1 shows representative learning rates compiled from various sources in the literature. There will be considerable variation from one organization to another within these large categories (Lee, 2014)

5.2 Learning curve

First of all, we need to look at the conditions. Is it even possible to apply the learning curve? We are going to look at the 5 conditions mentioned at section 4.2.

- We are dealing with repetitive tasks; to meet the obligation set by the Dutch government a very large number of houses must be renovated to NoM houses. Not every house will be the same, however it is expected that the process of renovating will be the same in overall.
- The 2nd condition is critical one in this case. We assume that most houses are the same due to the uniformity of many social renting houses. Still, there are even differences between houses that were totally similar when they were build. One house is better maintained while some other houses expanded with car pods, dormers and conservatories (ZAV in Dutch). These houses can be seen as ``special cases``. Luckily, there are still enough houses that remained original and thus it can be said that these houses are not customized. For these houses, this condition is met. In this thesis, we will focus on these houses from now on.
- We assume that the continuity of the workers is guaranteed. When the working conditions and wages are sufficient, we expect no problems with this condition.
- Due to the industrialization of the construction industry, the labor intensity on the constructions site is decreasing significantly. Though, there are still enough human operations concerned with a NoM renovation such as planning, managing, transporting, installing etc. Besides that, components such as

- prefab walls that are made in the factory also require some labor. So, the industrialization of the construction industry does not cause that this condition is not met, though it results in a higher learning rate and thus in lower learning effects. Still, in the beginning phase of the off-site prefabrication site, the labor intensity is high due to lower investments in the factories; there is still a lot of uncertainty for construction companies with the NoM renovations after all. When NoM renovations are becoming more and more familiar and cheaper, more investments in automation will be done. This can be considered as a part of the learning curve but also some economies of scale effects are in force here.
- The NoM renovation can be seen as a pretty complex operation. This is confirmed because e.g. the Stroomversnelling already received many complaints about the duration of the renovation and the quality of the NoM houses in general (BNR, 2016).

When looking at the conditions above, it can be concluded that the conditions are met. Thus the learning curve can be applied.

To create the learning curve of the NoM renovation, a learning rate must be set up first. The most correct way to do that is to look at the data of the costs and calculate the learning rate with this data. This can be seen as a post ante way of calculating the learning rate. When there is a lack of data this can lead to an invalid learning rate though. Due to the fact that our data is rather raw, limited and unsorted we do it in another way: by looking at the degree of automation of the product. This can be seen as an ex ante way of calculating the learning rate. The reason for the lack of data in this project will be given in the limitations part. Given the fact that the total process of renovating is still labor intensive you would expect a pretty low learning rate, which results in high learning. However, if the process will be up scaled, more automation and robotization is expected which results in less learning. This is still part of the learning process though. On the other hand, it is known that the learning rates in the construction industry are high. When considering these facts, comparing this industry with other industries and conducting an interview with the director of Stichting Pioneering which is an expert in this field, a learning effect of 90% is determined. The slope of the learning curve matches with the costs of the NoM renovations which were qualitatively collected during the interviews.

The total costs of the first unit must be determined. In this thesis, we use the data of 1 relevant construction company. The first unit cost is € 130,000. We do not take in consideration the maintenance and other operational period cost of the TCO, because they are not suitable for a learning curve application.

With the condition check and the input data of the first unit costs and the learning rate, an output can be calculated. This is done via MS Excel.

5.3 Learning curve

To calculate the learning curve of the NoM renovation the following calculation is used:

$$Y = 130{,}000 * X^{-0.152003093}$$

Where b is calculated via:

$$b = \frac{\log 90\%}{\log 2}$$

As explained in section 5.2, a learning rate (LR) of 90% is used. To gain insights in the other learning curves, we added the learning curves with a 85% and 95% learning rate. The curve has the shape of a hockey stick; the first part of the curve is very steep while further on, the curve tend to flatten.

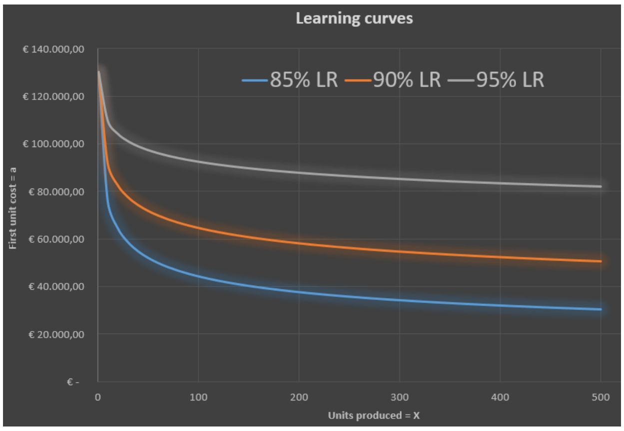

Figure 3: the learning curve of the NoM renovation

The orange curve shows us that because of the learning effects, the cost price per united decreases from €130,000 to around €50,000 when 500 units are produced.

5.4 Tendering strategy

In section 4.1, a definition of a tendering strategy was given. In this thesis, some components from this tendering strategy are omitted while I on other components will be focusing.

- The size of the tender offer. This will include the number of houses and the prices of these houses. To define the prices of these houses, among others the learning curve is used. When the learning curve is defined, a more estimated guess of the future costs of the NoM renovations can be given. When the costs are known, the number of houses can be defined.
- The number of companies that will execute the tender. This part is difficult. On the one hand, housing cooperatives want as many as possible houses in the tendering process to make the eventual investments profitable; On the other hand, the more construction companies get a part of the total tender offer, the more different initiatives and developments will be taking into consideration. Due to time limits and complexity of the problem, we focus on the execution of the tender of 1 company.
- Determination of the ground lot and the description of it. In this thesis, only the kind of houses similar to those of who can be seen in figure 1 and 2 are used. These houses are the most common in The Netherlands and due to their uniformity, they are suitable for the NoM renovation.
- The organization of the tender offer. We will not focus on this component of the tendering strategy, so this component will be omitted in this thesis.
- The steps in the tender offer and how these steps are carried out. Also, this part will be omitted.

6. RESULTS AND DISCUSSION

6.1 Trial and error method to calculate the tender offer

In figure 4, the 3 learning rates of 85%, 90% and 95% can be seen. The range on the x-asis goes until 1500 units, that is X = 1500. It is the same figure than 3, however this one goes until 1500 units instead of 500 units to give a bigger picture of the case.

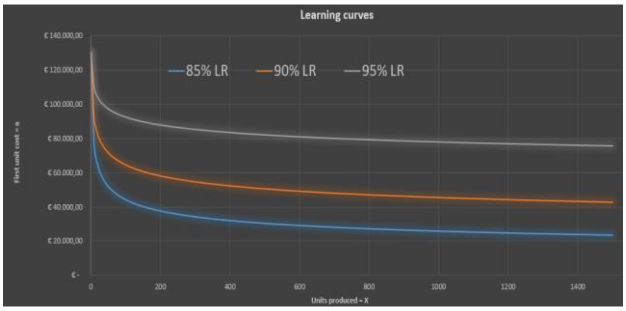

Figure 4: Learning rates until 1500 units (X = 1500)

Based on a 90% learning rate, the scenarios at table 2 are calculated. The first column shows the years; we limit us to 5 years from producing the first unit. The second column is about the distribution of the units over the 5 years. E.g. scenario 1 shows that every year 300 units will be renovated, while scenario 3 shows that the first year 40 units will be produced and this number of units will be raised every year in a some sort of exponential way. In column 3, the cumulative units at the beginning of the year can be seen. The reason why the units at the beginning of the year are taken, is simple: you learn by doing and when for example in year 3 a construction company has to set up a bid for its renovations that year, the bid price will be based on the experience it has gained in year 1 and 2. All scenarios will have a cumulative number of units of 1500 at the end; that is, we limit us to an unit size of 1500 renovations over 5 years. The fourth column shows us the cost price per unit for the given cumulative units; every cumulative unit has a different cost price after all. The higher the cumulative unit number, the lower the cost price. This is what the learning curve already showed. Column 5 shows us the total cost price, which is equal to the unit size times the cost price per unit. When this total cost price per year will be summed, we get the total cost price over 5 years, which can be seen in the right corner. In brief, this lead us to the next function:

$$\sum_{i=1}^{5} Xi * Pi$$

Where:

i = year

Xi = the number of units with the corresponding year.

Pi = The cost price per unit with the corresponding cumulative units at the beginning of the year.

To make the scenarios more realistic, two constraints are added. The first one is that the minimal number of renovations should be 20. The second one includes that the maximum yearly renovation capacity is equal to 1200 units. The latter prevents a situation where almost all the renovations are postponed and moved to the last year in order to get the lowest costs based on the learning curve.

6.2 Application of the trial and error method

The formula in section 6.1 gives us the following scenarios at table 2. The scenarios are already partly explained in that section.

Scenario 1						
Year	Units	Cumalative units at the beginning o/t year	Cost price per unit		Total cost price	
0	0	0	€	130.000,00	€	-
1	300	0	€	130.000,00	€	39.000.000,00
2	300	300	€	54.627,74	€	16.388.322,94
3	300	600	€	49.164,97	€	14.749.490,65
4	300	900	€	46.226,32	€	13.867.896,98
5	300	1200	€	44.248,47	€	13.274.541,59
		1500				
					€	97.280.252,16

Scenario 2						
Year	Units	Cumalative units at the beginning o/t year	Cost price per unit		Total cost price	
0	0	0	€	130.000,00	€	-
1	100	0	€	130.000,00	€	13.000.000,00
2	200	100	€	64.556,08	€	12.911.216,43
3	300	300	€	54.627,74	€	16.388.322,94
4	400	600	€	49.164,97	€	19.665.987,53
5	500	1000	€	45.491,90	€	22.745.949,80
		1500				
					€	84.711.476,70

Scenario 3						
Year	Units	Cumalative units at the beginning o/t year	Cost price per unit		Total cost price	
0	0	0	€	130.000,00	€	-
1	40	0	€	130.000,00	€	5.200.000,00
2	80	40	€	74.203,65	€	5.936.292,13
3	190	120	€	62.791,57	€	11.930.399,10
4	450	310	€	54.356,15	€	24.460.266,35
5	740	760	€	47.429,74	€	35.098.010,08
		1500				
					€	82.624.967,65

Scenario 4						
Year	Units	Cumalative units at the beginning o/t year	Cost price per unit		Total cost price	
0	0	0	€	130.000,00	€	-
1	40	0	€	130.000,00	€	5.200.000,00
2	60	40	€	74.203,65	€	4.452.219,10
3	200	100	€	64.556,08	€	12.911.216,43
4	400	300	€	54.627,74	€	21.851.097,26
5	800	700	€	48.026,36	€	38.421.085,97
		1500				
					€	82.835.618,76

Scenario 5						
Year	Units	Cumalative units at the beginning o/t year	Cost price per unit		Total cost price	
0	0	0	€	130.000,00	€	-
1	30	0	€	130.000,00	€	3.900.000,00
2	50	30	€	77.520,46	€	3.876.023,10
3	150	80	€	66.783,29	€	10.017.492,97
4	350	230	€	56.879,19	€	19.907.717,06
5	920	580	€	49.418,98	€	45.465.458,60
		1500				
					€	83.166.691,73

Scenario 6						
Year	Units	Cumalative units at the beginning o/t year	Cost price per unit		Total cost price	
0	0	0	€	130.000,00	€	-
1	20	0	€	130.000,00	€	2.600.000,00
2	40	20	€	82.448,50	€	3.297.940,07
3	80	60	€	69.768,42	€	5.581.473,26
4	160	140	€	61.337,38	€	9.813.981,49
5	1200	300	€	54.627,74	€	65.553.291,78
		1500				
					€	86.846.686,60

Table 2: The total costs when renovating a different number of units per year. Each scenario has its own distribution of unit renovations.

There is a pattern made between the different scenarios: scenario 1 is the most equally distributed regarding the units while scenario 6 has a shape, similar to an exponential graph. The other scenarios are between them.

When looking at the total cost price and some trial & error, we can conclude that it is more profitable to raise the production in an incremental way instead of distributing the renovations equally over the 5 year. Scenario 3 is the most affordable distribution of units. This distribution has a shape that is some sort of similar to an exponential shape, however scenarios 4 and 5 have that shape even more. Still, scenario 3 is the cheapest. The reason why a slowly starting renovation production is the most profitable, is due to the learning effect. The first units are considered very expensive; the amount that is learnt is small after all. When producing more and more, the construction company goes further and further in the learning process and because of that, more cost reductions due to learning effects takes place. A slowly starting production can create problems for a company, because it wants to gain market share as fast as possible, however due to the fact that the NoM renovation is an innovation, this is not really considered a problem. Big innovations such as the NoM renovation need time to diffuse after all. ``Diffusion is the process through which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2002)``. The degree of innovativeness determines how fast someone adapts an innovation in a social system. This degree is classified in 5 adaptors categories: (1) innovators, (2) early adaptors, (3) early majority, (4) late majority and (5) laggards. The innovators are first 2,5% of the individuals to adopt the innovations while the early majority are the next 13,5% of the individuals (Rogers, 2002). Given the fact that there were only a 1000 NoM houses in the beginning of 2017 (Agterhoek, 2017), the NoM renovations project is situated in the beginning of innovators category. So, there is enough space for residents to accept the innovation and that is why a slowly starting production is not a problem in this case. A positive experience of the residents with a NoM house will accelerate the diffusion of innovations which is in this case the NoM renovation.

The slowly starting productions which increases incrementally and exponentially is in essential also based on common sense. Nobody wants to invest a lot of money in something without learning how something works. Organizations/individuals first need to learn the product/process/service before upscaling their investments.

Given that the price of a NoM renovation is currently around €60,000/70,000 for a company that renovated around 200 companies, it can be concluded that the learning effects are not worked out yet. Though, the biggest cost reductions due to learning effects are already made. The 90% learning curve tends to flatten around €40,000, so at least €10,000 cost reductions should be achieved by means of economies of scale. This can be achieved with e.g. applying industrial practices in the construction market. Smart procurement by means of a join procurement organization is also an option. This organization buys components of the NoM renovations such as solar panels and heat pumps in bulk and achieves therewith economies of scale and thus cost reductions. This organization can sell these components to the construction companies.

7. CONCLUSION

This thesis showed the complex issues of the NoM renovation that the housing cooperatives, construction companies and government are facing. As with almost every other innovation it had its struggles, however the potential of this innovation is immense. This thesis showed how the tender offer of the tender strategy approximately should look like. To estimate the NoM renovation costs and therewith the tender offer, learning curves are used. There are conditions that should be met in order to apply the learning curve on the NoM renovation. Due to the industrialization of the construction market with amongst others the usage of an off-site prefabrication, the NoM renovation meet the conditions for an application of the learning curve. The learning curve which starts at €130,000 has a learning rate of 90% and tends to flatten around €40,000. With some trial & error and 2 constraints, the distribution of the renovations over 5 years which approximately had the lowest total costs is chosen. This is scenario 3. This scenario includes a distribution that has an exponential shape: the first 2/3 years are characterized with a low number of renovations while in the last year, a lot of renovations are carried out. This complies with the distribution of the houses renovated thus far in the last years. So, although there is some criticism on the pace of this number of renovations, this is not a thing to worry: there is still enough space for learning effects and mostly economies of scale effects. The learning effects are not worked out and the economies of scale should still be applied after all.

Cost reductions that reduce the price to €30,000 are not possible with learning effects alone. To reach this €30,000 or even lower, construction companies should take advantage of economies of scale and to a lesser extent R&D activities. The transition from on-site fabrication to off-site prefabrication is very important to reach cost reduction. Lean building, smart procurement by means of a joint procurement organization, 3D printing are just some examples which have the chance of reducing the cost price of a NoM renovation.

A tendering strategy for housing cooperatives that should bring the price down to €30,000 is impossible, because the reduction of the price should come from the construction companies. Nevertheless, a housing cooperatives can help to reduce the costs by using a tender offer which has the distribution of that from scenario 3.

8. LIMITATIONS, FURTHER RESEARCH AND COMPLETION

8.1 Limitations

First of all, bachelor thesis's in The Netherlands only last for 2-3 months, while on contrary the master thesis`s last for 5 months so the time for this thesis is limited. Besides that, the data about the NoM renovation costs are limited, which results in a more invalid learning curve. Due to the sensitivity of the topic and the culture of secrecy, it is very hard to find this data. Although the companies want to cooperate together by means of network organizations such as Stichting Pioneering, companies are reluctant to share this kind of sensitive information.

As already stated earlier, the thesis focused only on social renting houses and the social housing industry in The Netherlands. Houses differ from country to country, still it is valid to use parts of this thesis in other countries, because every country will also show similarities. We also assumed that the social renting houses are in some sort of way similar to each other.

This thesis is limited to only 1 company that wins the tender offer. However it is also possible that a tender consist of more companies and that more companies execute the production. When more companies are bidding, the competitive dialogue is a good tender method to use. In the case of a NoM renovation, the innovation partnership is also a tender method that should be considered by housing cooperatives.

In section 4.1 a definition of a tendering strategy is given. As already stated in section 5.4, the focus is on the tender offer which means that most of other parts of the tendering strategy are omitted. This leads to a limited tendering strategy.

Also, the fact that we only focus on learning effects and not the other three effects of price reductions, gives the cost price curve a rather limited view. Still, the cost curve gives us a right push in the direction; cost reductions by learning and R&D are not significant in this case.

This thesis focused on the costs of the NoM renovations. The reason for that is that learning curves cannot be applied on selling prices. The selling prices can be calculated by adding a margin of the construction company, however that does not change the results of this thesis. Scenario 3 will still be the most profitable.

We assumed that companies only benefit from learning effects when they are producing, although companies also learn a little when they not produce.

Given that only 5 year of the project is taken into consideration, this give us a limited view of the future; the lifetime of the NoM renovation projects who are driven and forced by the government are several decennia.

Finally, no optimization technique is used to calculate the optimal distribution of the renovation units over the years. Instead of that, a trial & error method is chosen. This is also sufficient; however, it is never that precise as an optimization method.

8.2 Further research

Because of the novelty and innovativeness of the NoM renovation, very little is written about the subject. It is inevitable that more will be written about this case in the future and I hope this thesis will contribute to the constructing & housing industry, future researches and writings. There are so many things to write and research about this topic in the future (see the limitations part). Further research can include e.g. the economies of scale effects to estimate the costs of the NoM renovations in a more precise way or include more tender participants with competitive dialogue and innovation partnerships.

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