Improving the decision-making process of sustainable renovation projects in the construction sector

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Preface

This report is the final result of my research conducted at Dura Vermeer Bouw Hengelo, which is written to fulfil the graduation requirements of the Industrial Engineering and Management Bachelor program at the University of Twente.

I want to thank Tine-Loes Hemmes, for guiding me throughout the process while also giving me a lot of freedom to decide my research scope. I want to thank Leonie Veltkamp, for her help and that she went along during the interview with a corporation.

Furthermore, I want to thank my first supervisor from the University of Twente, Patricia Rogetzer for all her time and effort to supervise my research. Her feedback helped me a lot in improving my research and her trust in me helped me in difficult times during the research. I want to thank my second supervisor, Peter Schuur.

Lastly, I want to thank my family and friends for their support during this thesis.

I hope you enjoy reading my bachelor thesis!

Sarah de Best
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Management summary

Dura Vermeer is a construction company that creates areas, projects, and buildings located in 24 places in The Netherlands (www.duravermeer.nl). The research is executed at the office located in Hengelo, which is active in the 'Construction and Real Estate' (Dura Vermeer, 2021). The goal of the research is to come up with improvements for the current decision-making process of a sustainable renovation project of Dura Vermeer together with a housing corporation in order to speed it up.

The Dutch Government has established climate goals for the Netherlands which are in accordance with the climate agreement goals of Paris. The climate goals of the Netherlands have an impact on the housing sector. Seven million houses must be carbon dioxide neutral by the end of 2050. This has an influence on the social rental houses in the Netherlands, which are owned by housing corporations which main tasks is to guarantee affordable and good quality houses for residents who have the least opportunities. To keep up with the climate agreement goals of the Netherlands, the corporations must renovate their real estate portfolio. When a complex of the real estate portfolio of the corporation must be renovated in a sustainable way, a construction company such as Dura Vermeer is necessary which can carry out the renovation activities.

It became clear, however, that in the current sustainable renovation process of Dura Vermeer together with the corporation the decision-making process of the corporation takes a very long time. Keeping the climate agreement goals of 2050 in mind, the decision-making process should take less time in order to shorten the sustainable renovation process of houses. Therefore, the main research question addressed in this thesis is formulated as follows:

> *How can the current decision-making process of the corporation together with Dura Vermeer be sped up in regard to making houses more sustainable?*

The decision-making process of Dura Vermeer and a corporation are analysed on the basis of interviews with involved employees of both companies. The decision-making process of Dura Vermeer is set in seven phases: acquisition phase, preselection phase, tender phase, contracting phase, structural design phase, preliminary design phase, definitive/technical design phase. During these phases, Dura Vermeer decides which sustainable measures are necessary to take in order to meet the requirements that the corporation be imposing on the renovation of the complex. The decision-making process of the corporation also insist on determining which sustainable measures are necessary in order to reduce the energy label of their real estate, such as isolating walls, installing double glazing windows and placing more efficient boilers. The corporation also decides in their decision-making process with which construction company they want to carry out the project with. Both these processes are mapped in the research using the BPMN method, to make the process understandable by all business users.

However, when analysing both decision-making processes, it emerged that there are difficulties with getting approval of the supervisory board within a corporation, manual process appears instead of digital processes, there is no optimal information exchange and that the process of getting consent of the residents takes a lot of time.

Based on the performed research and stated conclusions, recommendations are made to Dura Vermeer Bouw Hengelo and a corporation. It would be recommended to hold more supervisory board meetings within a corporation, so that approval of a project plan can be requested more often. The corporation should make use of a digital signature system for signing documents and contract between the corporation and Dura Vermeer. Furthermore, it is recommended that the corporation creates a digital project portal for projects, which will improve the information exchange between a corporation and Dura Vermeer. And a residents' committee which arranges the contact with residents of the houses or complexes who become renovated in a sustainable way should be addressed, which will reduce the time that is needed to collect the consent from the residents.

Reader's guide

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Chapter 6 – Conclusion and Recommendations
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Glossary

Construction site design - Design of the construction place so that the project can be executed in the most efficient way. Here, the place of the construction sites and material sites gets determined so that it causes the least disturbance for residents and neighbours (Heras, 2021) .

Decision-making process - The decision-making process starts at the selection phase and ends at the end of the plan preparation when the contract is signed. It involves all the decisions and tasks that needs to be finished before a contract for a new sustainable project can be signed (Dura Vermeer, 2019).

General construction site costs – The general construction site costs are directly related to the construction project, but not directly related to the parts of the building object. General construction site costs are costs of facilities, means of production and associated labor used in the project which cannot directly be attributed to parts of the building object (NVBK; Bouwend Nederland, 2018).

Housing corporation - A government body set up to maintain a register of housing associations, to promote and assist the development of registered housing associations and unregistered self-build societies, and to provide houses for letting (Oxford University Press, 2021).

Social rental houses - Social rental houses are provided by housing corporations (non-profit organizations that own, let, and manage rented housing) or a local council. As a social tenant, you rent your home from the housing corporation or council, who are your landlord. The key idea of social housing is that it is more affordable than private renting (Smeets & Dogge, 2007).

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BIM	Building information model
BPM	Business Process Management
BPMN	Business Process Model and Notation
IEM	Industrial Engineering and Management
IRR	Internal rate of return
UML	Unified Modelling Language
MPSM	Managerial problem-solving method

Contents

1 Introduction

This report is the final result for the bachelor thesis of the Industrial Engineering and Management program (IEM). This research was carried out at Dura Vermeer (www.duravermeer.nl) and provides improvements for the decision-making process of sustainable renovation projects in the construction sector.

1.1 Company description

Dura Vermeer is a construction company. The company is divided into two divisions: 'Construction and Real Estate' and 'Infrastructure'. The construction division is active in the housing, utility, and industrial construction. The infrastructure division includes road construction, rail construction and a consultancy. Dura Vermeer is located in 24 places in The Netherlands. The research is executed at the office located in Hengelo, which is active in the 'Construction and Real Estate'. In 2021, Dura Vermeer Bouw Hengelo has 360 employees (Dura Vermeer, 2021).

1.2 A housing corporation

The focus of the research is improving the decision-making process of sustainable renovation projects in the construction sector. This will be renovation projects of social rental houses. Social rental houses are owned by a housing corporation. It is therefore first important to explain what a housing corporation is.

A housing corporation is a not-for-profit housing provider approved and regulated by Government. Housing corporations are the main delivery vehicle for social housing (Czischke & Bortel, 2018). Given their social objectives, they develop, rent, manage, and sell houses and provide an extensive package of housing products and services. The main task of a housing corporation is to guarantee the availability of affordable, good quality housing for tenants who have the least opportunities (Smeets & Dogge, 2007).

However, the housing stock in the Netherlands is so large that they not only accommodate lower income groups, but also middle-class tenants who prefer to rent a house, for example older people, or tenants who feel forced to rent, such as single wage-earners who cannot afford an owner-occupied house.

Social housing is targeted to vulnerable groups within the population. Allocation is mostly done through waiting lists or choice based letting systems and priority is generally given by law to certain categories like people with a medical indication, social indication, age, homelessness, and refugees (Czischke & Bortel, 2018). As far as profit is concerned, the built-up capital should be invested back into the sector (Smeets & Dogge, 2007).

The affordable houses are mainly delivered by housing corporations; to a lesser extent by local authorities and private developers (Czischke & Bortel, 2018).

When a complex from the real estate portfolio of a housing corporation needs to be renovated in a sustainable way, a construction company is necessary which can carry out the renovation. Dura Vermeer is such a construction company. Dura Vermeer will carry out the (sustainability) renovation for the corporation. The corporation is therefore the client from Dura Vermeer. The relationship between Dura Vermeer and a corporation is depicted in Figure 1.

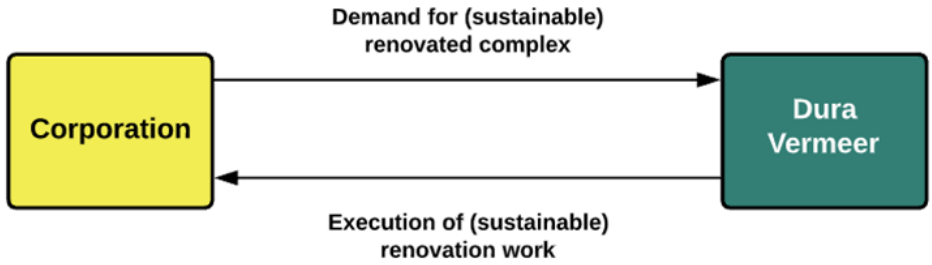

Figure 1: Relationship Dura Vermeer and corporation

1.3 Difference social rental sector and other housing sectors

The social rental sector is different from the free rental sector. In the social rental sector, the maximum rental price must be below €752,33 per month (Woonbond, 2021). In the free rental sector, there is no maximum rental price. In addition, in the social rental sector there is a maximum annual rent increase that prevents a house from becoming too expensive for people with limited financial resources. In the free rental sector, there is no maximum for the annual rent increase (Esteon, 2017). In both sectors, 70 percent of the residents must give consent on the sustainable renovation project (G. Kokkeler, Personal communication, June 25, 2021). This research focuses on social rental houses owned by housing corporations. However, houses in the social and free rental sector can also be owned by private landlord. The difference here is that the private landlords need to fund the sustainable renovation project itself. However, further the decision-making process and the involved steps look the same as a decision-making process of a sustainable renovation project with a corporation (G. Kokkeler, Personal communication, June 25, 2021).

When private house owners wants to renovate their house in a sustainable way, the decision-making process will look different. However, Dura Vermeer only executes projects one large scale and does not perform renovations on houses of private owners. This research can therefore not be applied to the sustainable renovation project of houses of private house owners.

1.4 Problem identification

The climate is changing worldwide and as a result the global average temperature is rising. The realization of the climate goals of Paris are necessary to prevent further global warming. For the housing sector in the Netherlands, the climate agreement has the consequence that the usage of

natural gas in houses should be stopped. Overall, seven million houses should be natural gas free in the Netherlands at the end of 2050 (Rijksoverheid, 2019).

Therefore, Dura Vermeer must provide sustainable houses to contribute to the climate agreements of 2050. A part of these houses are social rental houses, owned by housing corporations. Currently, however, the renovation process of making social rental houses (more) sustainable has a long lead time. A discrepancy can be found here, when keeping the climate agreement goals of 2050 in mind which insist on a process with a shorter lead time.

To shorten this lead time, decided is to focus on the decision-making process of a corporation. This focus point is chosen based on interviews with employees of Dura Vermeer. While searching for a focus point, it emerged that this step takes a lot of time and is also unpredictable.

This research analysed the problems in the current decision-making process in order to provide insight in the improvements to fasten the renovation process of making social rental houses (more) sustainable.

1.4.1 Problem cluster and motivation of action problem

When searching for the action problem within Dura Vermeer, there has been looked at the current situation of the company. To find the core problem, a list is made with existing problems within Dura Vermeer related to the process of making houses (more) sustainable. The following problems were found:

The sustainable solutions require high costs. Corporations which are involved in the process of making houses sustainable can often not afford these costs. There is no clear business model about who will pay for the sustainable investments in the construction sector. Therefore, the sustainability process of making houses sustainable cannot be resumed because there are no financial resources available.

The decision-making process of the corporations takes a long time. Therefore, Dura Vermeer must wait long before they can start building sustainable houses.

There are several stakeholders involved in the process of making houses sustainable. The process to arrange production resources is therefore complex. The process of making houses sustainable will therefore take long.

All these problems are leading to the action problem of Dura Vermeer: the current renovation process of making houses sustainable has a long lead time. The problems are all clustered in the problem cluster shown in Figure 2.

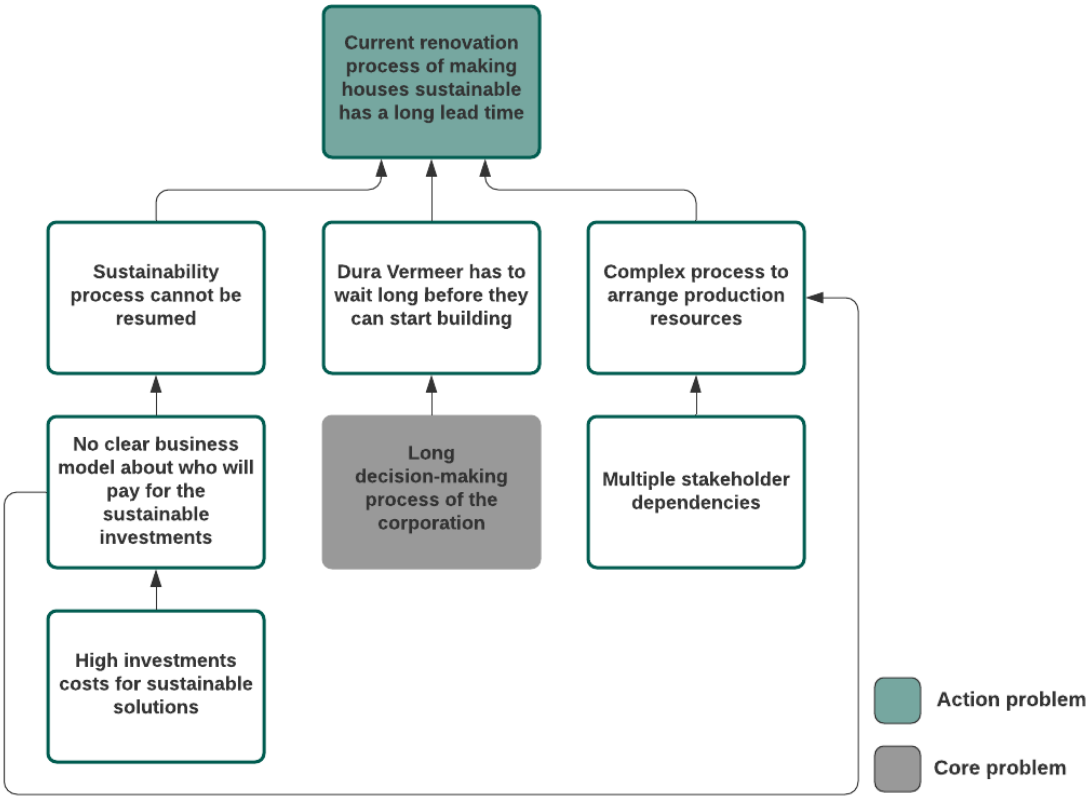

Figure 2: Problem cluster

1.4.2 Core problem

To find the core problem behind this action problem, interviews were conducted with employees of Dura Vermeer in order to understand all the existing problems. From this interviews and from analysing the problem cluster, it got clear that the biggest problem Dura Vermeer is dealing with is the long decision-making process of the corporation. Dura Vermeer must wait before the corporation finish their decision-making process. Only after this phase, Dura Vermeer can start making social rental houses sustainable.

The decision-making process is the process Dura Vermeer, and the corporation must undergo, before an agreement can be made. This involves all the decisions and tasks that needs to be finished before the contract can be signed. An in-depth analysis of the decision-making process is provided in Chapter 0.

1.5 Research question

The core problem of Dura Vermeer is the long decision-making process of the corporation. To solve this core problem, the following research question is made in which the answer to the research question solves the core problem and therefore the action problem of Dura Vermeer:

> *"How can the current decision-making process of the corporation together with Dura Vermeer be sped up in regard to making houses more sustainable?"*

1.6 Problem solving approach

This section covers the problem solving approach.

1.6.1 The 3D's – Do, discover and decide

To formulate the problem-solving approach, the 3D's are used.

Do encompasses all activities that needs to be performed during this research (Heerkens & Winden, 2017). During the research, the decision-making process of Dura Vermeer and a corporation were analysed. These processes were both mapped in a BPMN model. Based on the analyses and interviews with employees of both Dura Vermeer and the corporation, the problems of the long decision-making process were analysed and visualised in an Ishikawa-diagram. Based on the found problems, improvements were formulated. These improvements are recommended to Dura Vermeer together with the corporation in order to speed up their current decision-making process.

Discover is everything that needs to be known during the research. An important part is asking questions with the goal of obtaining knowledge (Heerkens & Winden, 2017). To answer the main research question, knowledge questions are made to formulate a solution. The following knowledge questions are answered to come up with an answer to the main research question.

1. *What does sustainability entail in the construction sector?*
2. *What does a typical decision-making process of sustainable projects in the construction sector look like?*
3. *How can processes be mapped in a clear way to have a good overview?*
4. *How does the decision-making process of a sustainable renovation project of Dura Vermeer look?*
5. *How does the decision-making process of a sustainable renovation project of a corporation look?*
6. *How can the main causes/problems be visualised?*
7. *What are problems in the current decision-making process of a sustainable renovation project of the corporation together with Dura Vermeer?*
8. *How can improvements be formulated for the decision-making process of a sustainable renovation project of the corporation together with Dura Vermeer?*
9. *What conclusion and recommendation can be made from conducting the research at Dura Vermeer?*

Decided is to focus on the social rental sector. The process of making houses sustainable in the social rental sector will be dependent on the corporation. Dura Vermeer wants to see improvement in this process instead of making private houses sustainable.

Decided is also to focus only on the decision-making process and not on the whole process of making houses more sustainable. This focus point has been made based on interview with employees of Dura Vermeer. The time limit of the research does not allow it to focus on the whole process of making houses (more) sustainable.

1.6.2 Systematic approach and deliverables

In order to solve the research question and knowledge questions, the Managerial problem-solving method (MPSM) is used, which is displayed in Figure 3 (Herkeens & Winden, 2017). The MPSM can be applied to various problems occurring in a multitude of situations in all subject areas and provides a step-by-step structure to solve business problem through research. MPSM describes a seven-step method designed to solve action problems. An action problem is a situation which is not as desired. The problem in this research matches this description, since there is a difference between the actual and desired situation, a long lead time of sustainable renovation project against the desired short lead time of sustainable renovation projects.

The problem identification and solution planning are part of the introduction (Figure 3, step 1 and 2). The problem analysis, solution generation and solution choice were executed while doing the research (Figure 3, step 3 to 5). The solution implementation and solution evaluation (Figure 3, step 6 and 7) are the responsibility of the company after the solutions are generated and are therefore not part of the scope of this research.

Table 1: Division of questions on the basis of MPSM

Step of MPSM	**Questions**
Step 3	1 to 7
Step 4	8
Step 5	9

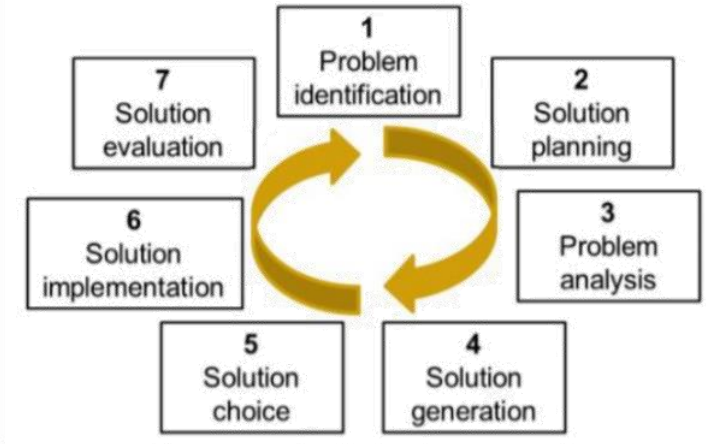

Figure 3: Managerial problem-solving method (Source: Herkeens, 2017)

Table 2 gives an overview of the used methodology and deliverable of each research question.

Table 2: Overview methodology and deliverables per research question

	Question	**Method**	**Deliverables**
1	What does sustainability entail in the construction sector?	Literature study	Explanation about sustainability in the construction sector
2	What does a typical decision-making process of sustainable projects in the construction sector look like?	Literature study	Explanation decision-making process of sustainable projects
3	How can processes be mapped in a clear way to have a good overview?	Literature study	Understanding of different mapping methods and argumentation of chosen method
4	How does the decision-making process of a sustainable renovation project of Dura Vermeer look?	Interviews and document analysis within Dura Vermeer	Business process model of decision-making process Dura Vermeer with textual explanation
5	How does the decision-making process of a sustainable renovation project of a corporation look?	Interviews with different corporations	Business process model of decision-making process of a corporation with textual explanation
6	How can the main causes/problems be visualised?	Literature study	Explanation about the Ishikawa-diagram which can be used to visualize causes of problems
7	What are problems in the current decision-making process of a sustainable renovation project of the corporation together with Dura Vermeer?	Business process analysis and interviews with employees of Dura Vermeer and corporations	List with problems and Ishikawa-diagram which visualizes the found problems
8	How can improvements be formulated for the decision-making process of a sustainable renovation project of the corporation together with Dura Vermeer?	Interviews with employees and literature study	List of possible improvements and evaluation of the improvements
9	What conclusion and recommendations can be made from conduction the research at Dura Vermeer?	Use of data found during the research	Final report with conclusion and recommendations

1.7 Renovation project

The focus of the research is improving the decision-making process of sustainable renovation projects in the construction sector. Therefore, it is important to explain what a renovation project entails and in which a sustainable renovation project differs from a standard renovation project. In Section 1.7.1 the difference between a sustainable renovation project and standard renovation project is explained. In Section 1.7.2 an example is provided of a sustainable renovation project Dura Vermeer performed.

1.7.1 Difference sustainable and standard renovation project

A standard renovation project is based on reparations and replacement of parts of the house. This normally involves a new bathroom, kitchen, and toilet (G. Kokkeler, Personal communication, June 25, 2021).

A sustainable renovation project is focussed on the installation of sustainable measures. The sustainable measures can be different and which sustainability measures will be taken is dependent on the complex . The following sustainability measures can possibly be implemented (G. Kokkeler, Personal communication, June 25, 2021).

The façade and the roof of the house can be isolated. The ground floors can be isolated by installing isolation materials in the crawl space under the floor. The house can be fitted with double glazing, which will prevent energy wastage and improve isolation of the house. The door to the outside of the house can be replaced with a new isolated door. Draft seals are placed on the rotating parts in the house (doors and windows) to prevent draft. In the existing window frames, ventilation grilles can be installed to ensure proper ventilation in the house. If the houses contain asbestos, for example in the sealant edges, this can professionally be removed prior to the installation of the new glass. Windowsills that contain asbestos can also be replaced. The boiler in the kitchen can be replaced by a new boiler which is more efficient. Solar panels can be installed on the roofs of the houses. The mentioned measure are all sustainable measure which must ensure that a house gets a lower energy label (Mulder, 2021).

The consent of the resident is also important for a sustainable renovation project. Here, 70% of the residents must give consent to the renovation project, only then the project will continue. The law states that if at least 70 percent of the residents within a complex of at least ten houses voluntarily agree to the renovation proposal, the proposal is deemed reasonable. By renovation, the law means 'partial renewal by alteration or addition'. In 2016, the Supreme Court added that there is only renovation if the change or addition objectively increases the living enjoyment. For example, in the case that the renovation will lead to a significant reduction in heating costs. If there is no renovation but necessary maintenance to maintain the building, the tenant has no right to consent and must cooperate with the work (Aedes, 2021). So, in a standard renovation project, the residents consent is not necessary. However, normally when a

sustainable renovation project will be carried out, the measures of a standard renovation project will also be realised.

1.7.2 Example sustainable renovation project of Dura Vermeer

This section will provide an example of a renovation project of Dura Vermeer. In Groningen, 81 apartments of a corporation are sustainably renovated during a project together with Dura Vermeer. Here, sustainable measures are taken to bring the apartment to a lower energy label and simultaneously standard renovation measures are taken. Both renovation measures will be explained.

1.7.2.1 Standard renovation measures

During the project in Groningen, standard renovation activities were carried out in order to maintain the apartments. The bathroom, kitchen and toilet are renovated in each apartment. In some apartments this had already been done several years ago, so the standard renovation activities have not taken place here. The bathroom is provided with new tiles on the floor and walls. The existing ceiling is repaired and the current toilet, sink, shelf, shower drain, showers fittings and taps are replaced.

Figure 4: Old versus new bathroom apartment Groningen (Source: Dura Vermeer Bouw Hengelo, 2021)

The kitchen is also replaced. New tiles are placed on the walls. The old worktop is replaced by a new one. The sink and mixer tap are replaced and the residents switch to electric cooking.

Figure 5: Old versus new kitchen apartment Groningen (Source: Dura Vermeer Bouw Hengelo, 2021)

1.7.2.2 Sustainable renovation measures

During the project in Groningen, sustainable renovation activities were carried out in order to lower the energy label of the apartments. The current boiler in the kitchen is replaced by a new one. The new boiler is more efficient than the old one.

Figure 6: Old versus new boiler apartment Groningen (Source: Dura Vermeer Bouw Hengelo, 2021)

The walls in the house are isolated which prevents energy waste and ensures a better isolation of the house.

Figure 7: Old versus new isolated walls apartment Groningen (Source: Dura Vermeer Bouw Hengelo, 2021)

The old radiators have been replaced with more efficient ones.

Figure 8: Old versus new radiator apartment Groningen (Source: Dura Vermeer Bouw Hengelo, 2021)

The old windows are replaced with double glazing.

Figure 9: Old versus new double glazing windows apartment Groningen (Source: Dura Vermeer Bouw Hengelo, 2021)

1.8 Summary chapter 1

Dura Vermeer is a construction company. To contribute to the climate agreement goals of 2050, Dura Vermeer must provide sustainable houses. Social rental houses owned by housing corporations are such houses. The main task of a housing corporation is to guarantee the availability of affordable, good quality housing for tenants who have the least opportunities. Currently, the decision-making process of making social rental houses more sustainable of the corporation take a lot of time. To solve this problem, the following main-research question is answered in the research: *How can the current decision-making process of the corporation together with Dura Vermeer be sped up in regard to making houses more sustainable?* The research provides improvements for the current decision-making process of sustainable renovation projects in order to shorten the lead time. A sustainable renovation project is a project which ensures that a house gets a lower energy label by executing sustainability measures like isolate the walls, installing a more efficient boiler or radiator (Mulder, 2021).

2 Theoretical framework

In this chapter, the theoretical framework of the research will be explained. This theory helps to better understand the problem. Section 2.1 covers a literature study about sustainability in the construction sector. Section 2.2 covers a literature study about the decision-making process in the construction sector. In Section 2.3, the most suitable method to analyse a business process will be determined. Section 2.4 determines what is the most suitable modelling method to model the decision-making process of Dura Vermeer and a corporation. Section 2.5 described a method to visualize the found problems in the current decision-making process.

2.1 Literature study sustainability in the construction sector

This section covers the knowledge question: What does sustainability entail in the construction sector? A literature study is conducted to gain an understanding about sustainability in the construction sector.

According to Berardi (2012), the increasing attention to sustainability is pushing the construction sector towards rapid changes. Policies, laws, and regulations around the world are asking the sector to adopt sustainable innovation in terms of products and processes to encourage more sustainable buildings. Sustainable buildings have been broadly defined as buildings that encompass environmental, social, and economic standards, together with technical aspects.

According to Yilmaz and Bakis (2015), people need a lot of buildings for sustaining their lives. These facility of buildings cause a lot of environmental problems during their construction, operation and maintenance, and destruction. Buildings consuming a huge amount of energy and natural resources have an impact on climate change by affecting quality of air and water in cities. These environmental problems caused by the construction industry can be substantially decreased via change in the applications.

So, sustainable construction is the application of sustainable development principles to a building life cycle from planning the construction, constructing, mining raw material to production material and turning it into construction material.

2.2 Literature study decision-making process

This section covers the knowledge question: What does a typical decision-making process of sustainable projects in the construction sector look like? A literature study is conducted to gain an understanding of the decision-making process of sustainable projects in the construction sector.

An explanation of the decision-making process for sustainable renovation projects in the construction sector can be found in Szafranko (2017), Meiling et al. (2012) and Zavadskas et al. (2008). According to Szafranko (2017), the decision-making process starts with setting up goals. This phase lies in the scope of responsibilities of a person directly making decisions.

Management in a construction business entails making series of decisions. Here, a decision is a choice of one option among available alternatives. Decisions can emerge at every stage of the decision-making process, from choosing the location of a new construction project, through the stage of making plans and designs, selecting technologies, materials, and structures, to issues regarding the management of the project itself, the project quality or potential risk (Szafranko, 2017).

Renovation processes of buildings are complex and uncertain in terms of decision-making, planning, and execution. According to Meiling et al. (2012) in renovation projects more emphasis should be laid on the preliminary investigations phase, where the main direction and goals in terms of time and resources for a renovation project are defined to achieve the initially defined results. Hence, the most significant decisions to achieve a successful project are taken already in this phase. In this preliminary investigation stage, the collection of various types of information takes place. This includes an inventory of the status of the building and the establishment of a documentation of the building prior to an alteration (Meiling et al., 2012). Renovation processes, however, would often start with poor documentation of building conditions.

According to Zavadskas et al. (2008), all decision-making processes start from the needs encouraging problem occurrence. In the first stage, an analysis of the existing building and its environment is made. Indicators that should be considered in this phase are, for instance, government policy, construction norms, environment pollution, credit rates, tax system, cultural environment, social policy, market conditions, inflation, unemployment rates, wages, labor conditions, the availability of natural resources, building depreciation and the economic value of the building. If the value of the building is too low, refurbishment is considered as economically inefficient from the point of value enhancement. The requirements of the stakeholders must also be fulfilled. Therefore, information about these stakeholders must also be collected.

The building owner's decision-making process for undertaking renovation differs a lot depending on the reason for starting the process. If the reason for renovation is to improve the building in terms of stand-alone measures, the decision factors are basic information, trustworthy advice, and willingness to act. The consequential improvements, on the other hand, are decided based on competing investments whereas for whole building renovation, the decision factors are professional expertise, quality contractors and finance (Meiling et al., 2012).

A decision to start a preliminary investigation process is often taken on management level. The motives for starting a renovation project are normally based on the age of the building, technical or performance deficiencies such as high costs. Tenant's needs and requirements and analysis of the surrounding environment can also have an influence on the decision to start a renovation process.

However, the range of potential actions available to property owners in renovations is limited by current laws and regulations that govern, for example, accessibility, energy use, rent setting and tenant's approval. Property owners' actions will also be influenced to a high degree by their manager/owner's directives and business plan, by local policy, the latter especially in the case of public municipal housing companies (Meiling et al., 2012).

So, management in a construction business entails making series of decisions. However, the found papers during the literature did not give an in-depth explanation of the decision-making process of a sustainable project in the construction sector and all the activities that are performed in this process. Some activities are explained but are not linked to the respective discipline that is responsible for this activity.

Jajac et al. (2015) covered a decision-making process applied to transport projects. The decision-making process is here applied to another sector than the construction sector.

Meiling et al. (2012) covered the decision-making process but applied it to the construction sector in Sweden. Sweden has a public housing sector, which is a form of housing tenure in which the property is usually owned by a government authority. The social rental sector in the Netherlands is usually owned by housing corporations. However, this literature paper was beneficial for the researcher because it gained an understanding of how a decision-making process look in the public housing sector.

However, none of the papers gave an in-depth understanding of a decision-making process of sustainable projects in the construction sector. Therefore, the benefit of the research is that it will provide an insight in the decision-making process of sustainable projects in the construction sector. With this research, the reader will gain an in-depth understanding of the decision-making process of sustainable projects in the construction sector and all the activities that come along with this process.

2.3 Business process analysis

To get an answer on the knowledge question: 'How does the decision-making process of a sustainable renovation project of Dura Vermeer look?' an analysis of the steps which are involved in this process is made. A literature study is conducted in order to find a proper analysis method. There are different methods to analyse a business process such as, for instance, Business process management (BPM), Unified modelling language (UML) and flow charts.

BPM – The most important goal of BPM is a better understanding of the operations a company performs and their relationships. The explicit representation of business processes is the core concept to achieving this better understanding. The aim of BPM is to increase the effectiveness and efficiency of organizational processes through their improvement (Lemanska-Majdzik & Okreglicka, 2015). Identifying the activities and their relationships and representing them by business process models allows stakeholders to communicate about these processes in

an efficient and effective manner (Weske, 2012). BPM is an approach that concentrates on optimising the ways business processes are performed in organisations with its advantage that a wide variety of modelling approaches has been specified in BPM. Think about the Business Process Modelling and Notation (BPMN) method, Petri Nets method and the Control Flow Pattern method. However, critics say that the steps an organization needs to take to take its BPM capability from level to level are seldom explicit from those models (Poeppelbuss, 2015).

UML – UML is a visual modelling language dominant in object-oriented software development. UML presents a standard way of modelling object-oriented systems that enhances systems development efforts. (Erickson, 2013). UML relies on graphical constructs. These constructs serve as the building blocks of UML diagrams. However, the similarity in graphical constructs in UML may hinder the human information cognitive process of search, recognition, and inference. This makes it difficult to understand the process (Siau, 2010).

Flowchart – Flowchart help to visualize industrial and business processes. Flowcharts are easy to understand for someone even with limited knowledge of the language (Kimber, Cromley, & Molnar-Kimber, 2018). They show how jobs flow through a network of tasks and decisions. However, flowchart does not display quantitative information about process flows (Kemper, Mast, & Mandjes, 2009).

Applying this knowledge to the processes at Dura Vermeer Bouw Hengelo, BPM would be the most suitable method to use for analysing the decision-making process. The aim of BPM suits the goal of the analysis perfectly; increase the effectiveness and efficiency of processes by improvements. The analysis of the decision-making process must lead to improvements which speed up the decision-making process of Dura Vermeer together with the corporation in the future. Besides this advantage, BPM uses a wide variety of modelling approaches. One of these approaches is BPMN. BPMN is very familiar to me and using BPMN to model the decision-making process saved therefore time in the research. Therefore, the BPM method is used for analysing the decision-making processes of Dura Vermeer Bouw Hengelo and the corporation.

Table 3 gives a summary of the advantages and disadvantages of the different business process analysis methods.

Table 3: Summary of business process analysis methods

	BPM	**UML**	**Flow chart**
Advantages	1. Increase effectiveness and efficiency of processes by improvements 2. Wide variety of modelling approaches	1. Suitable for modelling object-oriented systems that enhances systems development efforts	1. Are easy to understand for someone with limited knowledge of the language
Disadvantages	1. Improvements for operations or processes are seldom taken from the BPM models made	1. Similarities in graphical constructs makes it difficult to understand the graphical diagram and therefore the process	1. Does not display information about process flows

BPM is based on the observation that each product that a company provides to the market is the outcome of a number of activities performed. Business processes are the key instruments to organizing these activities and to improving the understanding of their interrelationships (Weske, 2012). BPM includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of business processes. Once the business process is represented with the activities, it can be subjects to analysis, improvement, and enactment. These aspects are covered in the Business Process Lifecycle. Figure 10 depicts the Business Process Lifecycle.

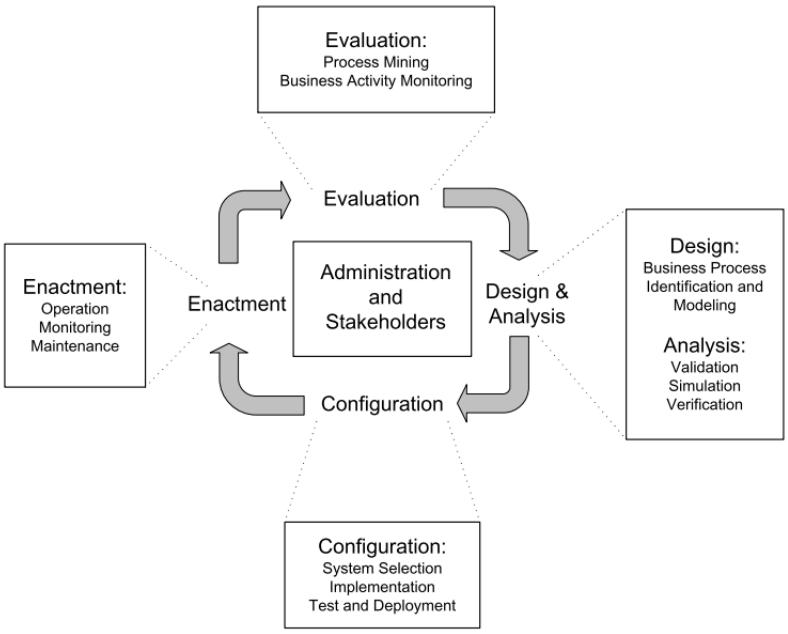

Figure 10: Business Process Lifecycle (Source: Weske, 2012)

The Business Process Lifecycle starts in the design and analysis phase. In this phase surveys are conducted on the business process and the organization and technical environment. Based on these surveys, the business process is identified, reviewed, validated, and represented by a business process model.

After the business process is developed and modelled, it needs to be validated. A method to validate the business process model is a workshop. In this workshop the involved persons discuss the business process model and whether it is reflected well.

Once the business process model is verified, the business process needs to be implemented. This is called the configuration phase. It can be implemented by a set of policies and procedures that the employees of the business need to comply with.

When the configuration phase is done, business process instances can be enacted. The process will be monitored. Process monitoring is an important mechanism for providing accurate information on the status of the business process instances.

When the enactment phase is done, the evaluation of the business process model will take place. The available information found in the different phases will be evaluated and used to improve the business process (Weske, 2012).

In the business process, there are several types of stakeholders with different knowledge, expertise, and experience. These stakeholders must cooperate closely in designing business processes and in developing adequate solutions for enacting them. Therefore, these stakeholders are in the middle of the Business Process lifecycle and play an important role in the business process.

2.4 Business process model and notation method

This section covers the knowledge question: how can processes be mapped in a clear way to have a good overview? A literature study is conducted to gain an understanding about the possible ways of how a process can be mapped.

During this research, business processes should be modelled. A business process consists of a set of activities that are performed in coordination in an organizational and technical environment. These activities jointly realize a business goal. A business process is enacted by a single organization, but it may interact with business processes performed by other organizations (Weske, 2012). For this research, the decision-making process of Dura Vermeer and a corporation is modelled. Various modelling methods can be found in the literature. Weske (2012) describes seven methods. From these seven methods, the Business Process Modelling Notation (BPMN) method is used. In recent years, BPM acquires on importance in business industry including the construction industry. In the business industry there are some common BPM tools such as BPMN which are also adapted in the construction industry for the purpose of process modelling (Gudnason & Scherer, 2012).

The primary goal of BPMN is to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the businesspeople who will manage and monitor those processes.

Besides this advantage, BPMN also aims at supporting the complete range of abstraction levels, from a business level to a technical implementation level. Therefore, the BPMN method will be used for modelling the business processes during this research. I used the BPMN method several times during my study and am therefore already familiar with this modelling language. Little to no time will be spend on understanding this modelling language, which will save time in my research. The research will benefit from this.

The element in business process diagrams is divided into four basic categories. Each category consists of a set of elements. Figure 11 depicts the four different categories.

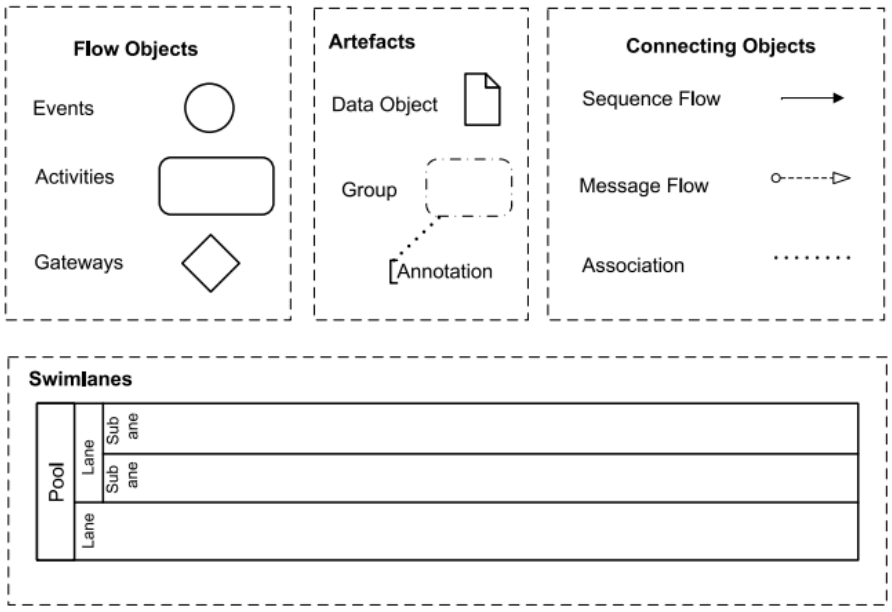

Figure 11: Categories of the BPMN method (Source: Weske, 2012)

For a detailed explanation of the different categories and elements of the BPMN method, it is referred to (Weske, 2012).

2.5 Ishikawa-diagram

This section covers the knowledge question: how can the main problems be visualised? In order to have a clear overview of the problems, it is helpful to make it visual. One way of making it visual, is by using an Ishikawa-diagram. An Ishikawa-diagram is a simple graphical instrument that is used to analyse the relation between a problem and all possible causes. The cause-effect diagram – fishbone or Ishikawa - was developed by Kaoru Ishikawa in order to determine and divide the causes of a given problem on main fields of causes (Luca, Pasare, & Stancioiu, 2017). The studied effect or negative problem is 'the fish head' and the potential causes and sub-causes define the 'fish-bone structure'. The main problem must be selected, this will be 'the fish head'.

The main factors that contribute to the problem, become main branches to the main arrow. For every major branch, smaller factors can be added as side branches (Ishikawa, 1982). Figure 12 depicts the format of an Ishikawa-diagram.

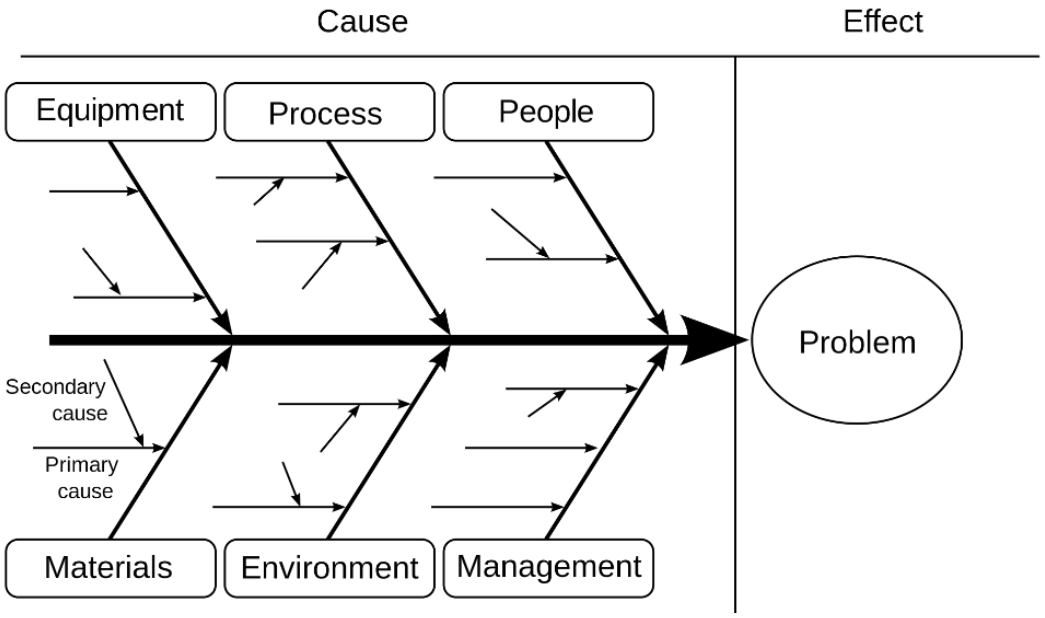

Figure 12: Format Ishikawa-diagram (Source: Wikipedia)

2.6 Summary chapter 2

Sustainable construction is the application of sustainable development principles to a building life cycle from planning the construction, constructing, mining raw material to production material and turning it into construction material.

To manage a sustainable construction project, series of decision should be made. However, an in-depth analysis of the decisions made in a sustainable renovation could not be found in the literature. The benefit of this research is that it will provide such an in-depth analysis about a decision-making process in the construction sector.

So, in order to analyse the decision-making process of Dura Vermeer and a corporation, the BPM method is used. The aim of BPM is to increase the effectiveness and efficiency organizational processes through their improvement. The advantage of BPM is the wide variety of modelling approaches that has been specified, such as the BPMN method. To model the decision-making processes of Dura Vermeer and a corporation, the BPMN modelling method is used in chapter 3 to visualize the decision-making process of Dura Vermeer and a corporation. When the decision-making processes are analysed, the Ishikawa-diagram will be used to visualize the causes of the long decision-making process. Chapter 4 will explain the find causes and visualizes it in an Ishikawa-diagram.

3 Current decision-making process

In this chapter, the current decision-making process will be analysed. It gives an answer on the following knowledge questions: How does the decision-making process of a sustainable renovation project of Dura Vermeer look? How does the decision-making process of a sustainable renovation project of a corporation look? To give an answer on these questions, this chapter is divided into two sections. Section 3.1 contains an analysis about the decision-making process of Dura Vermeer. Section 3.2 contains an analysis of the decision-making process of a corporation. An overview of the different disciplines from Dura Vermeer and a corporation which are involved in the decision-making process is shown in Table 4. All these disciplines got a separate lane in the BPMN model.

Table 4: Overview involved disciplines decision-making process Dura Vermeer and a corporation

	Dura Vermeer	**Corporation**
1	Management board	Management board
2	Tender manager	Supervisory Board
3	Project manager preparation	Project manager
4	Calculator	Financial Department
5	Project leader	
6	Social project manager	
7	Logistics and planning department	

3.1 Analysis decision-making process Dura Vermeer

Dura Vermeer created different flows, which shows all the different steps in a sustainability renovation project of houses in the social rental sector.

A sustainability renovation project within Dura Vermeer exists of four different main phases as depicted in Figure 13: (I) selection phase, (II) plan preparation phase, (III) realization phase, and (IV) use phase. These four main phases are further divided into several sub phases.

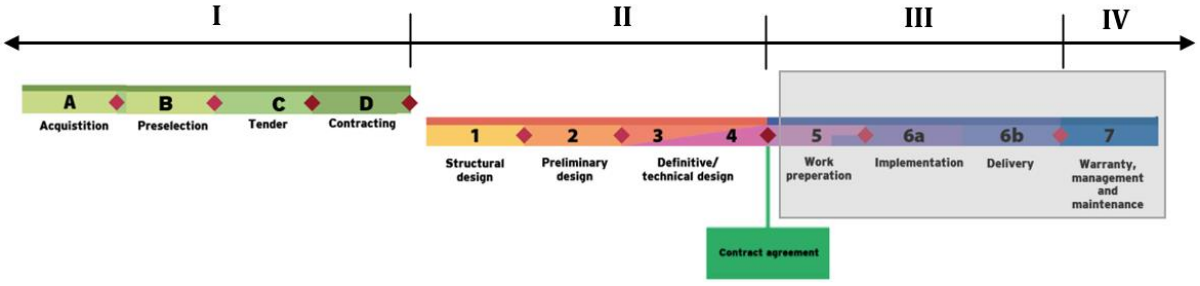

Figure 13: Flow sustainability renovation project (Source: Dura Vermeer Bouw Hengelo, 2021)

The decision-making process of a sustainability renovation project typically consists of the first seven sub phases shown in Figure 13: the acquisition phase (Figure 13, sub phase A), the preselection phase (Figure 13, sub phase B), the tender phase (Figure 13, sub phase C), the contracting phase (Figure 13, sub phase D), the structural design phase (Figure 13, sub phase 1),

the preliminary design phase (Figure 13, sub phase 2), and the definitive/technical design phase (Figure 13, sub phase 3 and 4). However, not all decision-making processes of Dura Vermeer follow all the seven phases. This can vary depending on the project. The realization of the project (Figure 13, from sub phase 5 onwards) will take place after these seven phases. The research focuses on the decision-making process of a sustainable renovation project. The phases before the contract is signed are therefore relevant for the research because those phases include the decision-making of a sustainable renovation project. The phases after the contract formation (Figure 13, grey box) are considered out of scope for this thesis and are not further analysed in the research.

The BPMN model of the decision-making process with preselection of a project with a corporation is shown in Figure 14. In appendix A, the BPMN model is displayed larger for readability.

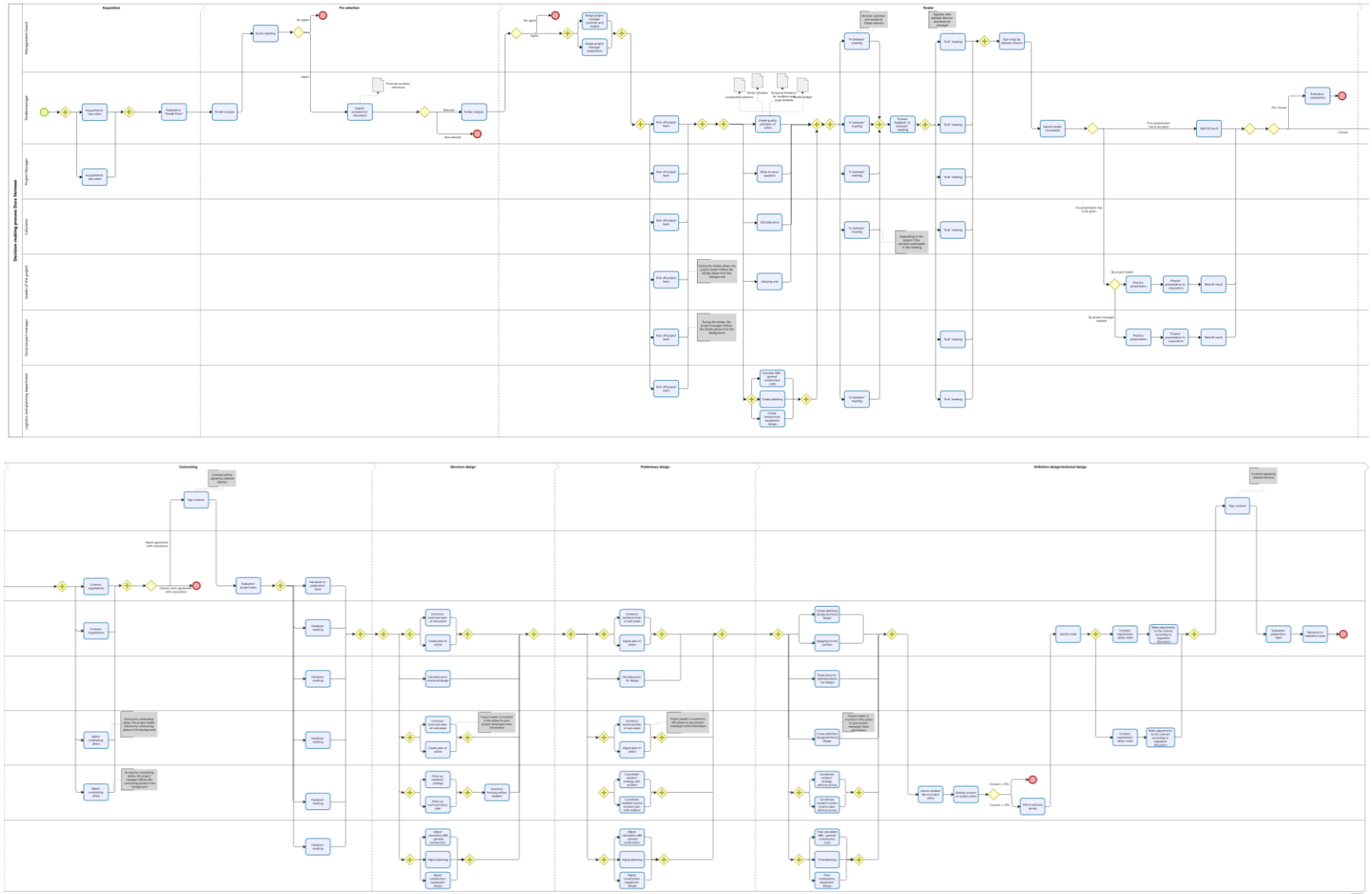

Figure 14: BPMN model whole decision-making process with preselection of a project with a corporation

The decision-making process of Dura Vermeer for this category starts at the corporation. The corporation announces a procurement of a building that has to be renovated. This procurement contains a schedule describing the requirements that the corporation set for the building. This is a building from the real estate property of the corporation. If Dura Vermeer is interested in the procurement, the acquisition phase (Figure 13, sub phase A) is starting. This is an informal phase before the actual preselection phase (Figure 13, sub phase B) of the decision-making process starts. What the acquisition phase looks like depends on the type of corporation. If it is a new corporation, Dura Vermeer and the new corporation will get to know each other in the acquisition phase. The overall strategy of Dura Vermeer ('Het Goede Doen') will be explained by the tender manager to the corporation. Corporations which are already known to Dura Vermeer, are corporations with which Dura Vermeer conducted a project within the past. For projects with known corporations, the acquisition phase (Figure 13, sub phase A), consist of a meeting to catch up. After this meeting, the process will continue with the preselection phase (Figure 13, sub phase B).

When the acquisition phase (Figure 13, sub phase A) is done, the preselection phase (Figure 13, sub phase B) will start. In the beginning of the preselection, the tender manager (who belongs to Dura Vermeer) sets up a tender analysis. This analysis contains the following subjects: schedule of the tender, description of the project, relationship with the corporation, competition, and chances to win the procurement. This tender analysis will be discussed with the management board in a go/no-meeting. Based on the tender analysis, the management board can decide whether Dura Vermeer continues with the procurement or not. There are different options to stop with the procurement in this phase: the building in the procurement is geographically too far away, the amount of houses that should be renovated are too few, the activities that needs to be taken are to small whereby the contractors price too low is.

If the management board does not agree to continue, the process will stop. Dura Vermeer will then not continue with the preselection phase (Figure 13, sub phase B). However, if the management board gives approval, the preselection documents can be submitted. The corporation will then know that Dura Vermeer is interested in the procurement. The preselection documents Dura Vermeer submits contain for example financial indicators about Dura Vermeer and references from previous projects and clients. Based on the submitted documents, the corporation will decide if Dura Vermeer will be selected for the tender based on selection criteria. The corporation gives points for each criterion and based on these points decides is if Dura Vermeer will be selected for the tender phase (Figure 13, sub phase C). If Dura Vermeer is not selected, the process will stop for Dura Vermeer. If they get chosen, the tender phase (Figure 13, sub phase C) will start. Figure 15 depicts the acquisition (Figure 13, sub phase

A) and preselection phase (Figure 13, sub phase B) of the decision-making process of Dura Vermeer.

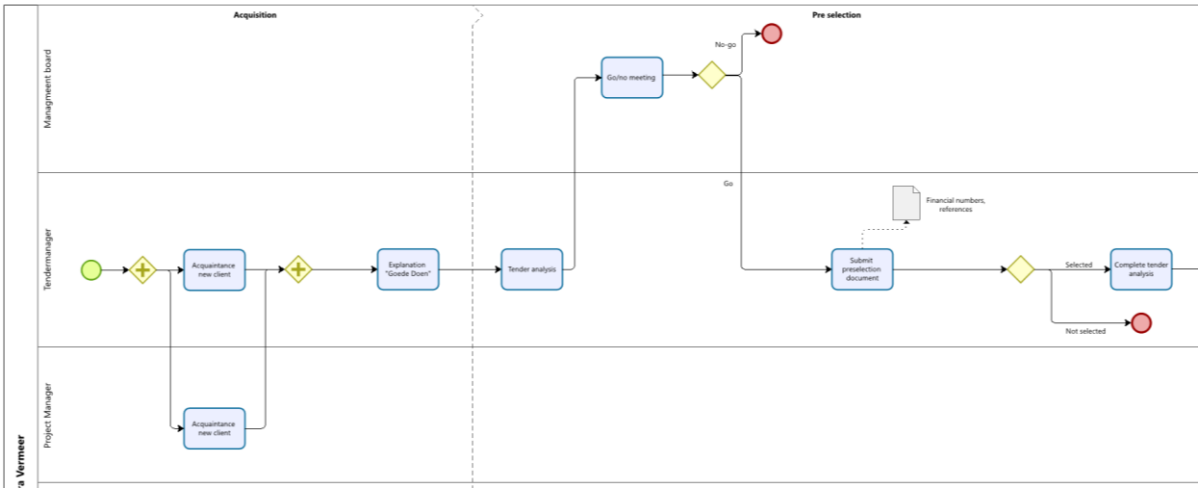

Figure 15: Phase I/ Sub phases A (Acquisition) and B (Preselection) of decision-making process Dura Vermeer Bouw Hengelo

When Dura Vermeer is selected for the tender, the tender phase (Figure 13, sub phase C) is starting. In this phase, Dura Vermeer makes a tender for the procurement of the corporation. At first, the tender manager completes the tender analysis. Additional information about the procurement will be included in the previous tender analysis from the preselection phase (Figure 13, sub phase B). The tender analysis is already discussed with the management board during this preselection phase (Figure 13, sub phase B), during the tender phase (Figure 13, sub phase C) only the additional information of the tender will be communicated with the management board. Based on the new additional information, the management board can decide whether Dura Vermeer continues with the procurement or not. There are different options to stop a procurement in this phase: the risks are too high, budget is not achievable, the schedule is not achievable or the relationship with the corporation is not good.

If the management agrees with the procurement, the management board assigns a tender manager and project manager. They are the leading managers in the tender phase (Figure 13, sub phase C). In the tender phase (Figure 13, sub phase C), the project leader, social project manager, calculator and the logistics and planning department are also involved. During the kick-off, the tender manager will give a presentation about the corporation and the procurement of the corporation to inform the project team about the scope of the project. The tender manager created a tender schedule. This schedule contains the important deadlines and structured planning of the tender phase (Figure 13, sub phase C). This schedule will also be discussed with the project team during the kick-off. After the kick-off, the tasks will be divided.

The tender manager is head responsible for the tender phase (Figure 13, sub phase C). The tender manager must make sure that the tender phase (Figure 13, sub phase C) is running well, that the tasks are divided and that everyone performs their tasks. The tender manager

must monitor the progress throughout the tender phase (Figure 13, sub phase C). Besides this role, the tender manager is responsible for the quality part of the procurement. Usually, the quality part contains a textual explanation of the measures that will be taken to meet the requirements set in the procurement of the corporation.

However, the components of the quality part can be different. The components the quality part must contain is dependent on the requirements set in the procurement of the corporation. It may therefore occur that other components are included in the quality part.

The project manager is together with the calculator responsible for the price part of the project and the measures that should be taken. They calculate the prices of the measures that should be taken in the project. These measures are based on a reference house. Dura Vermeer performs a technical inspection from this house. Based on the finding during this inspection, the measures that should be taken can be indicated. A price will be calculated for the measures. This will lead to a price for the measures for one house. In the preparation phase (Figure 13, sub phase 1 till 4) of the project, a detailed price will be calculated based on the technical inspections of all the houses. The price calculated in the tender phase (Figure 13, sub phase C) is therefore an estimated price, this price can change in the preparation phase (Figure 13, sub phase 1 to 4) of the project.

Beside the price part, a detailed overview must be given to the corporation about the partners Dura Vermeer is going to work with in the project. During the tender phase (Figure 13, sub phase C), the project manager arranges offers from various subcontractors. From these offers, Dura Vermeer choses the subcontractors they want to work with. The selection of these partners is not based on the price only. Dura Vermeer looks at the price, price-quality ratio, and completeness of the offer.

The logistics and planning department works closely together with the project manager and calculator. The logistics and planning department calculates the general construction site costs. This are the general construction costs each construction project has. The general construction site costs are directly related to the construction project, but not directly related to the parts of the building object. General construction site costs are costs of facilities, means of production and associated labor used in the project which cannot directly be attributed on parts of the building object (NVBK; Bouwend Nederland, 2018). An example of a general construction site costs is the facility cost for staff at the construction place. The project manager support the logistics and planning department with calculation the general construction site costs.

A detailed time schedule of the project will also be made by the logistics and planning department. And at least, the construction site design will be made by the logistics and planning department. This is a design of the construction place so that the project can be executed in the most efficient way. Here, the place of the construction sites and material sites gets determined.

During the tender phase (Figure 13, sub phase C), the leader of the project has an advising role. The leader of the project is mainly active in the realization phase. He can advise the managers in the beginning of the process about stuff they cannot foresee because they are not familiar with the realization phase (Figure 13, sub phase 5 to 7)

The social project manager is watching the tender phase (Figure 13, sub phase C) from the background. The social project manager has no active role during this phase.

During the tender phase (Figure 13, sub phase C), the tender manager, the project manager, the calculator and the logistics and planning department have close contact with each other.

When all the tasks are done, a meeting with all the involved disciplines will be conducted. The customer and market director and the director preparation will also be invited during this meeting. In this meeting, the quality part and price part will be discussed. After this meeting, the feedback from the meeting will be implemented in the tender.

After this feedback is implemented, the end meeting will take place with additional to the previous persons the statutory director and financial manager. In this meeting there can be made some adjustments to the tender, for example: the measures taken can be changed, the price can be adjusted, the tactic can be adjusted, or the opportunities and risks can be changed. When this meeting is done, the recap will be signed by the statutory director of Dura Vermeer Bouw Hengelo. The division 'Construction and Real Estate' of Dura Vermeer will also sign the recap. This recap contains the financial overview of the project. The recap exists of an intern and extern part. The intern part exists of the financial numbers of the project within Dura Vermeer. The extern part contains the same financial numbers but calculated for the corporation. This extern part will be sent as an overview to the corporation.

When this recap is signed, the tender documents will be submitted. Then Dura Vermeer must wait for the corporation to decide with which construction company they want to realize the project. However, if a presentation needs to be given to the corporation, this will be practiced and given in the meanwhile. The presentation will normally be given by the project leader, the social project manager, the residents consultant, or the executor of the project. One of these persons are chosen because they will also be the persons who the corporation will have to deal with in the realization phase (Figure 13, sub phase 5 to 7).

After this, the corporation will decide. If Dura Vermeer is not chosen out of the candidates, they want an evaluation meeting with the corporation. In this meeting Dura Vermeer wants to know why they are not chosen for the project. They can use this feedback for tenders in the future. Figure 16 depicts the tender phase (Figure 13, sub phase C).

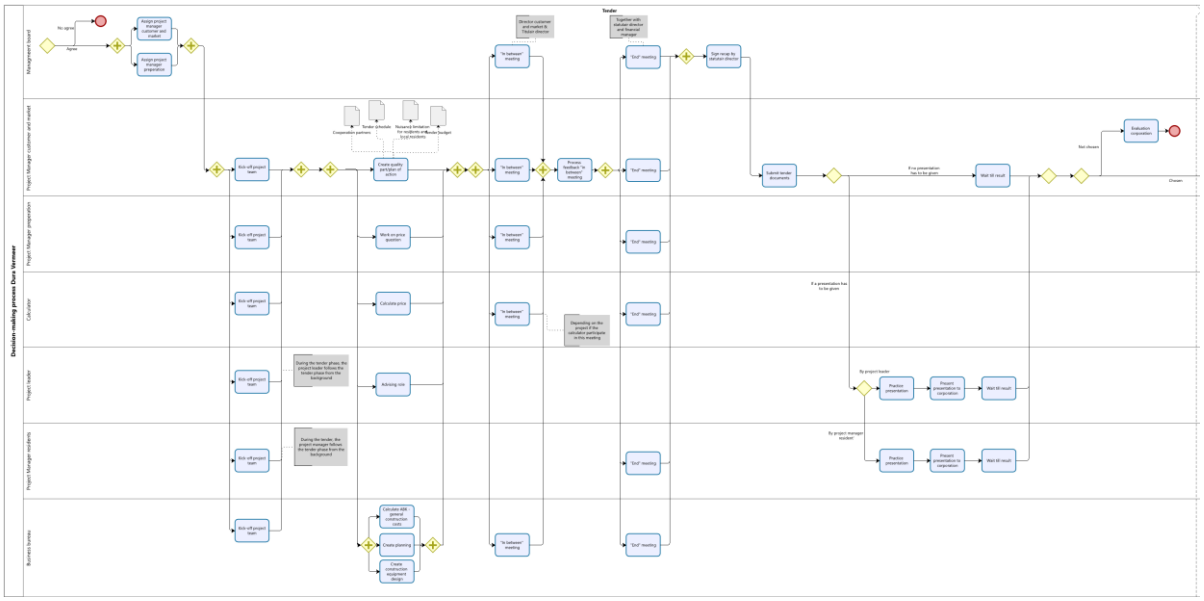

Figure 16: Phase 1/Sub phase C(Tender) of decision-making process Dura Vermeer Bouw Hengelo

When Dura Vermeer is chosen, the contracting phase (Figure 13, sub phase D) starts. Dura Vermeer negotiates with the corporation about the contract. The tender manager and the preparation manager will conduct these negotiations. However, it is possible that they cannot reach an agreement with the corporation about the contract. Then the process of Dura Vermeer will stop, and Dura Vermeer will not perform the project on behalf of the corporation. However, this almost never happens because Dura Vermeer had the possibility to ask questions about the contract in the tender phase (Figure 13, sub phase C). If the contract negotiations are successful, the contract will be signed by the statutory director. This contract is called the construction team agreement. After this step, the project will be handover to the preparation team. Figure 17 gives an overview of the contracting phase (Figure 13, sub phase D).

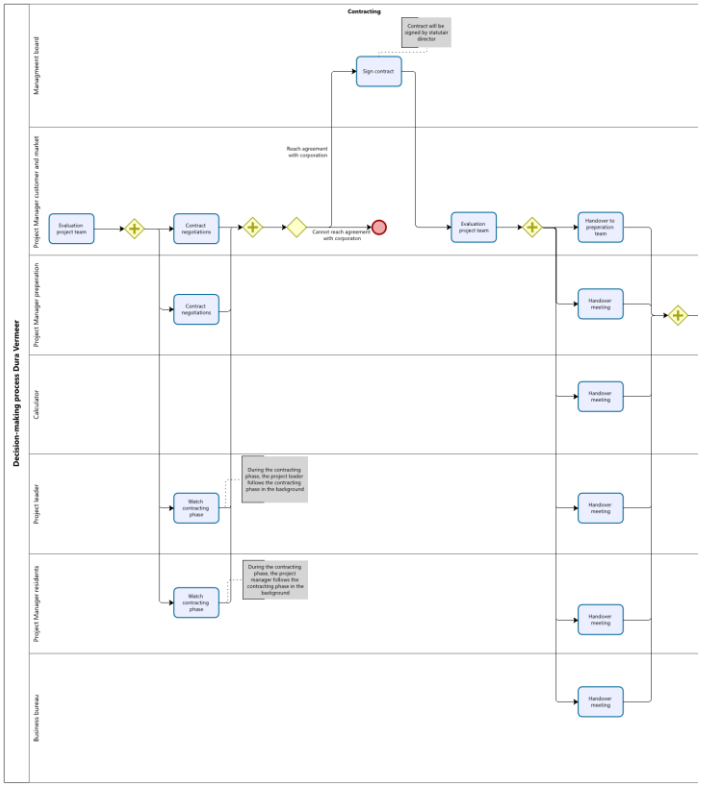

Figure 17: Phase I/ Sub phase D (contracting) of decision-making process Dura Vermeer Bouw Hengelo

After the contracting phase, the structural design phase (Figure 13, sub phase 1) will start. In this phase the project manager, leader of the project, social project manager, calculator and the logistics and planning department are involved.

The project manager creates the structural design of the project together with the project leader. They perform an inspection to the technical state of the real estate and will create a plan of action with measures which need to be taken in order to fulfil the requirements of the corporation. In this phase, meetings with the corporation will take place to discuss the findings and possible measures.

The calculator will adjust the price calculated in the tender according to the measures that needs to be taken to fulfil the requirements of the corporation. In the tender phase (Figure 13, sub phase C), a price is calculated according to a reference house. During the inspection of the technical state of the involved houses the defects of each house will become clear. These defects can differ from the defects found in the model house. Therefore, the price should be adjusted according to the found defects per house. The calculator is responsible for this calculation.

The social project manager develops a residents' strategy and a communication plan. During renovation projects, it is important that the residents are involved in the project as early as possible. Later in the project, the residents must give permission for the project. The more and the earlier the residents are involved in the process, the bigger the change they will give

permission to the project. The social project manager is therefore responsible for the communication with the residents. A list with the housing requirements of the residents will also be made by the social project manager. These requirements will be considered during the design phases. If the requirements of the residents are considered appropriately, it is more likely that the consent of 70% of the residents will be achieved (more about this process will be discussed when analysing the definitive and technical design phase (Figure 13, sub phase 3 and 4)).

The logistics and planning department will adjust the general construction site costs, schedule, and construction site design according to the adjustments made in the structural design phase.

In the preliminary design phase (Figure 13, sub phase 2), the same steps will be repeated. When the process goes from the structural design phase (Figure 13, sub phase 1) to the preliminary design phase (Figure 13, sub phase 2), the project becomes more specified. In the structural design phase (Figure 13, sub phase 2), everything is still open according to the decisions made. In the preliminary and definitive design phases (Figure 13, sub phase 2 till 4), more decisions will be taken which will lead to one definitive design. Figure 18 depicts an overview of the structural design (Figure 13, sub phase 1) and preliminary design phase (Figure 13, sub phase 2).

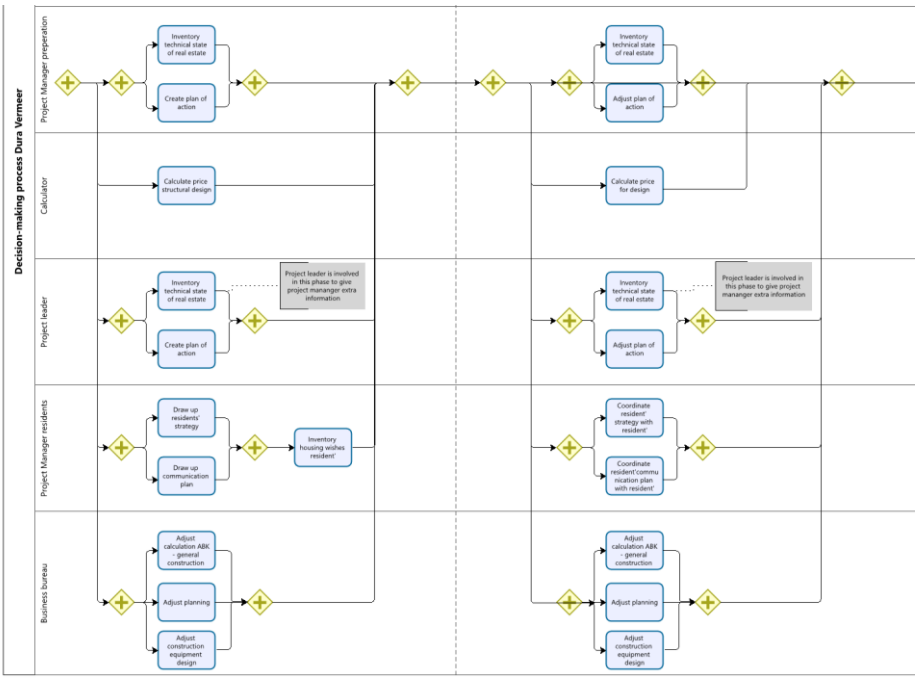

Figure 18: Phase II/ Sub phases 1 (structural design) and 2 (preliminary design) of decision-making process Dura Vermeer Bouw Hengelo

After the preliminary design phase (Figure 13, sub phase 2), the definitive and final design phase (Figure 13, sub phase 3 and 4) will take place. In this phase, the project and its plan will be fine-tuned. This will lead to a definitive design of the project. In this phase, the technical

design of the project will be designed by the project manager. The project manager will also apply for permits at the municipality. There are different permits: an environmental permit, a permit for aesthetics adjustments to the house and a permit for the demolition work.

The logistics and planning department will calculate the final general construction site costs and construction equipment site costs. They will also make the final schedule for the project.

When the final plan is clear, the social project manager will discuss the plans with the resident'. 70% of the resident' must give consent to the project, otherwise the project plan will not be realized. If this 70% is reached, the order can be submitted, and some small negotiations will be discussed with the corporation. Big contract negotiations are not necessary in this phase, the corporation was already involved in the plan preparation phase (Figure 13, sub phase 1 till 4) and therefore the most important agreements are already discussed in the previous phases. When these contract negotiations are done, the statutory director from Dura Vermeer Bouw Hengelo will sign the contract. The director of the corporation will also sign the contract. This contract is called a contractor agreement. An evaluation with the preparation team will take place after hand and the project will be handed over to the realization team within Dura Vermeer. Here the decision-making process of a sustainable project stops. Figure 19 gives an overview of the definitive and technical design phase (Figure 13, sub phase 3 and 4).

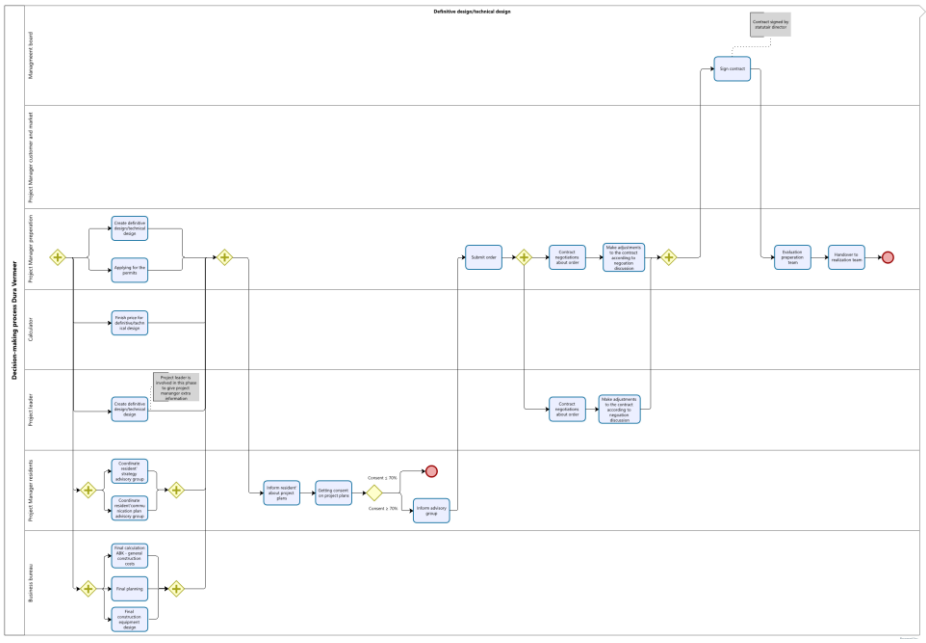

Figure 19: Phase II/ Sub phases 3 (defintive design) and 4 (technical design) of decision-making process Dura Vermeer

The decision-making process explained before is one of the decision-making processes which can occur. There are also different decision-making processes which does not contain all the seven sub phases. It is chosen to focus on the decision-making process with a preselection for one project with a new corporation. This focus point is chosen because the time limit of the

research will not allow it to come up with improvements of all the different decision-making processes. The analysed and explained decision-making process is the most comprehensive decision-making process which covers all the possible phases.

3.2 Analysis decision-making process corporation

In this chapter, the decision-making process of a corporation is analysed. It will provide an answer to the following knowledge question: How does the decision-making process of a sustainable renovation project of a corporation look? During the research, different corporations were interviewed. The goal of these interviews was to gain knowledge about the decision-making process of a corporation. With this knowledge, a BPMN model is created which graphically shows the decision-making process graphically from a corporation. In the decision-making process of a corporation, a division is made in projects with a tender phase and projects which will be carried out with a construction team agreement. Section 3.2.1 covers the decision-making process with a tender phase included. Section 3.2.2 covers the decision-making process with a construction team agreement. The decision to carry out a project with a tender or with a construction team agreement is not based on standard rules. They base this decision on their intuition and the complexity of the project. The price of the project is not a factor in this. This decision is made by the management board together with the project coordinator.

3.2.1 Decision-making process with a tender phase

The decision-making process of the corporation starts with establishing a long-term budget. This long-term budget is the financial representation of the policy of a corporation. The guiding principles are the business plan and the policy principles. In this long-term budget the plans for the upcoming years will be established. This budget will be established by all the different departments within a corporation: neighbourhoods department, housing department, operational department, and customer department. The long-term budget will be discussed with the management board. The approved long-term budget of the management board goes to the supervisory board. The long-term budget will be checked and approved by the supervisory board. The management board of the corporation decided that a complex should last 50 to 60 years from the time it is newly built. After these years, the life span of the complex is done. In order to maintain the complex for 50 to 60 years, maintenance will be carried out in and on the complex. Each complex that is part of a corporation its real estate portfolio has its own complex management plan. In this plan, the purpose of the complex is established. Based on this complex management plan, it is decided if the corporations wants to continue with the complex.

In 2050, all the social rental houses should be natural gas free. However, a corporation does not make their houses natural gas free immediately. The corporation expects that the sustainability measures will evolve over time. It is therefore not necessary to make the houses

natural gas free immediately. They will make their complexes more sustainable step- wise. They make a division in their current real estate according to the categories explained below.

Building complexes with a life span until 2050 should not become natural gas free. In these houses, the corporation only takes sustainability measures which bring the building complex at least to energy label B. Most of the time, this will become label A. They will renovate the kitchen, bathroom and toilet and the cavity will be insulated.

Building complexes with a life span longer than 2050 should become natural gas free to comply with the climate agreement goals of 2050. The corporation will make these building complexes stepwise natural gas free. The sustainability measures which can make complexes natural gas free can become cheaper in the future or new measures can be developed. The current sustainability measures are still in the innovation phase. Therefore, these measures will not immediately be taken.

If a building complex is scheduled in the long-term budget, first the complex management plan of the complex will be looked at. The project coordinator will establish a project plan. This project plan will be based on some small investigations. The project plan reviews the information resulting from the investigations of the complex: area, occupancy, rental price etcetera, the financial indicators, ambitions, and goals of the complex.

When the project manager established this project plan, it will be presented to the management board. They must approve the project, only after this approval, the process can continue. Figure 20 depicts the first steps of the decision-making process of a corporation.

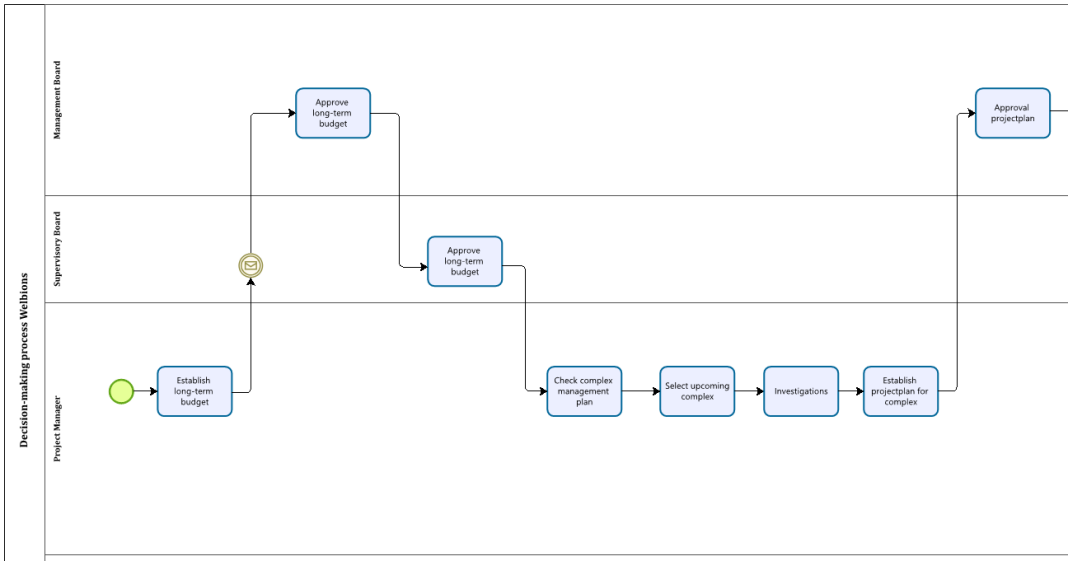

Figure 20: Decision-making process of a corporation with a tender phase first steps

When the management board gave approval, the project coordinator will continue with establishing the project plan. The project plan consists of the following components:

Results of investigations **–** different investigations must be carried out. First, an asbestos inspection must be performed. This investigation shows where there is asbestos in the complex. Secondly, a flora and fauna inspection must be performed. A map of the plants and animals in the area of the planned project will be established during this investigation. Thirdly, an energetic inspection will take place. An energetic inspection provides insight into the current state of the houses and what the best investment is in making the houses more sustainable. Lastly, a constructive inspection must be performed. The constructive condition of the complex will be established during this investigation.

Financial results **–** the financial department within a corporation will calculate the price of the sustainability measures that should be taken. In this financial document, the investment amount and new rental price for the residents are established. An external company will calculate of the corporation can get grants and how much grant this will be. The sustainability measures which should be taken are specified based on the finding of the investigations.

Advice to management board **–** the project coordinator will establish the advice for the management board. The project coordinator will give advice if the corporation should continue with the complex and make it more sustainable. They will base this decision on the results of the investigations and on the financial results. All these information will be merged into the final project plan. Figure 21 will depict the steps explained above of the decision-making process of a corporation of a sustainable renovation project with a tender.

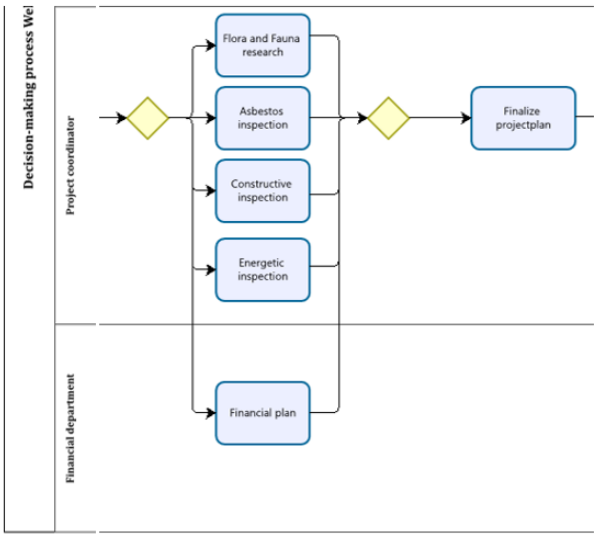

Figure 21: Decision-making process of a corporation with tender phase second phase

When the project plan is established, it will be sent to the management board. The management board will base their decision on strategic, financial, organisation and technical criteria. Based on these criteria, the management board will decide if the corporation will continue with the project or not. The management board meets every 14 days. If the price of the project is above 1.5 million, the supervisory board must check the decision of the management board of

the corporation, below 1,5 million this additional check is not required. The supervisory board consists of independent persons coming from outside the organisation. These people have acquired considerable knowledge in their own fields which they apply when checking the decision of the management board. The supervisory board will base this decision on the same criteria the management board does. The supervisory board meets five times a year. If the supervisory board agrees with the decision of the management board, the project will continue. The decision of the management board will result in a decision-making document. In this decision-making document, the approval of the management board and supervisory board is established. Figure 22 depicts the above explained steps of the decision-making process of a corporation.

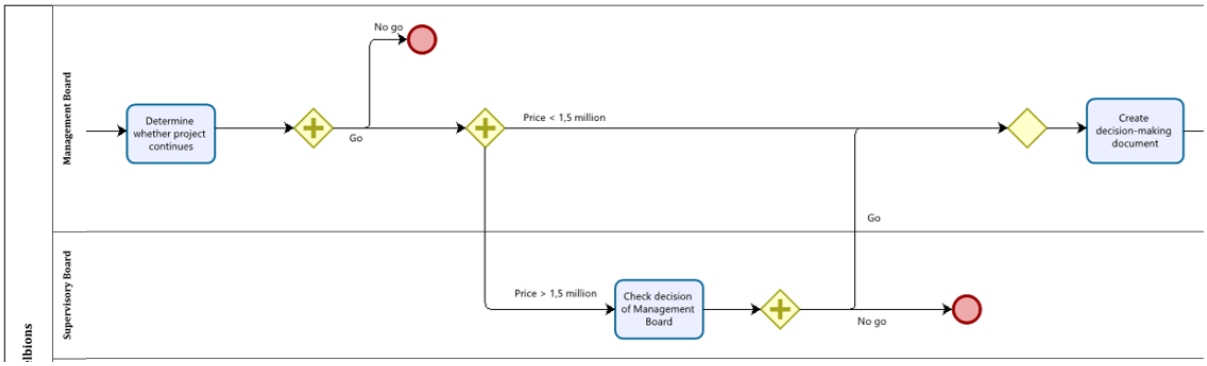

Figure 22: Decision-making process of a corporation with tender phase third phase

After the decision-making document is established, a procurement will be sent to selected construction companies. Here, the tender phase will start. In this phase, the corporation will invite different construction companies for the tender. The corporation works together with different known construction companies. But it is also possible that a new construction company may carry out the project because they are selected for the tender. However, an unknown construction company will rarely be invited for a tender. The amount of construction companies that will be selected for the tender will be based on the price of the project. Table 5 depicts this distinction.

Table 5: Division selection construction companies

Project between 1,5 million and 3 million	Invite 3 construction companies
Project > 3 million	Invite 5 construction companies

The different construction companies will calculate the price of the measures that should be taken mentioned in the project plan of the corporation. Based on the offer of the construction companies, the corporation will decide which construction company may realize the project. Which construction company is selected for the tender will be based on the procurement of the corporation. It can be based on the price of the project, but also about the sustainability measures the construction company offers. There are no standard rules within a corporation

about choosing a construction company for the procurement. Then, some contract negations will take place and after these negotiations the contract will be signed by the management board of the corporation. After these phases, the realization of the sustainable renovation project can take place. Figure 23 depicts the last steps of the decision-making process with a tender phase of the corporation.

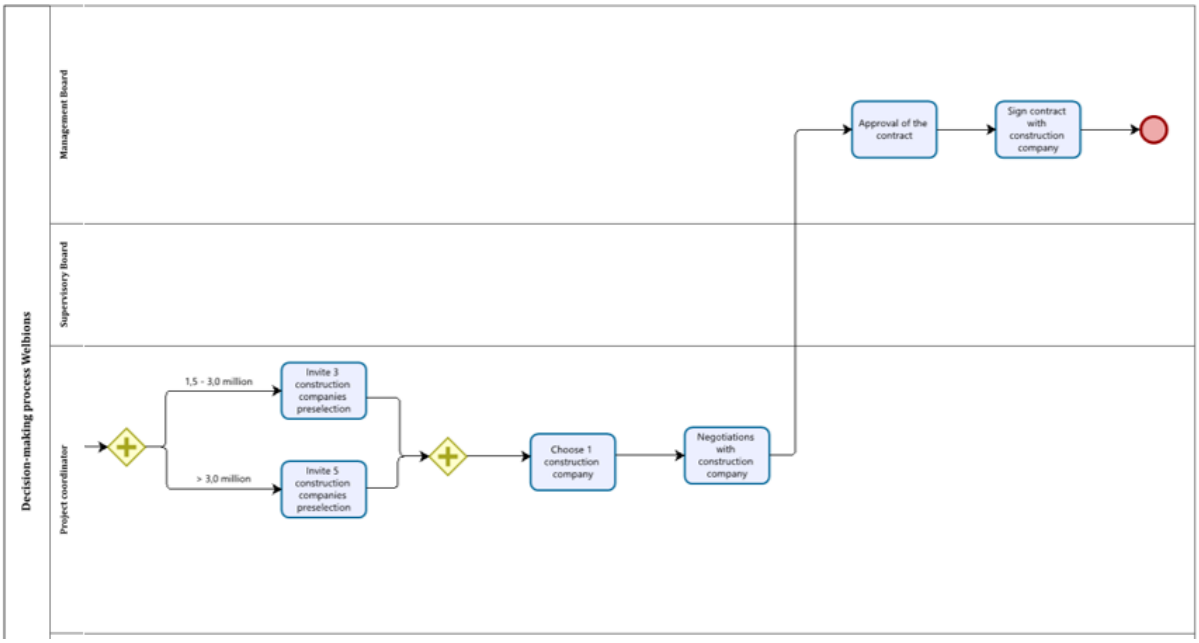

Figure 23: Decision-making process of a corporation with a tender fourth phase

3.2.2 Decision-making process with a construction team agreement

However, most of the projects of a corporation will be carried out with a construction team agreement. The difference between a tender and construction team agreement is that a construction team agreement will be given away to one construction company. With a tender, three to five construction companies will be invited. In the beginning it is not sure which construction company will carry out the project. With a construction team agreement, the construction company will be involved in the project from the beginning. The project manager and management board of the corporation will decide together which construction company they want to carry out the project with. This construction company will be invited. When both parties agree on the construction team agreement, it will be signed. This is the start of the cooperation between the corporation and the construction company. Figure 24 depicts the first phase of the decision-making process of a corporation with a construction team agreement.

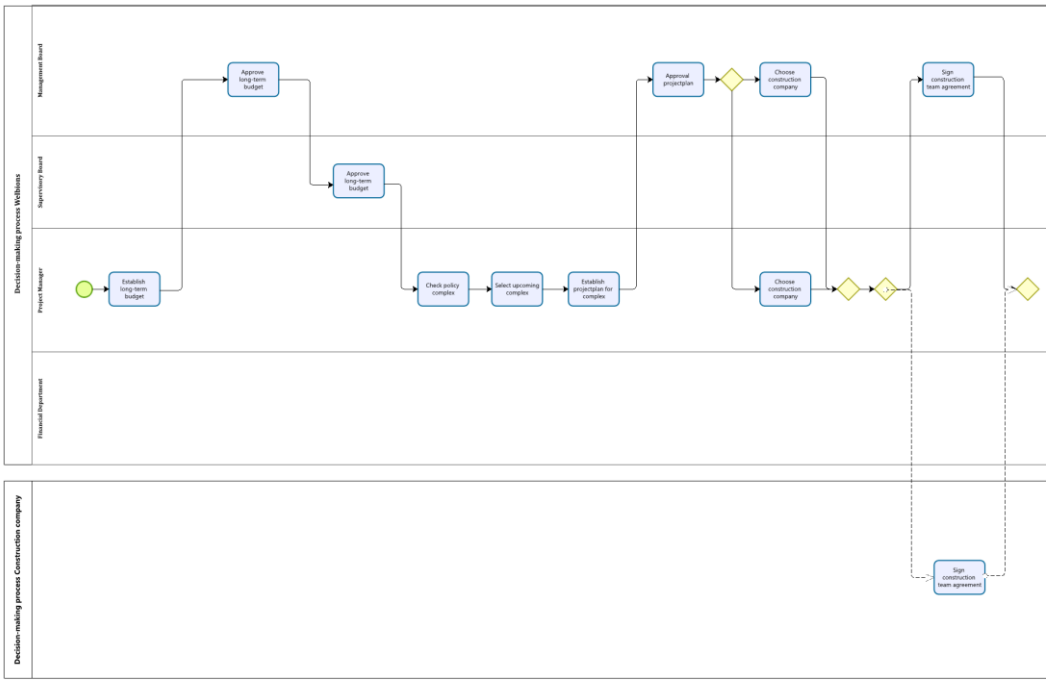

Figure 24: Decision-making process of a corporation with a construction team agreement first phase

When the construction team agreement is signed, the cooperation between the corporation and the construction company starts. The construction company will first carry out the investigations at the complex. This are the flora and fauna research, asbestos inspection, and constructive inspection. When these inspections are done, the corporation and the construction company will establish the sustainability measures which are necessary to realize the ambitions and goals set in the policy plan of the complex. Simultaneously, the construction company will calculate the price of the sustainability measures. The measures and the price part will be combined in the project plan. Figure 25 depicts the steps explained above of the decision-making process of a corporation with a construction team agreement.

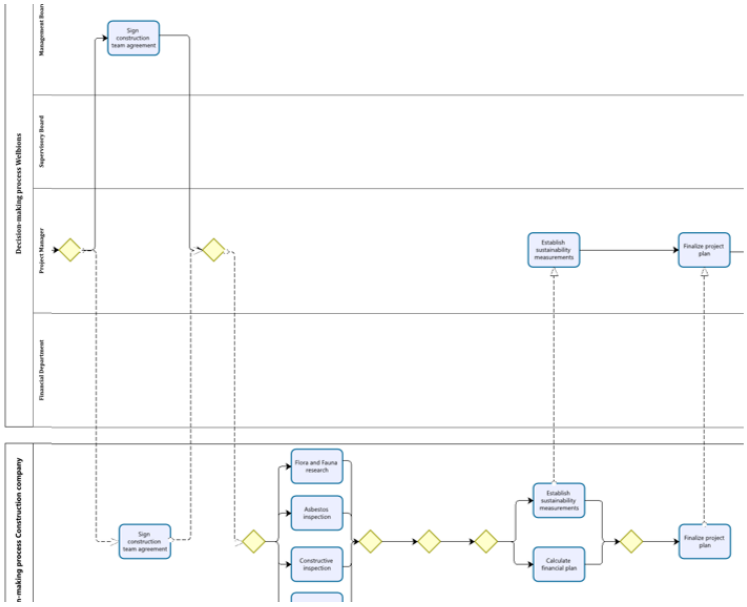

Figure 25: Decision-making process of a corporation with a construction team agreement second phase

The next steps in the decision-making process of a corporation are the same as in the decision-making process of a corporation with a tender phase. This can be read in Section 3.2.1. After the decision of the management board, some contract negotiations will take place about the price. When these contract negotiations are done, the corporation and the construction company will both sign the contract, and the realization of the project can start. Here, the decision-making process of a construction team agreement of a corporation will start.

3.3 Summary chapter 3

The decision-making process of Dura Vermeer starts at the acquisition phase (Figure 13, sub phase A), in which Dura Vermeer and the corporation get to know each other or catch up during a meeting. In the preselection phase (Figure 13, sub phase B) Dura Vermeer chooses to participate in the procurement of the corporation by submitting the selection documents. In the tender phase (Figure 13, sub phase C) Dura Vermeer will establish the tender documents which consists of a quality and price part. Usually, the quality part contains a textual explanation of the measures that will be taken to meet the requirements set in the procurement of the corporation. The price part will contain the price for the sustainable measures that should be taken based on a reference house. When Dura Vermeer gets chosen for the project, the contract will be signed in the contracting phase (Figure 13, sub phase D). In the structural design phase and preliminary design phase (Figure 13, sub phase 1 and 2), the project is further elaborated in terms of the measures to be taken and the price. In the definitive/technical design phase (Figure 13, sub phase 3 and 4), the design and plan of the project is finished and the contract between Dura Vermeer and the corporation will be signed.

The decision-making process of the corporation is divided into a process with a tender phase or with a framework agreement. In both cases, the project coordinator will establish a project plan which represent the plans of the complex that should be renovated in a sustainable way. The management board and supervisory board must give approval on this plan. In a project with a tender, the construction company will be chosen after the project plan is established. In a project with a construction team agreement, the construction company will help with establishing the project plan from the beginning of the project.

4 Problem identification decision-making process

In this chapter, an overview of the problems in the decision-making process of Dura Vermeer together with the corporation is given. It gives an answer on the following knowledge question: What are problems in the current decision-making process of a sustainable renovation project of the corporation together with Dura Vermeer? After discussing the problems, the findings will be presented in an Ishikawa- diagram.

When analysing the decision-making process of Dura Vermeer together with the corporation, problems were found. In Figure 26 and Figure 27, the BPMN models of the decision-making process of Dura Vermeer and a corporation are shown with the found problems which have an orange square around it. An in-depth analysis of the found problems is provided in section 4.1 till section 4.7.

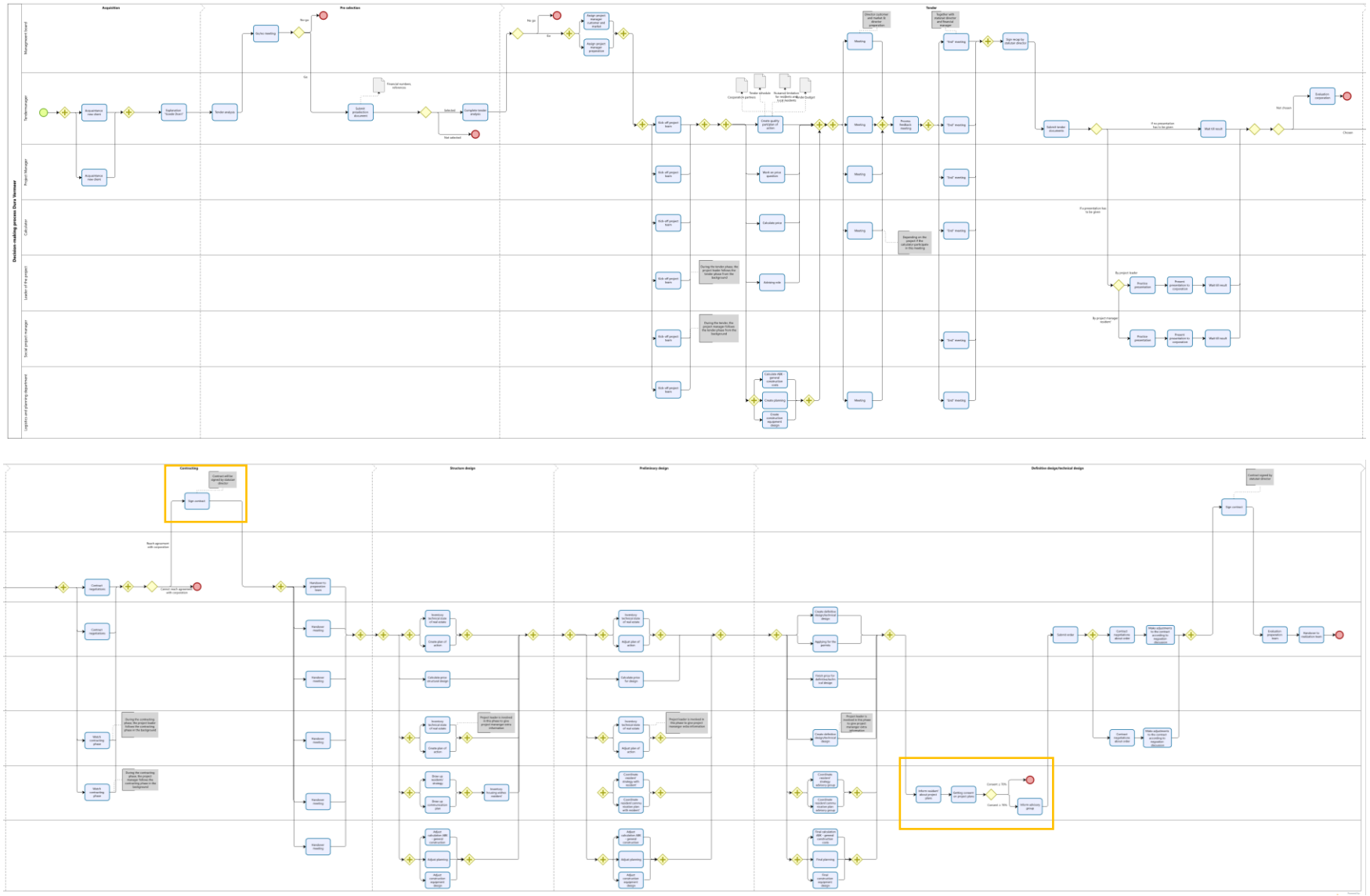

Figure 26: BPMN model decision-making process Dura Vermeer with found problems

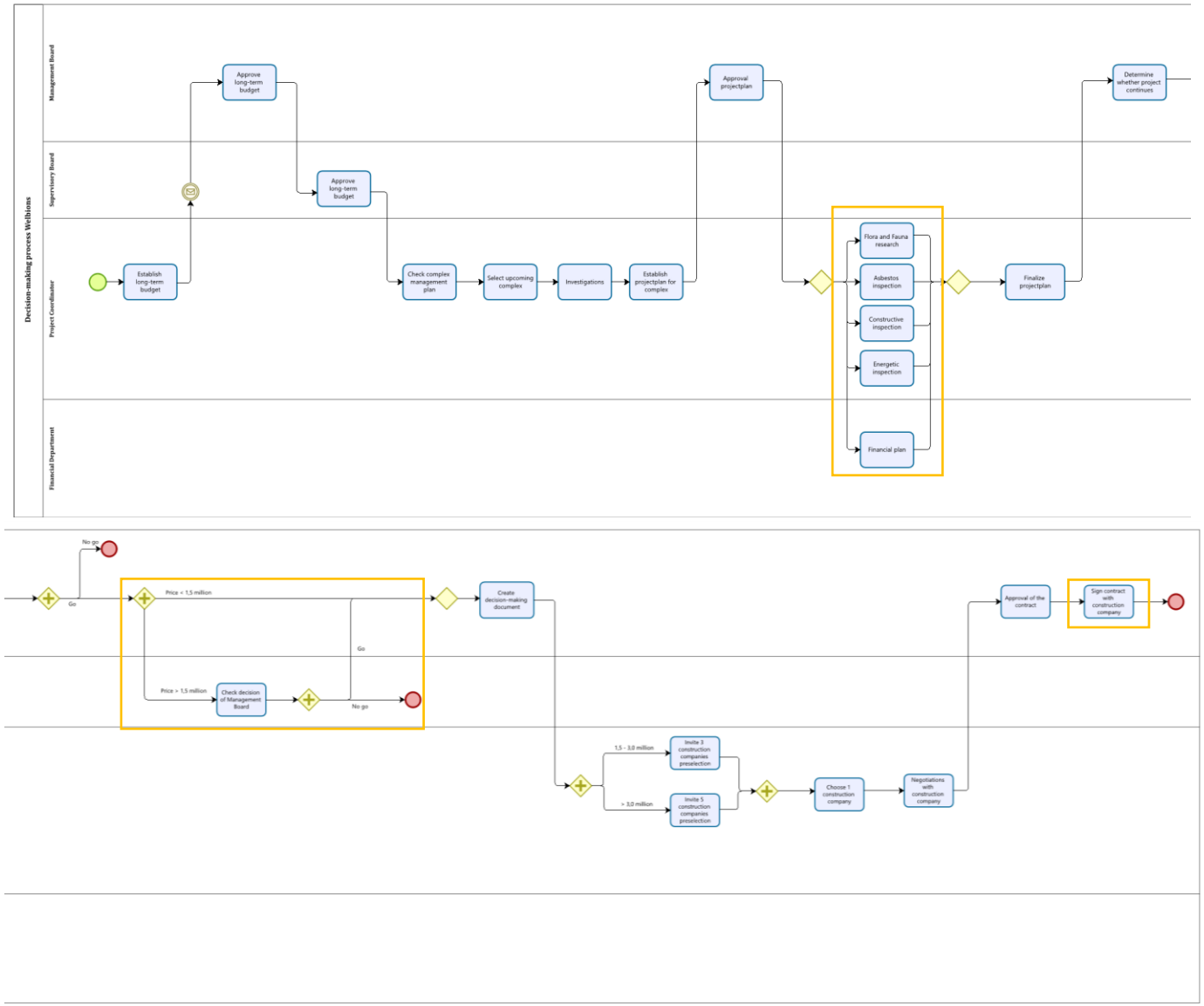

Figure 27: BPMN model decision-making process of a corporation with found problems

4.1 Not enough supervisory board meetings

Projects with a price higher than 1.5 million need approval of the supervisory board within a corporation. The supervisory board must check the decision of the management board of the corporation. However, where the management board of a corporation meets each 14 days, the supervisory board only meets 5 times a year. The project coordinator who wants to receive approval on his/her project plan must therefore take into account the deadlines to ask for approval. If a project plan is finished one week after the meeting of the supervisory board, he or she must wait circa two months before the next meeting of the supervisory board takes place. Without the approval of the supervisory board, project with a price bigger than 1,5 million cannot continue. Currently, it sometimes happens that the project coordinator must wait for approval of the supervisory board on his project plan. The process can easily get delay due to this issue.

Importance of solving this issue

It is important for the project coordinator of a corporation to know when the meetings of the management board and supervisory board take place. He can take these meetings in account when making the planning of the project plan. In this way, the project coordinator knows when the project plan should be finished in order to reach the meeting of the management board and the supervisory Board. This ensures no delay to minimum delay of the project related to this problem. More meetings of the supervisory board can also take place. So, the project coordinator of the corporation has more opportunities to ask for approval on his/her project plan.

4.2 Supervisory board does not discuss project plan during the meeting

Added to the problem above, it also happens that the supervisory board does not discuss the project plan during the meeting, because there is no time anymore to discuss the project plan. In this case, the project coordinator has achieved the deadline of the supervisory board meeting. However, due to the supervisory board he or she cannot receive approval.

Importance of solving this issue

If a project plan is not included in the meeting of the supervisory board, the planning of the project coordinator for the project will not be correct anymore or he/she must adjust the planning. The project coordinator must wait for approval of the project plan, which he or she can receive during the next meeting of the supervisory board which takes place in circa two months. So, this quickly causes a lot of delay.

4.3 No digital signature system within corporation

When documents and contracts need to be signed within a corporation, this will be done manually. When the corporation and the construction company both must sign a contract, the corporation first will print the document. The document will normally be printed by the administrative department withing the corporation. This also means the involvement of another

new person in the decision-making process which is not efficient. The printed document will be signed manually within the corporation. When this is done, the document will be sent by letter to the construction company. The construction company must sign the document also manually and then send it back to the corporation. The whole process of signing the documents requires many actions and also costs much time. However, these actions, apart from the actual signing, do not add value to the process.

Importance of solving this issue
The issue of having no sign system within the corporation must be solved. Currently, the whole process of signing document with a construction company take a lot of time. Because it must be sent by a letter to the construction company. Before the contract is signed from both sides, some time has elapsed. The time needed for printing the document and sending it by letter to the construction company and vice versa can then be used for the further steps in the process.

4.4 Information exchange not optimal

Currently, documents are exchanged via e-mail between the corporation and Dura Vermeer. In the decision-making process of a project with a tender phase, the procurement documents from the corporation will be send to the contact person of the construction company by e-mail. When the construction company send the tender documents back to the corporation, the contact person will also receive this documents. That means that in both organisations, the members of the project team are dependent on the contact person for information.

The contact person must also ensure that all the team member receives the information, which enholds an extra step in the decision-making process of the corporation and Dura Vermeer.

However, if the corporation has a construction team agreement with a construction company and this company makes use of a project portal, they will make use of this project portal. During a construction team agreement with Dura Vermeer, the corporation makes use of the project portal BIM 360. BIM stands for Building Information Model. BIM 360 is a platform for more efficient collaboration on BIM projects in the cloud. BIM 360 streamlines communication and centralises data in BIM project (Cad & Company, 2021). Dura Vermeer makes use of BIM 360 for their projects.

Importance of solving this issue
The current working way is not very efficient. The whole project team is dependent on one person for information about the project. The contact person should also send the information to all the team members, which involves an extra step in the decision-making process of the corporation and Dura Vermeer.

4.5 Coordination of investigations by external party

In the decision-making process of a corporation within a tender phase, the corporpation must collect the data of the necessary investigations themselves: flora and fauna inspection, asbestos inspection, constructive inspection and energetic inspection. This means that an external party must perform the investigations for the corporation. As these investigations are carried out by a different party, this requires some coordination. When interviewing the project manager of a corporation, he pointed out that this step in their decision-making process takes the most time. In a construction team agreement, the construction companies carry out these investigations. This saves time for the corporation, then they only need to interpret the data they received form the investigations performed by the construction company.

Importance of solving this issue

According to the interviewed corporations, this is the most time-consuming step in the decision-making process of the corporation. It is therefore important that this issue gets solved in order to speed up the decision-making process of the corporation.

4.6 Increase in material costs

During the interview with the project manager of a corporation, he indicated that the current problem they are facing is that they cannot carry out their projects because the prices of the materials are risen this year. The corporation agreed on a price with the construction company for a project. The demand for materials has increased and the production – partly due to COVID-19 – cannot keep this up. Therefore, the materials costs for the construction companies increased. However, there are clausules in the contract with material suppliers in which Dura Vermeer agreed on a price for a certain time frame. The material suppliers must deliver the materials for the agreed price within the given time frame. When the time frame is expired, Dura Vermeer must pay the new material price and then they should discuss the project price with the corporation, because Dura Vermeer can then not realize the project based on the historical prices. This means that more budget from the corporation is necessary for the project in order to realize it. This will make the project of the corporation less feasible. In both case, the increase in material costs will create problems and more time is necessary in order to discuss the change in material costs. This will increase the delay in the decision-making process of Dura Vermeer together with a corporation.

Importance of solving this issue

Some contracts of project were signed when we were not yet aware of COVID-19. The material costs were normal in this period. But now, when COVID-19 exists, they are facing the problem of increasing material costs. The demand for materials has increased and the production – partly due to COVID-19 – cannot keep this up. A conclusion that can be made from this problem is that there is a time gap between the contracting phase and the actual realization phase of the project.

If the realization phase started directly after the contracting phase, this problem would not occur.

However, this problem goes about an increase in materials costs while the research goes about improving the decision-making process of sustainable renovation projects. Solving this problem is therefore out of scope for the research.

4.7 Time to collect consent from 70% the residents

The advisor of sustainability of a corporation mentioned that they experience the most delay in the process due to the residents. 70% of the residents must give consent on the renovation project. Without this 70%, the renovation project cannot continue. It is therefore really important that this consent will be achieved. In most of the cases, the construction company will collect the consent together with the corporation. However, this is depending on the kind of procurement of the corporation. The consent will not always be achieved. In that case, not enough residents gave permission for the renovation project. Delays take place from this moment on. Conversations will take place with the residents who do not gave permission, so that they can still achieve the consent. However, this takes time and causes delay in the decision-making process.

Importance of solving this issue

It is important that this issue get solved. Without consent from 70% of the residents, the project cannot continue. It is also desirable that this consent will be collected during the first collection round to minimize delay in the project. The steps after the consent step (Figure *13*, sub phase D) can only start after the consent has been received.

4.8 Summary chapter 4

The found problems in the current decision-making process can be placed into of the following categories depicted in Table 6.

Table 6: Problems decision-making process of a corporation per category

Process	**Equipment**	**Management**	**Materials**	**People**
Corporation must carry out research themselves	No signature system	Supervisory board only meets 5 times a year	Increase in material costs	Supervisory board does not discuss project plan
Information exchange not optimal				
Time to collect consent from 70% of the residents				

Visualising these problems using an Ishikawa diagram, results in Figure 28.

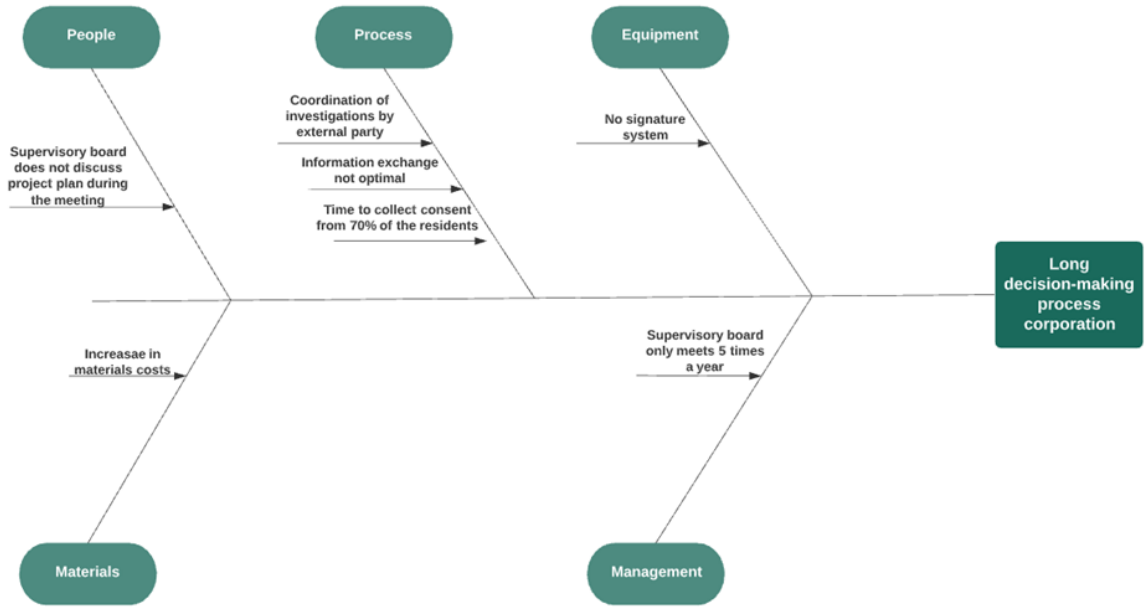

Figure 28: Ishikawa-diagram problems decision-making process of a corporation

5 Improvements

In this chapter, different improvements will be provided for the problems mentioned in the earlier chapter. It gives an answer on the following knowledge question: How can improvements be formulated for the decision-making process of a sustainable renovation project of the corporation together with Dura Vermeer?

5.1 More frequent meetings of supervisory board

Improvement

As mentioned in Section 4.1, the supervisory board of a corporation only meets 5 times a year. It is important that the project coordinator knows when the meetings take place of the supervisory board. The project coordinator can take these meeting dates in advance while making the planning of the project plan. It should be recommended to a corporation to fix the dates of the meetings of the supervisory board in advance each year. The project coordinator can take into account these dates when starting with the project. Knowing when the dates of meetings of the supervisory board are, also motivates the employees of a corporation to actively be involved in the process. In this way, delay due to the approval of the supervisory board can be minimalized in the decision-making process of a corporation which can speed up the process.

If we search for overlaps in the decision-making process of a corporation with a tender phase with fixed design and drawing and the decision-making process of Dura Vermeer, Dura Vermeer is not involved yet in the process when the project manager needs approval. Therefore, solving the problem of the supervisory board will not direct have an influence on the decision-making process of Dura Vermeer with a tender phase.

If Dura Vermeer has a construction team agreement with a corporation, the problem of the supervisory board does have an influence on the decision-making process of both organisations. The approval of the supervisory board will then take place when Dura Vermeer is already involved in the project (because Dura Vermeer will work together with the corporation on the project plan the supervisory board must approve). During a project with a construction team agreement, it is thus also important that Dura Vermeer knows when the meetings of the supervisory board take place.

Additional to this improvement, it will be recommended to a corporation to plan more often meetings of the supervisory board. This ensures that there are more opportunities for the project manager to ask for approval which decreases the possible delay in sustainable projects.

Evaluation of improvement

When we evaluate this solution regarding reducing the lead time, this solution will have a positive influence on the lead time of the decision-making process of Dura Vermeer together with a corporation. Establishing the supervisory meetings, a year in advance and planning more

meetings will reduce the delay due to not achieving the deadline of asking for approval. This will reduce the lead time of the process of making houses (more) sustainable.

5.2 Address chairman for supervisory board meeting

Improvement

As mentioned in Section 4.2, the supervisory board does not always discuss the project plan during the meeting when there is no time anymore to discuss the project plan. An agenda must be created before the meeting starts. This contains all the items to be discussed during the meeting. It is so clear to those present what will be discussed at the meeting. No new items can be added to the agenda during the meeting. The most important items on the agenda must be given priority. These are the points that must be discussed at the meeting anyway. If it is not possible to discuss all the items, those that have no priority will be carried over to the next meeting of the Supervisory Board. This ensures that the items with priority will definitely be discussed during the meeting.

A chairman should be addressed before the meeting. This chairman must make the agenda. He or she must estimate how long items will take to discuss. He will guide the meeting and therefore knows when to stop discussing an item and move on to the next. The chairman must also ensure that they stuck to the agenda and no other points will be discussed during the meeting which are not on the agenda. The interviewed corporations indicated that they do not use a chairman during meetings.

Another solution which you can think of is placing the responsibility lower in the organisation. This means that persons holding lower positions in the organisation can make the decision about a project plan. In the case of the interviewed corporations, this could be the management board who meet each fourteen days. However, according to the project coordinator, it rarely happens that the management board makes a decision on their own and ask written consent to the supervisory board.

It should also be recommended to plan more meetings of the supervisory board. All the items that should be discussed during the meeting can so be divided over more meetings. In a meeting, there will be more time to discuss the items when there are less items on the agenda. This also ensures that the project plan of the project manager will be discussed in the meeting and that the project manager receives approval.

Evaluation of improvement

When referring back to the solution mentioned in Section 4.1 , this solution will reduce the lead time of the decision-making process of Dura Vermeer together with a corporation. To ensure that the project plan will be discussed in the meeting, more meetings will be planned, and a chairman will be addressed. This will reduce the lead time of the process of making social rental houses (more) sustainable. However, it cannot be 100% guaranteed that addressing a chairman

to the meeting will ensure that the project plan will be discussed in the meeting. It can turn out that an item on the agenda took more time than estimated. The problem of not discussing the project plan in the meeting will then contain to exist. Establishing more meetings per year will guarantee more that the project plan will definitely be discussed during a meeting.

5.3 Use of digital signature system within housing corporation

Improvement

As mentioned in Section 4.3, a corporation does not have a digital signature system. If a document or contract needs to be signed by the construction company which they are working together with, the corporation must send the document or contract by letter to the construction company. Figure 29 gives an overview of these steps in a BPMN-model. The activities which are circled in red do not add value to the process. The activities with an orange square around it add value to the process but can be carried out more efficient.

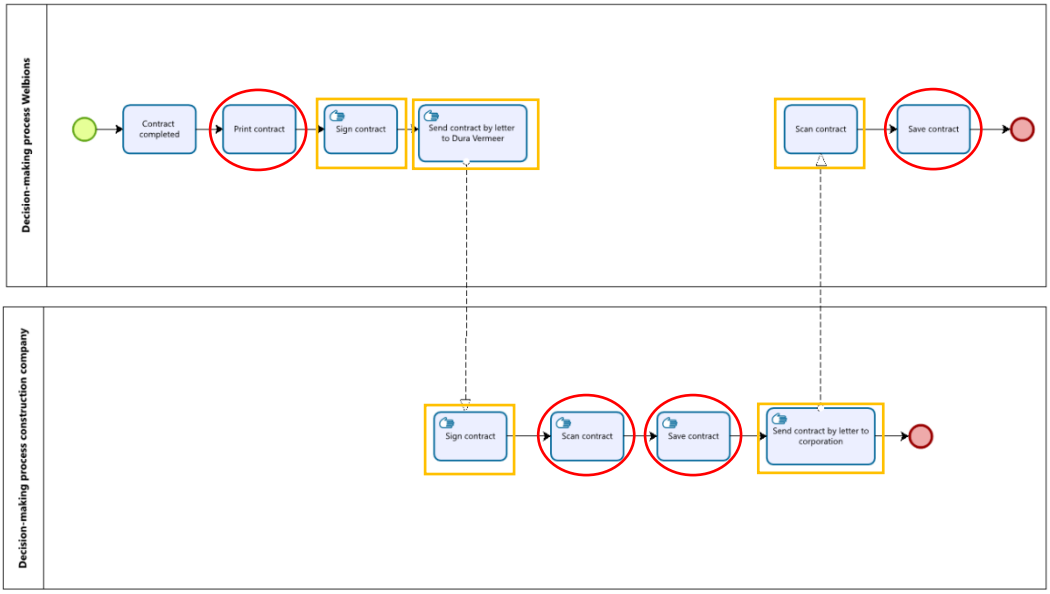

Figure 29: BPMN model of the signature phase of a document or contract of a corporation with a construction company

It would be recommended to make use of a digital signature system. Within a digital signature system, the document or contract that needs to be signed can be uploaded. The e-mail address of the person authorised to sign the document must be filled in and then the document or contract can be sent to that person. The person will receive a mail with a link to sign the document or contract. When the person has signed, the person who send the document will receive an email with the notification that the contract is signed. Both parties has then signed the document or contract and the phase of signing the documents is finished.

Digital signature systems enable businesses to make their processes of signing documents or contracts go faster. A digital signature system will increase the response time. It

eliminates tasks in the decision-making process and increases convenience for customers and employees which need to sign documents or contracts (DocuSign, 2021).

Dura Vermeer uses the signature system DocuSign. DocuSign supports digital signing. The experiences with DocuSign of Dura Vermeer are positive. It is an easy tool to use and saves time in the process according to employees of Dura Vermeer who work with DocuSign. Therefore, it is recommended to the corporation to make use of a digital signing system like DocuSign. This can also be another digital signing system than DocuSign. Figure 30 gives an overview of the BPMN-model of the new signature phase with the use of a digital signature system. The activities with a green square around it are new activities. The number of steps to be taken has been reduced in the new situation as can be seen in the new BPMN-model. This ensures fewer steps in the process, which will speed up the decision-making process.

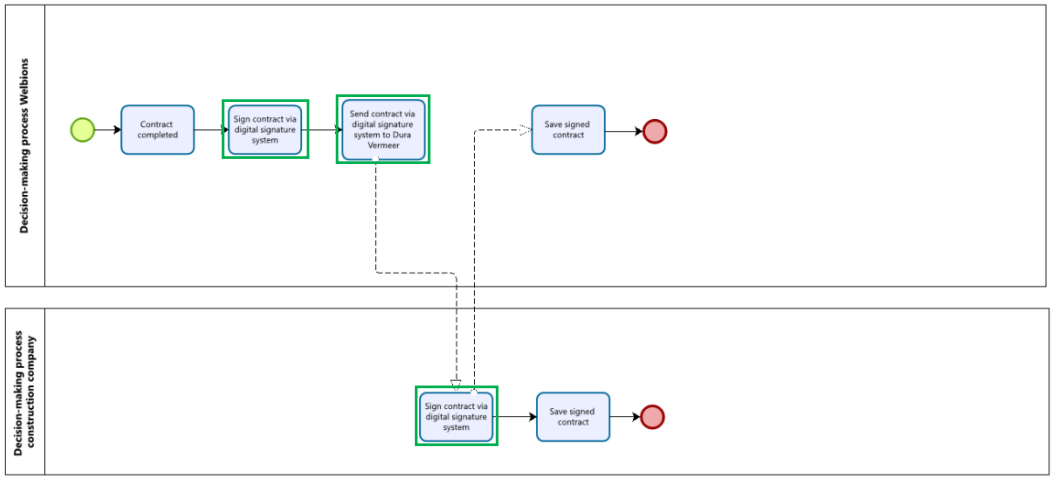

Figure 30: BPMN-model of the new signature phase of a document or contract of a corporation with a construction company

Evaluation of improvement

Making use of a digital signature system will improve the lead time of the decision-making process of Dura Vermeer together with a corporation. As shown in Figure 29 and Figure 30, a digital signature system reduces the steps in the decision-making process which will save time. The administrative department within a corporation will not be needed anymore in the new process. This will improve the efficiency of the decision-making process.

5.4 Use of digital project portal within housing corporation

The current working way of a corporation is very inefficient. The whole project team is dependent on one contact person. The contact person must also send the information and documents to all the project team members, which involves an extra step in the decision-making process. The BPMN-model of the current way of working related to the information exchange of documents and information is depicted in Figure 31. The activities with an orange square around it add value to the process but can be carried out more efficient.

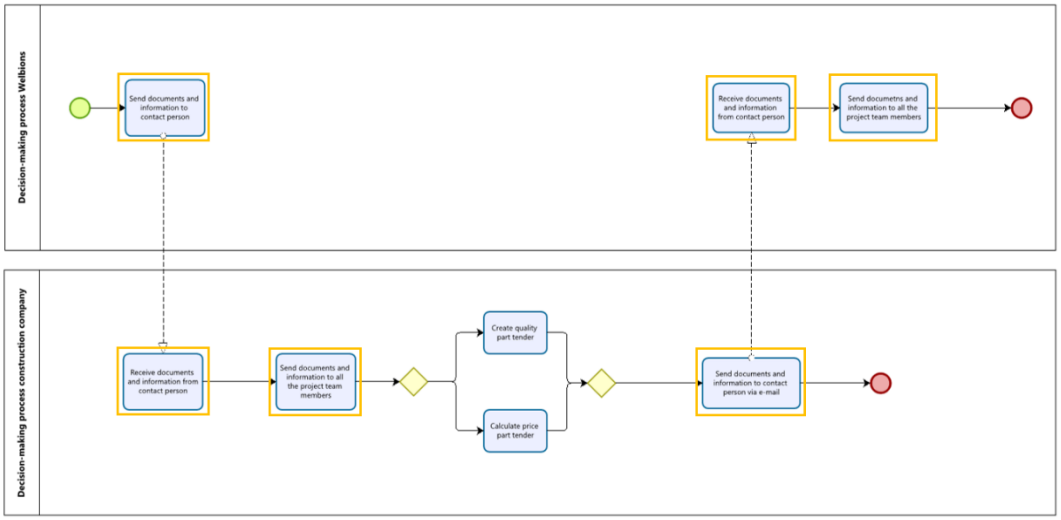

Figure 31: BPMN-model current working way of sending and saving documents within a corporation

Improvement

A solution to this problem would be a project portal on the website of the corporation. This is a separate page on which the corporation can upload all the documents and information. Dura Vermeer has access to this page on which they can find the documents and information. The whole project team has access to this project portal, which eliminates the step of sending the documents and information to all the project team members. When Dura Vermeer wants to share documents or information with the corporation, they can upload these documents to the project portal. The corporation can find the documents and information of Dura Vermeer on this project portal, and all the project team member of the corporation have access to this project portal. As shown in Figure 32, the project portal saves time; it requires less activities than in the old working way. The activities with a green square around it in the BPMN-model indicate new activities.

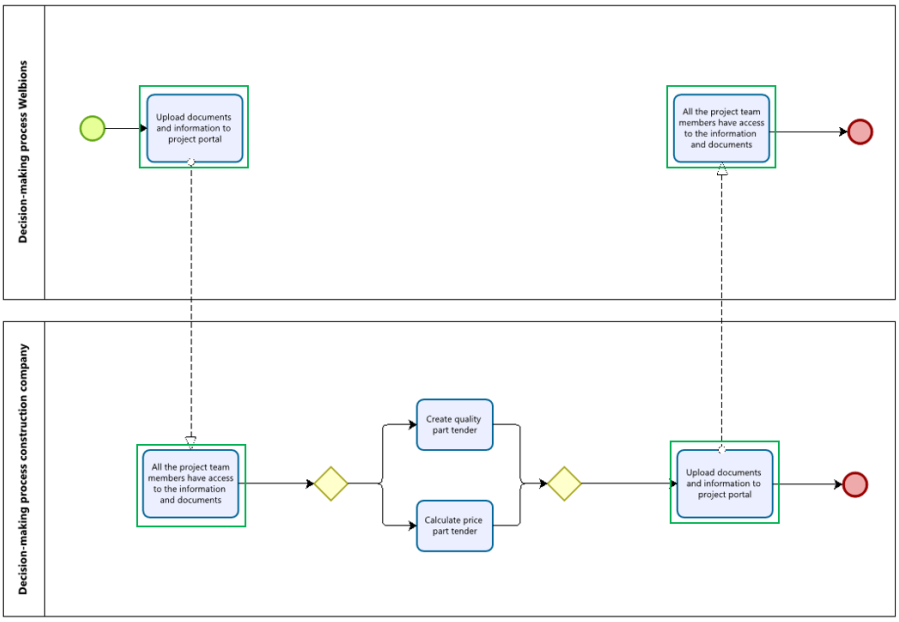

Figure 32: BPMN-model new working way of sending and saving documents within a corporation

Evaluation of improvement

Making use of a project portal will improve the effectiveness of the decision-making process of a corporation. It will be recommended to make use of a project portal which will increase the efficiency of the process and also makes it easier for both the corporation and Dura Vermeer to reach the other company. This will increase the communication between the corporation and Dura Vermeer.

5.5 Partnership and supply-chain collaboration

As mentioned previously in this thesis, the coordination of investigations in the tender process of the corporation is the most consuming step. But although this is the most time-consuming step in the decision-making process of the corporation, a solution to this problem cannot be found. Creating a separate department in a corporation who performs the investigations is not realistic. The corporations interviewed are too small for this and setting up different department with different disciplines is not efficient and cost much time. So, this step in the decision-making process of a corporation will always exists, even though it is the most time-consuming step.

However, learned from this problem and the interviews is, that it is important that the construction company and corporation become partners. Because some of the interviewed corporations work with partners, their renovation projects run properly. It is important that construction companies help from the beginning of the project with the investigations and establishing the sustainability measures. The construction companies know more about the realization of projects than a corporation and their expertise can be used to create the most efficient projects, according to the advisor of sustainability of a corporation. The project manager of another corporation also pointed out that projects which are performed with partners are more pleasant.

In the European construction industry, the concept of partnering has firstly been introduced in the early 1990s. Partnering refers to a long-term commitment between two or more organizations in which shared understanding, common goals and trust develop for the benefits of improving construction according to Construction Industry Institute (1991).

The objectives of partnering are to promote the use of collaborative, more open and less hierarchical relationships between actors in projects according to Alderman and Ivory (cited in Crespin-Mazet et al., 2014).

Beyond increased productivity and reduced costs, partnering was presented as an opportunity to reduce project times, improve quality, and improve customer satisfaction and stability according to Bresnen & Marshall (cited in Crespin-Mazet et al., 2014). According to Castro et al. (cited in Crespin-Mazet et al., 2014) firms are more likely to form associations with other firms when they have previously worked together on similar projects and have previously established ties of cooperation.

A benefit of partnership is a reduction of the construction time by 10% according to Black et al. (cited in Beach et al., 2005). Furthermore, there is an increased willingness to share risk; increased confidence of success; reduced exposure to project risk; enhanced transfer of practices and processes to other projects; improved co-operation; increased understanding of parties/less adversarial relationships; better team spirit; more effective communication; learning from partnering improving overall company competitiveness; increased customer satisfaction; improved employee skills and improved motivation of employees according to Black et al., Scott and Haksever et al. (cited in Beach et al., 2005).

Partnership requires a certain degree of collaboration. A supply chain collaboration can be defined as an on-going relationship between two firms that involves a commitment over an extended time period, and a mutual sharing of information and the risks and reward of the relationship, in this research between a construction company and housing corporation according to Ellram and Hendrick (cited in Cao and Zhang, 2013).

Supply chain collaboration requires information sharing. According to Cao and Zhang (2013) apart from exchange of demand information, exchange of more strategic information within a supply chain, including strategy, market, financial, technology, or new product information, may be important to ensure the long-term prosperity of partnerships. This requires well-structured yet open and information communication flows according to Kadefors (cited in Cao and Zhang, 2013).

According to Bennet and Jayes (cited in Crespin-Mazet et al., 2014) common goals can also be seen as a key element of partnership. According to Eliashberg and Michie (cited in Cao and Zhang, 2013), goal congruence refers to the degree of common goal accomplishment and it is used to assess the level of collaboration among supply chain partners. Supply chain partners should understand each other's goal and help each other accomplish the goal.

An open communication mechanism is essential for companies engaged in the close interorganizational relationships such as partnership. Communication between parties is necessary to understand each parties expectations, attitudes, and limitations. The study by Black et al. (cited in Beach et al., 2005) showed that contractors considered this a critical factor for success.

Decision synchronization is also important in supply chain collaboration. Decision synchronization refers to the process by which supply chain partners coordinate activities in supply chain planning and operations for optimizing the supply chain benefits according to Simatupang et al. (cited in Cao and Zhang, 2013). Here, the corporation can coordinate the investigations to Dura Vermeer, which will save time in the decision-making process of the corporation which will benefit the whole process of making houses (more) sustainable.

Lastly, trust is very important. When trust is present, partners find it easier to communicate and share information. The degree of trust between parties is dependent on factors such as the duration of the relationship, whether the project benefits were shared equitably and whether the behaviour of the parties was appropriate according to Beach et al.

It is therefore recommended for Dura Vermeer and corporations to invest in partnerships instead of arm length relationships where organisations avoid sharing information, keep each other at arm length and retain benefits from themselves. Partnership has several proven benefits from which Dura Vermeer and a corporation can both benefit.

5.6 Setting up a residents' committee

Improvement

As mentioned previously in this thesis, the advisor of sustainability of a corporation mentioned that they experience the most delay in the process of the residents. The steps after the consent step (Figure 4, sub phase D) can only start after this 70% percent has been received.

According to the project manager of a corporation, appointing a resident's committee speeds up the achievement of consent from 70% of the residents. The most important activities of the residents committee is that they maintain the contact between the corporation and the residents. The residents committee must ensure that the residents are positive against the renovation activities so that the 70% gets achieved. Appointing a resident committee really helps to achieve this consent according to the project coordinator of the corporation. For future projects, it is recommended to always appoint a residents committee.

When searching for literature, an interesting study passed by. According to Hauge and Thomsen (2012), it is important that the time frame of the decision-making process should not be too tight. All residents must have the possibility to understand the importance of the renovation and to develop a feeling of ownership toward the projects, which may support emotionally based choices. They should not feel that they are persuaded to by the board, advisors, or the corporation. Based on experiences, voting should not be done before the residents have understood the content and importance of the renovation.

According to Hauge and Thomsen (2012), the organization of the decision-making process by the board is of main importance for a successful decision process on renovation. A precondition is that the advisors in the corporations and the board are good initiators in the decision-making process. Successful decision-making processes are dependent on trustworthy and engaged individuals organizing and initiating the decision-making process. Interviews with each resident about the renovation project in the beginning of the process, gives a clear overview of what the residents are concerned about and what their needs are. This may be time-consuming but increases the residents' feeling of ownership to the project.

It is especially important to be clear about economic consequences because personal economy and differences in economy among residents are threats to ambitious renovation projects. A general rule of thumb should be that the residents get detailed information about the monthly costs for the renovation and what they can save on less energy use for heating. The residents' answer for maintenance should also be stressed, and cost-benefit analysis on the consequences of taking action should be compared to what it costs to do nothing in the long run.

Another good advice is to present exemplary projects of renovation with figures. Experiences shows that if the residents gets presentations on the planned renovation in an easy language with pictures and illustration, they are able to understand the meaning of the renovation for their everyday life. If the information is given in small portions over a longer time span, the ground for decision-making is well-prepared. The study also gave examples from large housing corporations were

long-term maintenance plans are open and available to the residents, and despite a significant increase in monthly costs, the residents are looking forward towards renovation and the positive changes they expect. If residents had not been informed about the planned changes, it would have been more difficult to engage them. This confirms the necessity to involve the resident in the renovation plans at an early stage to make the decision mature.

The study confirms that the power of exemplary projects is strong. One conclusion is that in order to make an environmentally friendly upgrading a natural choice, good examples of sustainable upgrades are essential.

So, in order to receive the consent from the residents, the above-described points will be recommended to take place in the decision-making process in order to maximize the chance of getting consent from 70% of the residents. When the corporation does not have the time and capacity to conduct the communication with the residents, it will be recommended that this task will be transferred to Dura Vermeer.

Evaluation of improvement

According to literature, early and good communication with residents increases the possibility of getting consent from 70% of the residents. This will minimize the possibility of getting delay in the process because the consent of the residents is not achieved yet.

The recommendation of transferring the task of communication with the residents to Dura Vermeer will also have a positive impact on the lead time of the process of making houses (more) sustainable. This task will be taken away from the corporation, which will cause a decrease in the time of their decision-making process.

5.7 Involve construction companies from the beginning

During the interviews, it got noticed that all the corporation strive to early involvement of the construction companies in the process of making houses (more) sustainable. When searching for relevant literature, a literature study of Pitt et al. (2008) was found. According to Pitt et al. (2008), involvement of the constructors in the decision on how sustainable a building project may be can reduce costs, improve health and safety. Hence, greater involvement and constructive interaction from the demand side, will inevitably improve good practice initiatives, drawing closer linkages to the supply side, and consequently, in the delivery of improved sustainable construction. Recommended will be that the constructors will be involved in the decision-making process from the beginning. A form of cooperation between the corporation and construction company from the start is a construction team agreement.

A construction team can be characterised as a partnership between the client (in this case the corporation) and a construction company to come up with a design for the project. In the design phase, the construction company will contribute his expertise in the area of execution, planning and the associated costs. For the corporation and the construction company, this has benefits. The contractor can, through his own involvement in the preparation of the construction project, bring his specific experience and expertise to the construction team.

From this experience and expertise, the contractor can make suggestions regarding the costs, quality, and efficiency of the efficiency of the construction plan. The principal is thus guaranteed that the project will be realized in the most efficient way, with the best possible balance between price and quality (Bouwend Nederland, 2021).

For the construction company, participating in a construction team agreement also has advantages. The construction company who is participating in the construction team agreement is more aware of the project than other construction companies. The construction company who participates in a construction team agreement also has the prospect of being the first and only one to submit a price offer for the work to be carried out (Bouwend Nederland, 2021). So, a win-win situation for both the construction company and the corporation.

During the interview with a corporation, asked was what worked better, a project with a tender phase where the construction company is involved later on, or a project with a construction team agreement where the construction company is involved from the beginning. The project manager of the corporation answered that in terms of organisation a construction team agreement was more pleasant. Here, the construction company carry out the investigations and are involved when deciding which sustainable measure will be taken to make the building more sustainable. For the corporation, this way of working is more pleasant and convenient.

During the interview with another corporation, the advisor of sustainability told that from their experience, construction companies often only focus on the realisation phase (Figure

13, phase III) of projects and invest less time in the selection and plan preparation phase (Figure 13, phase I and II). The most efficient way of working for the corporation is with construction companies which are involved from the beginning of the project. So, working more in construction team agreements is also a good solution here.

Evaluation of improvement

According to literature, but also based on practice, early involvement of the construction companies in the renovation process of making houses (more) sustainable will reduce costs, improve health and safety. It will therefore highly be recommended to corporations to involve construction companies early in the process. This can be done by working with construction team agreements. Working with partners will also increase the efficiency of making houses (more) sustainable and the time of the decision-making process will indirectly benefit from this.

5.8 Summary

The impact of the improvements is shown in Table 7. The improvements were presented to Dura Vermeer and the impact was discussed together. The improvements are weighted against the economic, ecological, social and lead time impact.

Table 7: Improvements weighted against impact

	Economic impact	**Ecological impact**	**Social impact**	**Impact on lead time of process**	**Grade**
Improvement					
Frequent meeting of supervisory board	-	-/+	-/+	++	6,25
Address chairman for supervisory board meeting	-/+	-/+	-/+	+	6,5
Use of digital signature system	-/+	+	-/+	++	6,75
Use of digital project portal	-/+	-/+	-/+	++	6,5
Partnership and supply-chain collaboration	++	+	-/+	+	7
Setting up a residents' committee	-	-/+	++	+	6,5
Involvement construction companies from the beginning	++	+	-/+	+	7

Table 8: Weighting system for the improvements

Sign	-	-/+	+	++
Grade	5	6	7	8

6 Conclusion and Recommendations

This section answers the knowledge question: What conclusion and recommendation can be made from conducting the research at Dura Vermeer? The core problem and the research question are first summarized in section 6.1.1 and section 6.1.2. Then, in section 6.1.3 the sub research question are answered, which lead to answering the main research question and giving recommendations to Dura Vermeer in section 6.2. In section 6.3 the limitations of the research are addressed and in section 6.4 future research is recommended.

6.1 Conclusion

6.1.1 Core problem

The action problem which was found at Dura Vermeer Bouw Hengelo was the long lead time of the renovation process of making social rental houses (more) sustainable. A discrepancy can be found here, when keeping the climate agreement goals of 2050 in mind which insist on a process with a shorter lead time. To shorten this lead time, the core problem is analysed based on interview with employees of Dura Vermeer. While searching for the core problem, it emerged that the decision-making process of the corporation takes a lot of time.

6.1.2 Research question

The corresonding research question therefore had to result in a way to gain insight into the current decision-making process in order to find (possible) problems. The main research question that is answered in the research is:

How can the current decision-making process of the corporation together with Dura Vermeer be sped up in regard to making houses more sustanainable?

To give an answer on this main research question, several sub research questions are made.

6.1.3 Sub research questions

The current decision-making process of Dura Vermeer is analysed. The data is collected by interviews with the employees involved in the decision-making process of Dura Vermeer. The decision-making process of Dura Vermeer is displayed in a BPMN model. According to a literature study, the BPMN method seems to be the most suitable for modelling the decision-making process.

Then, the decision-making of a corporation is analysed. In order to get a good understanding of this process, different corporations were interviewed. Based on these interviews, the decision-making process of the corporation could be mapped out. The BPMN method is also used here for modelling the process.

The found information about both processes and the BPMN models are used to find the problems in the current decision-making process which causes a long time. The first found problem found was the supervisory board who only meets five times a year. This caused delay in

the decision-making process because the supervisory board must approve the project plan of projects with a price higher than 1.5 million. It also happens that the supervisory board does not check the project plan during their meeting, due to time constraints which also causes delay in the current decision-making process.

The corporations interviewed do not use a digital signature system. The contracts and documents that needs to be signed should be send by letters, which causes delay. The information exchange is also not optimal currently. The information of the procurement will be sent via e-mail which involves many unnecessary steps when sending the documents to different construction companies.

Another problem found was the time to collect consent from 70% of the residents. Currently, the corporation experience the most delay in their decision-making process due to the residents who does not always want to give consent on a sustainable renovation project.

All the found problems were visualized in an Ishikawa-diagram to have a clear overview of the problems.

6.2 Recommendations

After having answered all the sub research questions, the main research question could be answered. In order to speed up the decision-making process of Dura Vermeer together with the corporation, the problems has been solved.

To be sure that the project coordinator of the corporation can ask approval on his or her project plan, the meetings of the supervisory board should be fixed a year in advance. The project manager then knows when a project plan should be finished in order to receive approval.

To be sure the project plan gets discussed in a meeting, a chairman should be addressed which makes an agenda with priority before the meeting. The project plan who needs approval should be prioritized in this agenda. Extra meetings of the supervisory board can also be planned in both cases to be sure to receive approval of the supervisory board on time.

For the signature problem of a corporation, it is important that they introduce a digital signature system, like DocuSign. The use of a digital signature system will reduce the steps in the decision-making process, which saves time.

To optimize the exchange of information, it would be recommended to introduce a project portal within a corporation. On this project portal, the corporation can upload the procurement documents. The construction companies can access this portal via the website of the corporation. Here, the construction companies can upload their tender documents. These are therefore also easily accessible for the corporation.

To spend less time on collecting the consent of 70% of residents, it is important that a residents' committee will be established. According to the project coordinator of the corporation, this residents' committee helps with achieving the 70% earlier. Furthermore, it will

be recommended to make the time frame of future decision-making processes not too short. Interviews should take place with each resident to understand their concerns and needs; the economic consequences should be addressed to residents and exemplary project of renovations will help in getting consent from 70% of the residents. If a corporation does not have time for the communication with the residents, this task should fully be transferred to Dura Vermeer. This will cause a decrease in the time of the decision-making process of a corporation.

Not related to a found problem but therefore not less important is working more in construction team agreements and with partners. A sustainable renovation project where the construction company is involved from the beginning, reduces costs, improve health and safety. A benefit of partnership is a reduction of the construction time by 10%.

It is up to Dura Vermeer and a corporation to determine which improvements they want to implement in the future. Table 7, which displays the improvements against the impact, can be used for this.

6.3 Limitations of the research

Finally, some limitation due to the method and the provided data will be addressed. Chosen is to only focus on the social rental sector and not on private houses. During interviews with employees of Dura Vermeer, it got clear that Dura Vermeer is facing a problem in the process of making social rental houses sustainable together with a corporation. The research can be applied to sustainable renovation projects of private landlord, as explained in Section 1.3. However, the research cannot be applied to a sustainable renovation project of a house of a private owner. The research is therefore not usable to all the housing sectors.

Because interviews were conducted in the research, the research got more subjective. The participants answered the questions from his or her experiences and opinion. This involved subjectivity. This is a limitation of the research.

The research is not generalizable to all industries. However, it can be applied to other companies active in the construction sector.

The improvements found during the research were not implemented. The research would become too large if the found improvements were implemented. However, in Section 6.4 it is recommended to Dura Vermeer and the corporation to implement the found improvements.

6.4 Future research

During the research, the problems in the current decision-making process were analysed in order to make the process go faster. Chosen is to not come up with improvements for the whole process of making houses more sustainable, but only for the decision-making process. It would be recommended to Dura Vermeer to perform future research to the sustainable renovation process in order to know where there are further improvements in the whole process so that it can be speed up even more.

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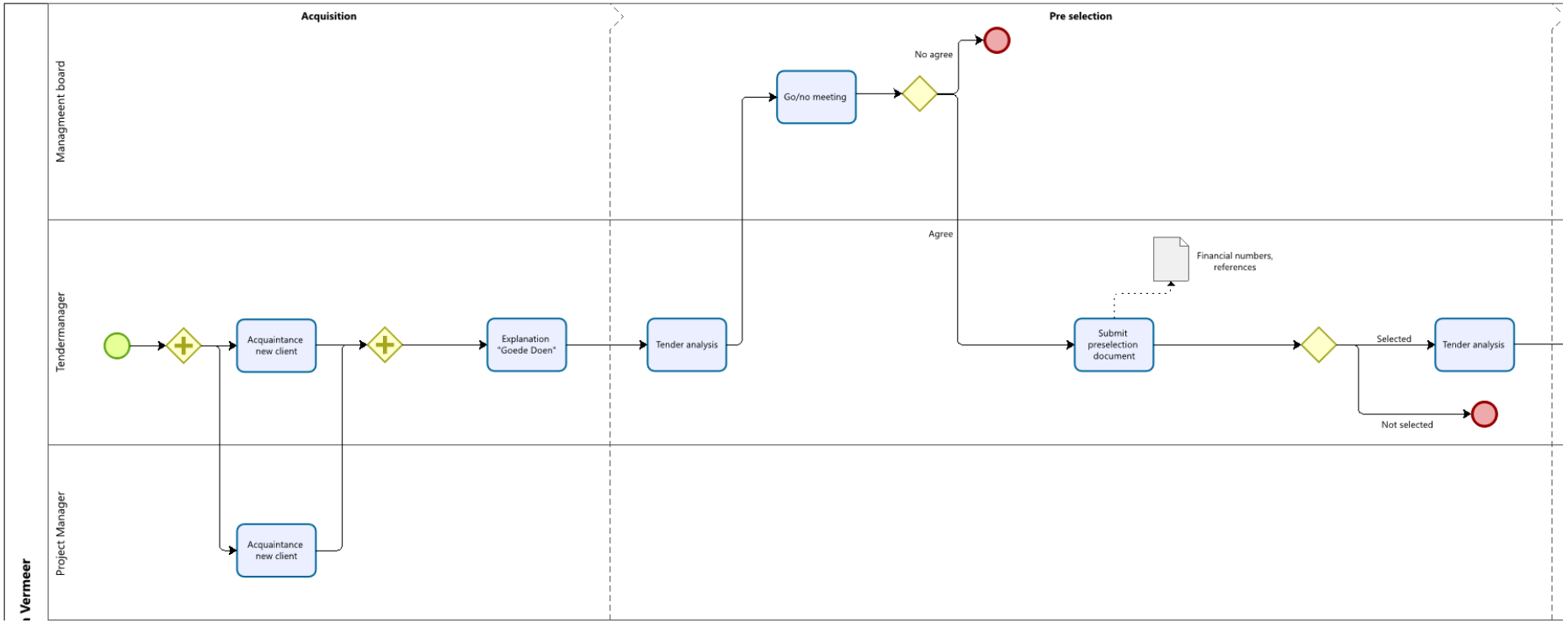
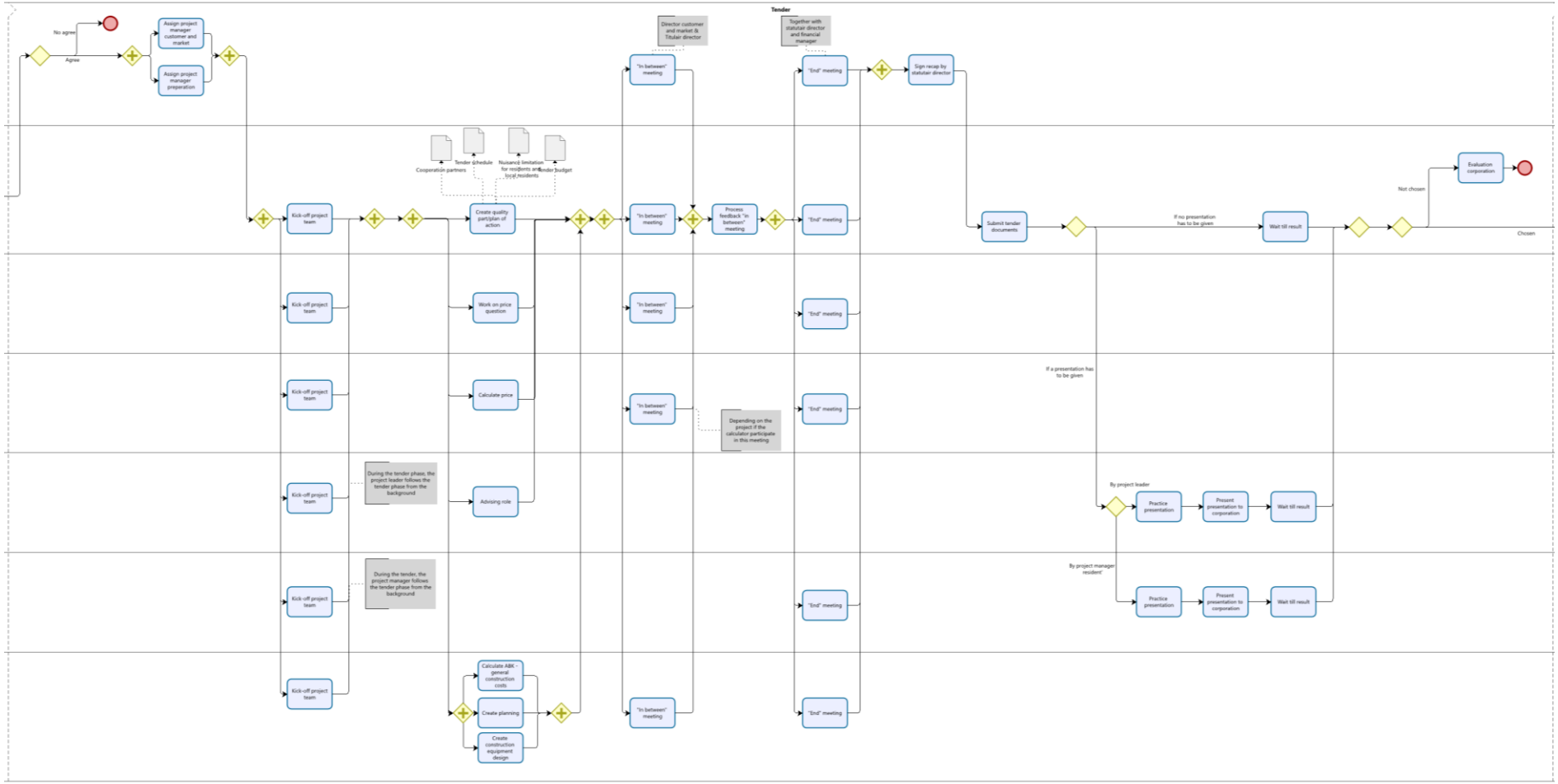
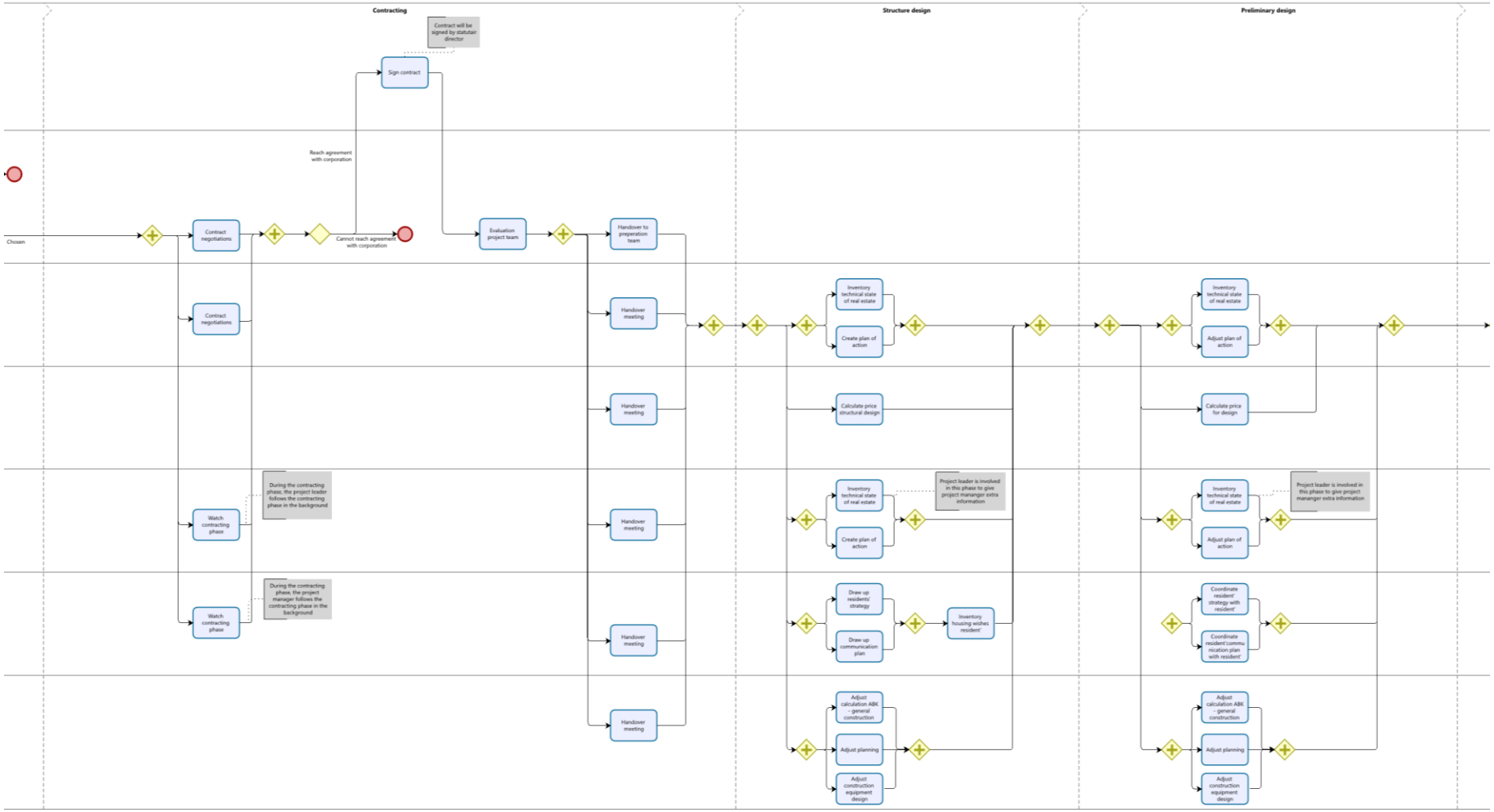
Appendix A – BPMN model decision-making process Dura Vermeer



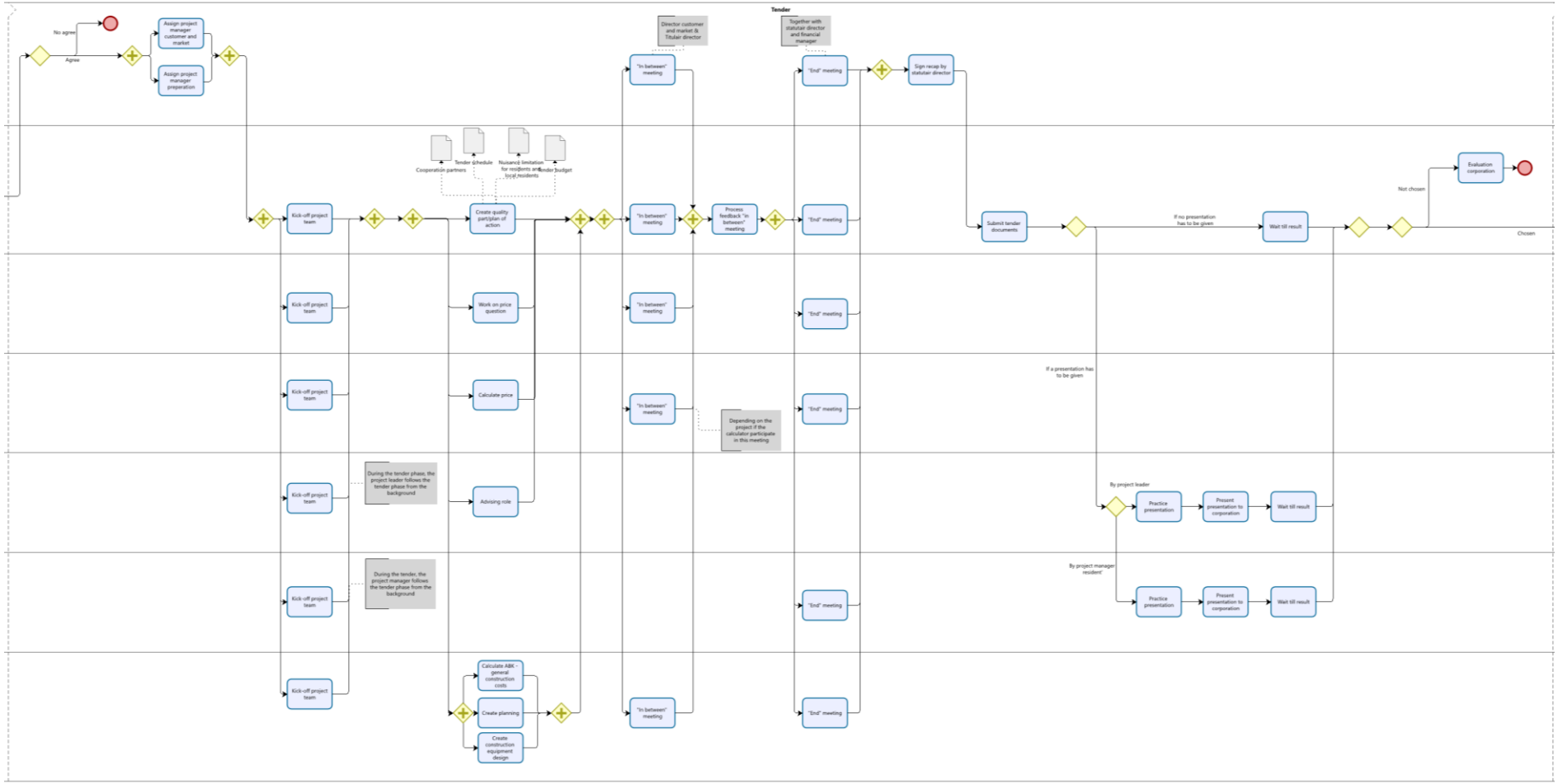
Appendix A 1: BPMN model Dura Vermeer part 1



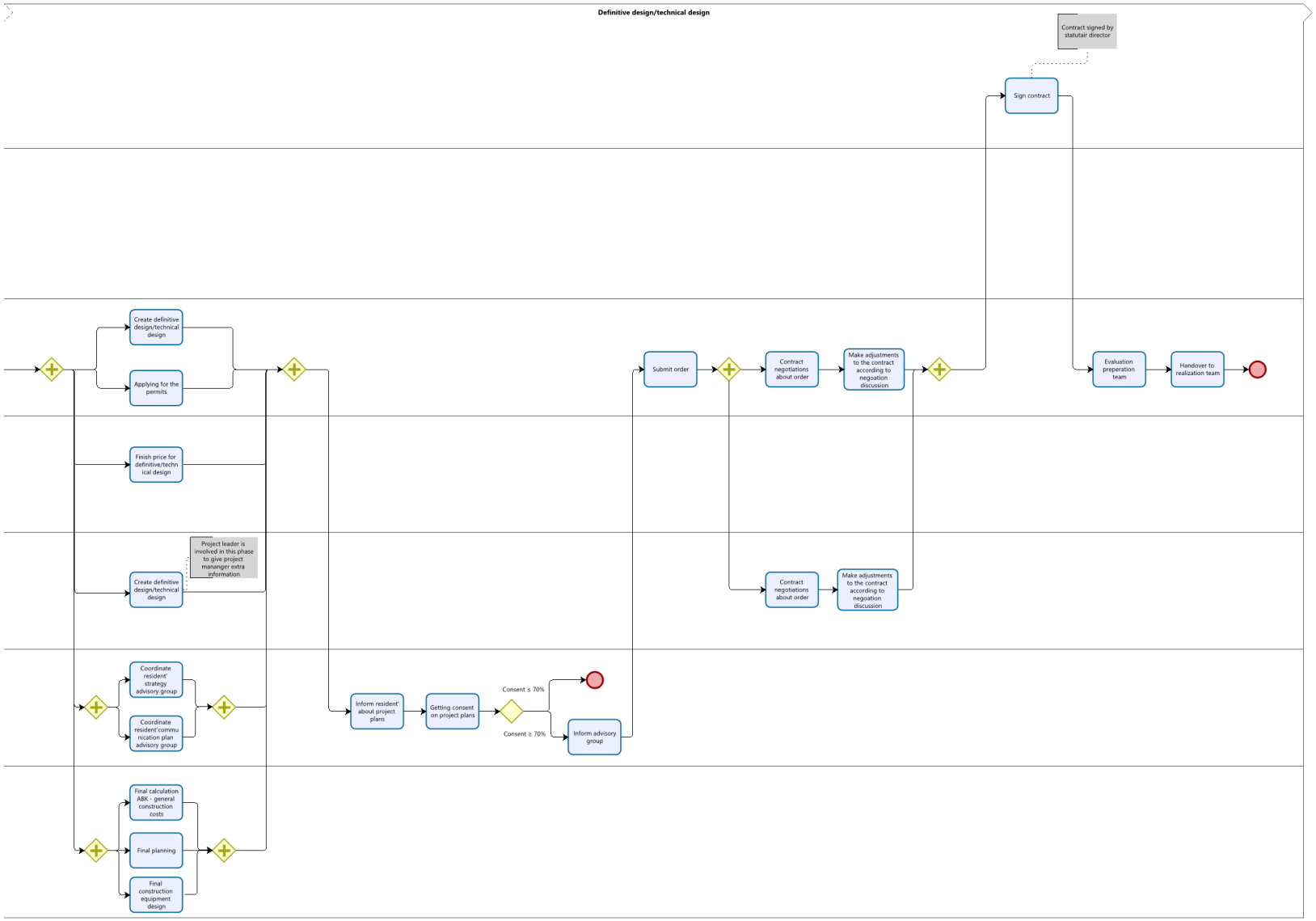
Appendix A 2: BPMN model Dura Vermeer part 2



Appendix A 3: BPMN model Dura Vermeer part 3

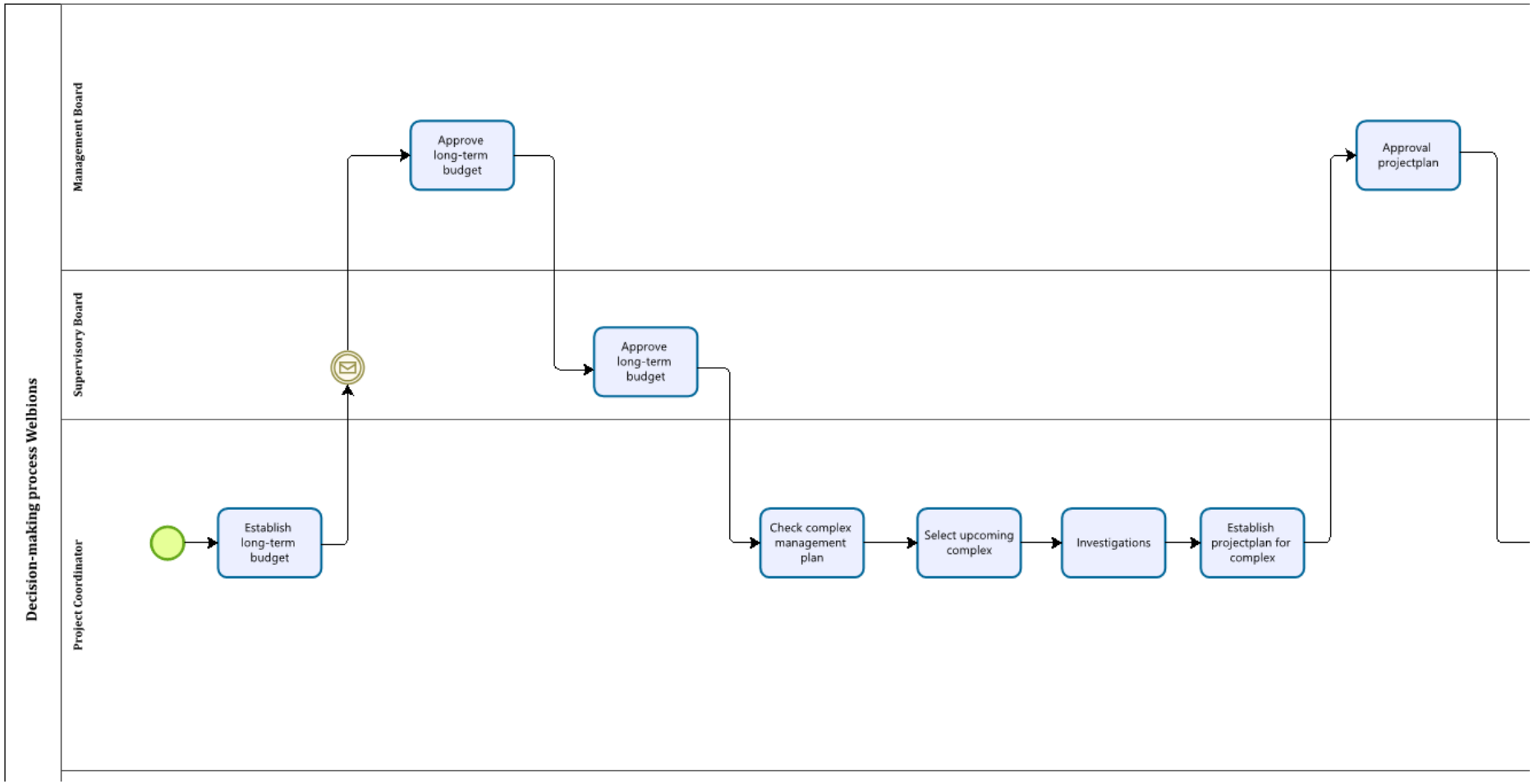


Appendix A 4: BPMN model Dura Vermeer part 4

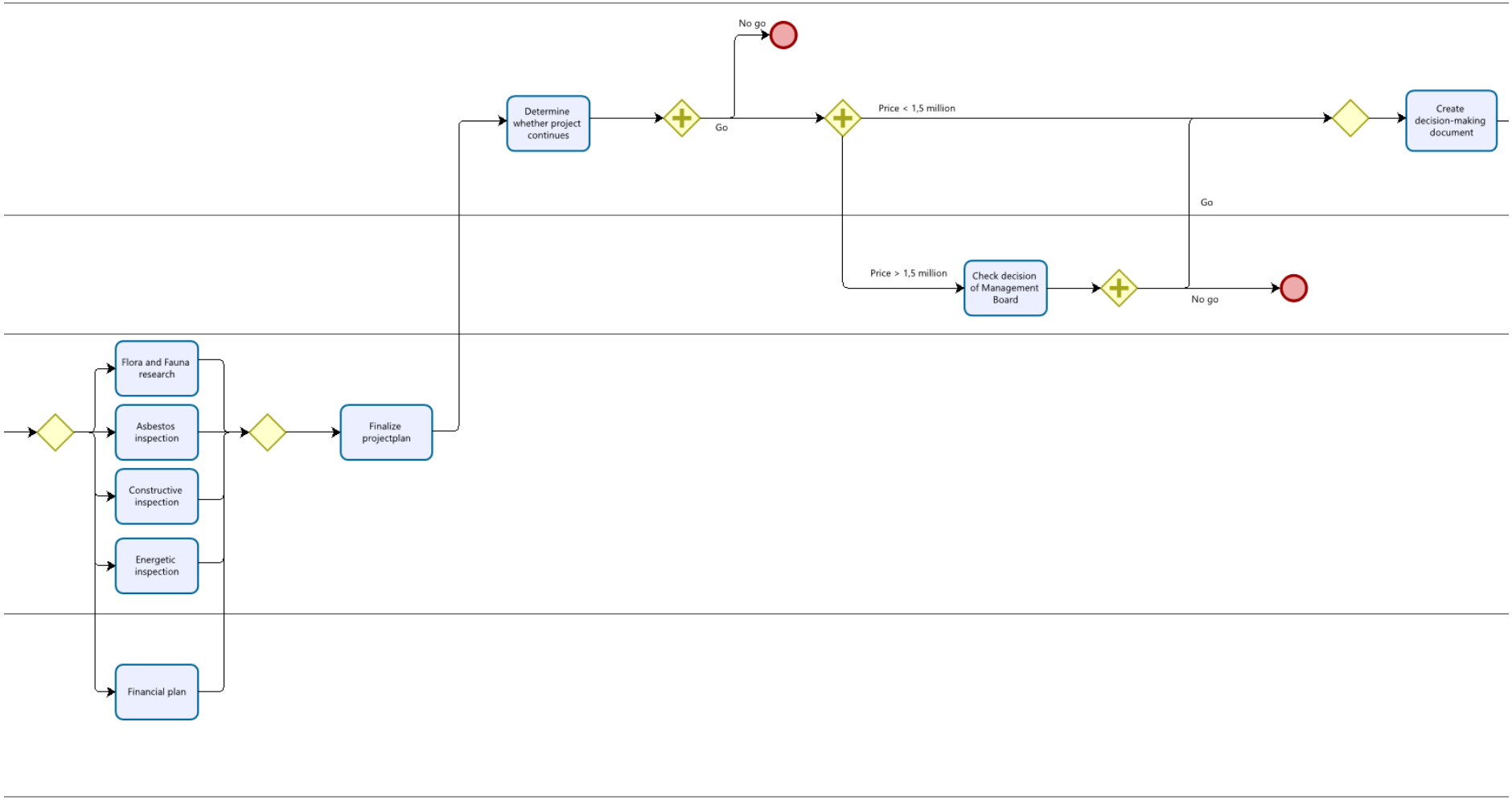


Appendix A 5: BPMN model Dura Vermeer part 5

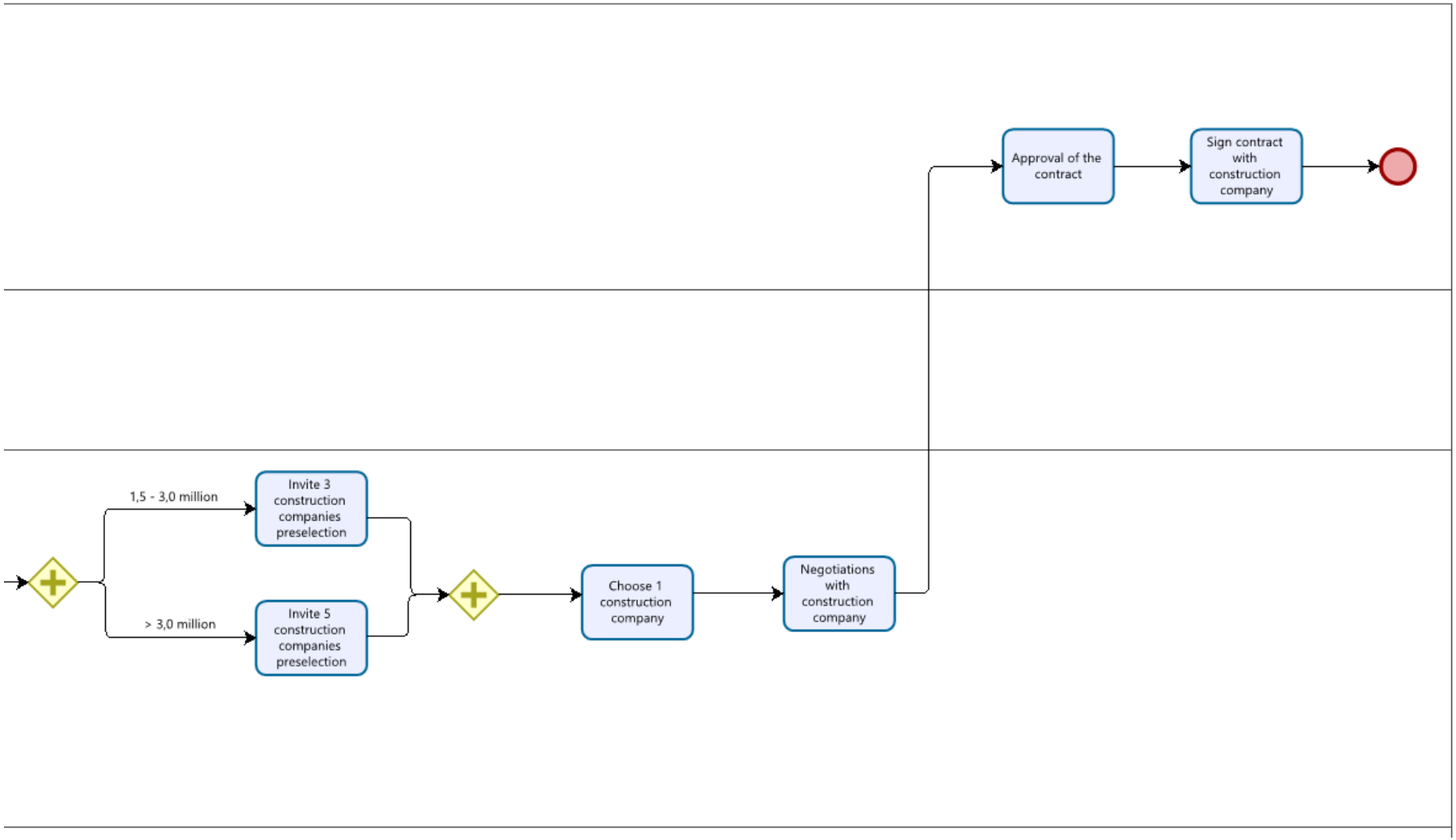
Appendix B – BPMN model decision-making process of a corporation



Appendix B 1: : BPMN model corporation part 1



Appendix B 2: : BPMN model corporation part 2



Appendix B 3: : BPMN model corporation part 3