The benefits of participatory value evaluation in a company environment

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The benefits of participatory value evaluation in a company environment

A masters thesis on the possible benefits from the use of PVE in a company environment by conducting a PVE survey for Liander asset management

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Summary

This study will be conducted as a master's thesis for the programme Management of technology at Delft University of Technology. This study hopes to help principal value evaluation (PVE) develop so that companies can be more efficient and also enjoy the benefits that this method brings. It also aims to help Liander and possibly other companies in designing the most efficient life cycle for their assets. Hopefully saving resources and reducing waste, which results in less costs and a better environment.

PVE is a novel method for the evaluation of policy options. PVE is designed to enable mass participation of citizens in the decision-making process by providing an accessible method to communicate their opinion to policymakers on the policies in question. In a PVE survey, the participants use an online tool where they are given the role of the policymaker. The participants are given several options, all with their own benefits and drawbacks, and a budget. They can then distribute the budget between the different options as they see fit or choose to pick no options at all. At the end of the survey, the participants are asked to elaborate on their decisions and their advice on the subject. The survey helps policy advisors in gaining insight into the needs and wishes of citizens as well as their reasoning.

In previous use cases, PVE was tested in a government-citizen relation. However, no research has been done on the usability of PVE within a company environment. Research on other participation methods has shown that the participation of employees in decision-making can boost the motivation of employees (Irawanto, 2015), job satisfaction, organizational commitment, innovativeness, employee performance (Fernandez & Moldogaziev, 2013) and organizational performance (Spreitzer & Mishra, 1999). However, not all forms of participation in decision making will see the same results. Some methods of participation such as short-term participation (Cotton, Vollrath, Froggatt, Lengnick-Hall, & Jennings, 1988) or participation where participants do not feel listened to (Corgnet & González, 2013), have a negative impact on the employees. Large companies might also enjoy the benefits of the mass participation that PVE offers. Therefore, the goal of this thesis is to see whether the benefits and drawbacks of PVE found in previous use cases also apply to the use of PVE within a company environment. This will be done by answering the following research question:

"To what extend do the benefits of PVEs that are deployed in citizen to government context apply to the use of PVE within a company environment?"

This question will be answered by conducting a PVE experiment for Liander asset management. Liander is one of three energy distribution system operators (DSO's) in the Netherlands. Liander makes sure that 3.1 million Dutch households are connected to the electricity grid and 2.5 million households are connected to the gas network. Figure 1-1 shows the regions in which they operate. Although Liander makes decisions on public infrastructure, they do not function as a government but more as a private company that works for the government. Liander is however not exposed to the open market where financial considerations play a big part. Therefore, the priorities and the decisions made could be influenced by Lianders position in the government regulated regime compared to companies in the open market.

To answer the research question, the following sub-questions have been formulated:

- SQ 1: What benefits and drawbacks of PVE have been found in a citizen to government use case?
- SQ 2: How do a company use case and a government-citizen use case compare?
- SQ 3: What benefits and drawbacks are expected to translate to a company use case?
- SQ 4: What are the characteristics of a PVE designed for a company and how does this differ from a government-citizen PVE?

- SQ 5: What are the qualitative and quantitative results of the company PVE?
- SQ 6: What benefits and drawbacks did the participants mentioned regarding the PVE in which they participated?
- SQ 7: What possible uses and changes do the participants envision for PVE?

Sub question 1: What benefits and drawbacks of PVE have been found in a citizen to government use case?

The benefits and drawbacks of previous cases are gathered to test the translation of these benefits and drawbacks to the company environment. This was done with desk research on previous use cases of PVE. The following cases were explored:

1. Long term ambition for rivers
2. Transport region of Amsterdam
3. Heating transition Utrecht
4. Energy policy Súdwest-Fryslân
5. Corona intelligent lockdown strategy

In the reports written on these use cases the following benefits were found:

1. Participation of the silent majority: A low entry barrier leads to the participation of many citizens that were previously not able or did not want to spend the time to participate in policy evaluation.
2. Transmitting of local knowledge: Policymakers gather information from participants that can be closely involved in the subject and who have ideas and opinions on the best course of action.
3. Strong feeling of inclusion in participants: Participants feel valued by the government when they can share their opinion on policies. It gives participants the idea that they are being listened to.
4. Awareness methodology: Participants get to see the benefits and drawbacks of policies and how complex the considerations can be. This understanding gives participants more sympathy for the decisions made by the government.

And the following drawback:

1. Entry barrier: Because the PVE tool is an online webpage some elderly citizens are incapable of participating due to the lack of knowledge on the internet and computers.

Sub question 2: How do a company use case and a government-citizen use case compare?

A comparison between the two environments is made to predict and explain the translation of benefits and drawbacks from one environment to the other. The comparison is done with the use of agency theory. Agency theory describes the relation between a principal and an agent and makes predictions on how they will behave based on their relation and environment. In both the past PVE cases and in the company PVE survey that was done for this thesis, a principal-agent relation can be found, however their relation and environment are not the same. Therefore, Agency Theory was used to compare the environments and relation between the principal and the agent in past PVE cases and the company PVE survey. Table 1 summarizes the differences that were found.

	Government-citizen environment	Company environment
Freedom of the agent	More	Less
Flow of information	From principal to agent	From agent to principal
Contract type	Outcome-based	Behaviour-based

Table 1: Differences between government-citizen and company environment

Sub question 3: What benefits and drawbacks are expected to translate to a company use case?

The benefits and drawbacks that were identified were explored in the context of the government-citizen environment, and subsequently compared to the company environment. Based on the differences between the two environments and with the help of the predictions made by agency theory, the following predictions were made:

- *Prediction 1: The benefits of participation of the silent majority will be less pronounced with the direct mandate than with the indirect mandate.*
- *Prediction 2: The benefits of transmitting of local knowledge will be similar with the direct mandate as in the indirect mandate.*
- *Prediction 3: The benefits of the strong feeling of inclusion in participants will be similar with the direct mandate as in the indirect mandate.*
- *Prediction 4: The benefits of awareness methodology will be similar with the direct mandate as in the indirect mandate.*
- *Prediction 5: The drawback of a high entry barrier for certain groups of people will not be seen in the direct mandate.*
- *Prediction 6: In the direct mandate, the agents will be more risk-averse than the principals*

Sub question 4: What are the characteristics of a PVE designed for a company and how does this differ from a government-citizen PVE?

Before designing the PVE survey, the subject of the PVE was explored to see what would need to be incorporated into the survey. The subject of the PVE is decisions on the life cycle of the architectural side of a compact secondary substation. This is part of asset management done by Liander. Schneider, et al. (2006) describe asset management as “operating a group of assets over the whole technical life cycle guaranteeing a suitable return and ensuring defined service and security standards” in their paper on asset management for energy suppliers. They note how the bulk of the cost for energy suppliers are related to maintenance and capital depreciation. They show that asset management is used to decrease these costs by optimising the utilisation of the remaining life of the asset while considering the reliability of the service and distribution of the cost.

Three major factors of consideration in the life cycle decision making progress were identified.

- Asset condition
- Life cycle costs (LCC)
- Risk assessment

Asset condition describes the state and degradation of the asset. The asset is divided into seven architectural building parts. For each building part, a condition score is calculated according to NEN2767 norms, based on the age and expected lifespan of the part. The condition score deteriorates over time.

The life cycle costs include all the costs that are relevant to the asset over its entire life cycle. Including development, acquisition, placement, inspection, repair, operation, and disposal costs.

For risk assessment, three factors are used. Company values, the risk matrix, and the willingness to take risk. The company values are the values that a company stands for and is willing to work towards. These company values are included in the risk matrix. The risk matrix is used to translate the different types of risk from different company values to a uniform scale of risk levels. The risk level is determined by two variables. The chance of an event to happen and the severity of the consequences. The last component is the willingness to take risk. The decision-maker looks at the company values, uses the risk matrix to translate those risks into a uniform scale and lastly on the bases of these two things has to decide if the risk presented is acceptable or not.

The survey includes all three major factors of consideration in the life cycle design. The compact secondary substation will be split into its building parts (pavement, hinges and locks, door, roof construction, walls, cellar, and grating). First, the participants will need to decide on the condition of the different building parts. They have a budget available to spend between the building parts. When they decided on a strategy the PVE tool will translate their decisions into a risk level with the help of the risk matrix. The participants can then decide if the risks are acceptable or not.

To avoid too much complexity and to make the PVE more inclusive, some simplifications are made. Three of the six company values are included. Safety, quality of delivery, and financial risk. The LCC will include only costs that the participant can influence. Other costs such as development costs, placement cost and removal costs are not included in the budget. The survey will include only the option to repair or replace a building part. There are other factors such as maintenance or the intensity of use that can be influenced in a real life cycle, but these are not included.

The existing online tool did not have the capabilities for the condition or cost calculations. Therefore, a new PVE tool has been developed in excel for this purpose.

The participant will decide on how and when to maintain the seven architectural building parts of the compact secondary substation. These decisions will result in a risk level for three different company values, safety risk, quality of delivery and financial risk. For each of the seven building parts, participants decide two things. The first decision is at which condition they think action should be taken to improve the condition. The second decision is what this action should then be taken encompasses. There are two options, repair and replacement. Because of repair becomes less effective each time, the participant is asked how many times they want to repair a part before they want to replace it. With these two decisions the life cycle, the number of repairs and replacements and the associated costs are calculated over a 100-year life cycle. Participants are given a budget from which these costs are deducted. From the resulting condition scores and with the help of the risk matrix, the total risk is calculated for each of the company values. The participant then decides whether these risks are acceptable.

Once satisfied with their decisions the participants are asked to answer two sets of questions, one set related to their decisions on the secondary substation and the results, and one set related to PVE as a participation method within Liander. The first set of question were asked so participants could explain why they made certain decisions. This was done to gain more information on their perception and viewpoint on the life cycle of the asset. As well to see how realistic they thought the life cycle model and the results it gave was, this information is used to test the validity of the quantitative results by comparing it to prediction 6. The second set of questions also allowed participants to share other ideas or visions they have on PVE. These questions were asked to see how the different departments experienced the use of PVE, this experience and the benefits and drawbacks that participants list, will be used to answer the predictions on the translation of the benefits and drawbacks.

The participants have been grouped on three different abstraction levels to gain more insight into possible principal-agent relations. On the most abstract level, the participants are grouped into clients and contractors. Secondly, the participants were grouped into 4 categories, indirect clients, direct clients, Netcare, and Indirect contractors. On the least abstract level, the participants were grouped into the eight different functions that they fulfil within Liander.

Sub question 5: What are the qualitative and quantitative results of the company PVE?

The survey results showed that there were four different principal-agent relations between the participants. In all four of those, the agent was more risk-averse than the principal. This supports prediction 6. The results also show that not all departments or functions have the same view on all building parts. This can be explained by the different ways that each function looks at the life cycle. Operational personnel do not have the same goal as a policy advisor. The choice substantiation of the participants also showed that not all participants are aware of the same options or consequences. For instance, contractors all claim that safety is the most important value. However, they tend to spare costs on the pavement, thinking it is not important. Clients, however, spend more on the pavement arguing that saving on the pavement brings safety risks. Another example is the roof and the cellar. The participants have different ideas on the importance, repairability and replaceability of these building parts.

It became clear that because of the different functions the participants have within Liander, they all had a different vision for what PVE should be. When asked about their vision for PVE the participants proposed a method for PVE to aid them with their tasks.

Sub question 6: What benefits and drawbacks did the participants mention regarding the PVE in which they participated?

The results of the open questions showed no benefit from the participation of silent majority. Employees that are relevant for the subject or wanted to be involved are already involved in the decision-making process. Other employees had no interest in being involved. This result support prediction 1.

The benefit of transmission of local knowledge was found in the results. Participants also shared their view for PVE from which it became clear that there is a need for a simple way to collect information from other parties. In contrast to the government-citizen environment, not one party but most parties are in search of information from other parties. This supports prediction 2.

Due to the lack of employees that wants to be but is not involved in the decision-making progress, no added benefits over current participation methods were found on the feeling of inclusion among participants. Therefore prediction 3 is not supported.

Of the participants, 39% said they gained more insight into the considerations involved in a life cycle design. Surprisingly, this was mostly among a department that was already closely involved in the process. While participants further away from these decisions mentioned that the PVE offered little to no new information. So, prediction 4 is supported. However, the benefits were seen in different groups than expected.

The entry barrier would not have been present if the PVE was done with the original tools from the author. However, the PVE became more complex, Excel was used to build the PVE survey in and therefore the program that the participants had to use. Due to the increased complexity, some explanation was necessary. Not all the employees had a laptop with screen sharing software to easily

do this, leading to an entry barrier due to the increased complexity of the survey. So, prediction 5 is also partly supported because the survey became more complex.

Sub question 7: What possible uses and changes do the participants envision for PVE?

Participants proposed different changes to PVE to suit their needs. Depending on the responsibilities and tasks of the participants, they suggested changes to PVE that would help them in their work or solve a problem that they have.

Four main ways to use PVE have been proposed:

1. Use PVE as an easy way to share their knowledge, experience and preferences.
2. Use PVE as a way to build a knowledge base that can be easily accessed.
3. PVE as a method to gain insight into the effects that different choices have and as a tool to aid in making decisions.
4. PVE as a way to gather information from multiple departments and teams.

These different visions vary in complexity of the PVE but also in how PVE is integrated with the rest of the database and the workflow.

Conclusion

During this experiment, it became clear that the biggest difference between the government-citizen and the company environment is the complexity of the relations between the participants of the PVE. There are multiple departments that all have different goals and different levels of knowledge. Between and within these different departments, principal-agent relations were observed on multiple layers.

To answer the main research question: *"To what extend do the benefits of PVEs that are deployed in citizen to government context also apply to the use of PVE within a company environment?"*

Not all the benefits transfer directly to a company environment. However, employees see potential to use PVE in different ways that would benefit efficiency or the flow of information. These visions do not necessarily align with the original form of PVE. They could be more complex by using it as a simulation and calculation tool, used for data gathering and accessing for the longer term, or used in smaller groups as an easier more to the point way of sharing experience compared to team meetings.

Discussion and recommendations

The research done during this thesis should be viewed as exploratory research. PVE is a novel method and was taken out of the environment it was designed for, to explore how well it would fit a company environment. The research in this thesis was done at Liander. No other company environments were used to test the predictions or to verify the results. The company environment within Liander might not be reflective of all other company environments nor will this PVE subject be reflective of all other subjects that PVE could be used for within a company environment. Further research could explore more companies.

It is also important to note that a limited number of 18 employees participated in the PVE survey. The results are therefore not significant enough to draw any conclusions with certainty based on the data provided by the participants.

Further research into how a PVE tool can be designed to allow companies to adapt the PVE to their needs. Participants mentioned functions such as incorporating more complex models/simulations, collecting, and retrieving the data. Currently, the PVE tool does not allow for any form of calculations

of functions that would be required for this purpose. Interacting with the current database of the companies for uploading and downloading data to and from the PVE could also be helpful for the function of the PVE envisioned by the participants. For the models/simulations for instance, the same calculations would often be made on different assets/data. To make this easier a PVE tool can be designed to be more easily integrated with current databases and workflows. The use of for instance an API could be considered.

Further research can be done into the use of PVE as a replacement for meetings. Participants with functions that mostly participated in meetings to contribute in the form of a report saw PVE as a method of replacing meetings that they found long and boring. Research into the viability of PVE for this function could help identify an increase in the productivity of these employees.

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1. Introduction

In the current society, we are dependent on many different public facilities. Examples of these facilities are roads, public transportation networks or dykes. The government makes decisions on building and maintaining these facilities. These decisions are made to benefit the citizens. For instance, better roads and transportation networks can shorten travelling time and stronger dykes keep us safe from floods. These projects are helpful, but they are expensive. Although most citizens do not have a direct influence on these decisions, they do pay for them via the taxes that the government collects from them. Citizens do have some influence: they vote on who gets to represent them and make decisions for them in the coming years. However, this does not always make for a fair cost distribution and the considerations made by the government are not always transparent to citizens. To help the government in deciding what projects they can best spend money on, and to give citizens a way to share their opinion and to give them insight in the considerations that need to be made Mouter, Koster and Dekker (2019) designed the participatory value evaluation (PVE) method. PVE is a public project appraisal method designed to enable mass participation of citizens in government decision making by putting them in the role of the decision maker via an online survey. They weigh the given benefits and drawbacks of the available options and explain why they made the choices that they did. The eventual decision maker can use this data to gain insight into the situation and opinions of citizens.

PVE has been applied to some real-world cases, an example of this is the transport region of Amsterdam (Mouter, Koster, Dekker, & Borst, 2018). In this case, a PVE study was requested by the transport region to gain insight into the preferences of citizens on the different infrastructural projects that could be carried out.

In previous use cases, PVE was tested in a government-citizen relation. However, no research has been done on the usability of PVE within a company environment. Research has shown that the participation of employees in decision-making can boost the motivation of employees (Irawanto, 2015), job satisfaction, organizational commitment, innovativeness, employee performance (Fernandez & Moldogaziev, 2013) and organizational performance (Spreitzer & Mishra, 1999). However, not all forms of participation in decision making will see the same results. Some methods of participation such as short-term participation (Cotton, Vollrath, Froggatt, Lengnick-Hall, & Jennings, 1988) or participation where participants do not feel listened to (Corgnet & González, 2013), have a negative impact on the employees. Large companies might also enjoy the benefits of the mass participation that PVE offers. Therefore, the goal of this thesis is to see whether the benefits and drawbacks of PVE found in previous use cases also apply to the use of PVE within a company environment.

The following research question will be answered:

"To what extend do the benefits of PVEs that are deployed in citizen to government context apply to the use of PVE within a company environment?"

To answer this question the following sub-questions have been formulated:

SQ 1: What benefits and drawback of PVE have been found in a citizen to government use case?

First, the benefits and drawbacks found in citizen to government PVE cases need to be identified. The previous use cases will be explored, and the benefits and drawbacks found by the authors will be gathered.

SQ 2: How do a company use case and a government-citizen use case compare?

The environment of a government-citizen use case will be explored to explain the benefits and drawbacks found in previous government-citizen use cases. The company environment will also be explored and compared to the government-citizen use case.

SQ 3: What benefits and drawbacks are expected to translate to a company use case?

Differences and similarities found between the government-citizen environment and the company environment will be used to predict how well the benefits and drawbacks found in previous cases will translate to the company use case.

SQ 4: What are the characteristics of a PVE designed for a company and how does this differ from a government-citizen PVE?

Before designing the PVE, the desired subject, level of detail, functionality and type of participants will be consulted. When knowing what the company wants from the PVE and how it differs from a government-citizen PVE, the design of the PVE can start.

SQ 5: What are the qualitative and quantitative results of the company PVE?

The results of the PVE will be gathered and explored. The qualitative and quantitative data on the PVE subject will both be used to help answer the subject of the PVE.

SQ 6: What benefits and drawbacks did the participants mentioned regarding the PVE in which they participated?

The participants will be tested on the predicted benefits and drawbacks. These and other benefits and drawbacks found by participants during there PVE survey will be noted and used to form a conclusion.

SQ 7: What possible uses and changes do the participants envision for PVE?

Participants also get the option to recommend changes they would like to see in the PVE. These changes and the use cases proposed by participants will be explored to see what future they envision for PVE within the company environment.

1.1 Liander asset management

The research in this thesis will be conducted at and with the help of Liander asset management. Liander is one of three energy distribution system operators (DSO's) in the Netherlands. Liander makes sure that 3.1 million Dutch households are connected to the electricity grid and 2.5 million households are connected to the gas network. Figure 1-1 shows the regions in which they operate. Although Liander makes decisions on public infrastructure, they do not function as a government but as a private company that works for the government. Liander is however not exposed to the open market where financial considerations play a big part. Therefore, the priorities and the decisions made could be influenced by Lianders position in the government regulated regime compared to companies in the open market.

Figure 1-1:Operating area Liander - Source: Liander.nl

Liander asset management is responsible for the condition and of physical assets used in the energy distribution network and the design of a strategical asset management policy. This entails that they make a plan for the life cycle of an asset, concerning, maintenance, repair, replacing and upgrading their assets. The PVE conducted in this thesis will focus on the architectural part of their compact secondary substations.

1.2 Thesis outline

In chapter 3 a closer look will be taken at PVE and past use cases. The benefits and drawbacks will be explored and listed. In chapter 4 principal-agent theory will be used to analyse the governmental usage of PVE and explain the benefits and drawbacks that were found in chapter 3. Principal-agent theory predicts how the agent will behave in relation to the principal's wishes. These predictions are made based on the environment they are in and relation that the two have with each other, and will therefore be used to explore the differences between the government-citizen PVE use case and the company PVE use case and to predict how the benefits and drawbacks of PVE will translate from the government-citizen use case to company use case. Chapter 5 will explore the life cycle and degradation of the compact secondary substations that will be used in the PVE. Chapter 6 will detail the design of the PVE questionnaire and discuss the changes from the original PVE that were made to accommodate the wishes of Liander. In chapter 7 the de results of the PVE will be analysed. Chapter 8 will focus on the participants: their experiences with the PVE, the benefits and drawbacks that they mentioned and the visions that they have for the use of PVE within Liander. Chapter 9 summarises and explains the findings done in the previous chapters. Chapter 10 will look back at the predictions of chapter 4 and explain why these predictions are or aren't supported by the findings of the survey. The last chapter concludes the research question and recommendations for the use of PVE within a company environment.

2. Methodology

This thesis investigates the possibility for the use of PVE in a company environment. The benefits and drawbacks found in past use cases of PVE will be identified then the environment of these previous PVE cases will be compared to a company environment to predict how well these benefits and drawbacks might translate. In cooperation with Liander asset management a PVE will be made and executed within Liander. The results will be analysed to see if the survey provides usable and realistic results and the Participants will be questioned on their experience and opinion of the PVE survey. The results and Participants their opinion and experience will be used to evaluate the predictions on the translation of benefits and drawbacks. This chapter will further elaborate on each of these steps and explain the methods used.

2.1 Identifying the benefits and drawbacks of previous PVE cases

PVE is a relatively new method and few use cases exist. The authors of the method have tested the use of PVE within the Netherlands and made extensive reports on these studies. To identify the benefits and drawbacks of previous PVE researches a desk study is done in which these reports were explored. During this study the benefits and drawbacks were listed. The following reports have been explored:

1. Long term ambition for rivers
2. Transport region of Amsterdam
3. Heating transition Utrecht
4. Energy policy Súdwest-Fryslân
5. Corona intelligent lockdown strategy

2.2 Comparing the past PVE and company environments and making predictions

To help make predictions on the translation of benefits and drawbacks, the differences between the two environments were explored. For this comparison Agency Theory was used. Agency theory describes the relation between a principal and an agent and makes predictions on how they will behave based on their relation and environment. The principal is in essence the party that instructs or hires the agent to do something for them in exchange for something. In both the past PVE cases and in the company PVE survey that was done for this thesis, a principal-agent relation can be found however their relation and environment are not the same. Therefore, Agency Theory was used to compare the environments and relation between the principal and the agent in past PVE cases and the company PVE survey. The differences found between the previous PVE environments and the company environment were used to make predictions on the translation of the benefits and drawbacks from previous PVE environment to a company PVE environment. The predictions that Agency Theory gives on the behaviour of the principals and the agents can also help to verify that the company PVE survey provides valid results.

2.3 PVE subject exploration

Together with Liander asset management, a suitable subject was found for this PVE survey. They are interested in the vision of employees across different departments and functions on the decisions that must be made on the life cycle of an asset. This is a suitable subject for PVE because of the many different employees that are involved in with the asset. Because these employees have different functions, they do not share one perspective which can result in different opinions but also different insights. Because of these differences, this subject was chosen for the PVE survey.

To incorporate this subject into a PVE survey, the life cycle of an asset was explored. This started with a desk study on the documentation from Liander on the life cycle of their assets and documentation on the NEN norms for asset management and life cycle management. This was supplemented by

interviews with experts from Liander. Once all relevant variables were understood it was possible to start designing the PVE survey.

2.4 Designing the PVE survey

The design of the PVE survey was done in with feedback of multiple experts from Liander. With their help, it was decided to choose three of the risk factors used in their life cycle design as variables in the PVE. Safety, quality of supply and financial risk. Because of the complexity of the calculations that had to be made in the survey, Excel was used as the survey tool instead of the PVE online tool. After several iterations of the program, that differed in the amount of information that was given and clarity of the information presented, the final survey was created.

At the end of the survey two sets of questions were asked. First questions on the subject and the results of the PVE. These question were asked so participants could explain why they made certain decisions. This was done to gain more information on their perception and viewpoint on the five-cycle of the asset. As well to see how realistic they thought the life cycle model and the results it gave was, this information is used to test the validity of the quantitative results.

The second set of questions was on the participant's experience with the PVE, their willingness to gain insight and willingness to participate in the decision-making process and the use of PVE for this purpose. This set of questions also allowed participants to share other ideas or visions they have on PVE. These questions were asked to see how the different department experienced the use of PVE, this experience and the benefits and drawbacks that participants list, will be used to answer the predictions on the translation of the benefits and drawbacks.

During the design of the PVE, the participants were grouped into three different abstraction levels. Grouping the participants and exploring the flow of information and the function that they have is important to identify the possible principal-agent relations that could exist between them. This in turn is necessary to test the predictions made with the help of the Agency Theory. This was also necessary for the use of agency theory to validate the data given by the PVE survey.

2.5 Interpreting the survey results

Because of the small number of participants (18), it was decided not to use the multiple discrete-continuous extreme value model (MDCEV) the authors used in previous PVE cases. Instead, the results were imported into Excel and put into graphs. These graphs allowed for the comparison between and within different groups and departments. In consultation with experts from Liander, four strategies were identified depending on the number of repairs and the condition that the participants choose. The results of the questions on the results of the PVE were also explored to gauge how realistic the results were.

The second set of questions was explored to see what benefits and drawbacks the participants experienced. These benefits and drawbacks were compared to the predictions made on the translation of the benefits and drawbacks. This along with the participants their vision on how they think PVE can be useful in their environment lead to a conclusion for the main research question and to recommendations on how PVE could best be suited for use in a company environment.

3. Participatory value evaluation

In this chapter, PVE will be further explored. Previous use cases will be discussed and the benefits and drawbacks of PVE that were found in these use cases will also be listed.

3.1 Participatory value evaluation in detail

In PVE the participants get a budget which can be spent on proposed projects. However, the user has the option to partially or entirely shift the budget to next year if the projects are not desirable. There are two PVE formats: the static budget PVE and the dynamic budget PVE. In the static budget PVE, any unused budget will be shifted to the next year. In the dynamic budget PVE, the user can also choose to reduce or raise taxes and thereby the budget. The flexible budget PVE creates a link between the government budget and people their private income and provides insight in the user's preferences on both (Mouter, Koster, & Dekker, 2019, p. 3).

The process documented by the authors is as follows. A PVE is conducted via an online tool, this tool (Mouter, Koster, Dekker, & Borst, 2019) is shown in Figure 3-1. A larger figure is depicted in appendix A: Online PVE tool. Participants do not need to go to a specific location and the tool is easily distributable. This allows for cheap and easy mass participation across all citizen groups because of the low entry barrier (Mouter, Koster, & Dekker, 2019). The online tool gives the participants a public budget and a set of projects, that each have their own costs and benefits, on which they can spend this budget. Essentially putting them in the seat of the governmental decision-makers. The projects are defined by attributes, the participant can see these attributes and pick projects according to their preferences. They can also delegate their decision to an expert or party that they trust or agree with, this will select a predetermined set of choices.

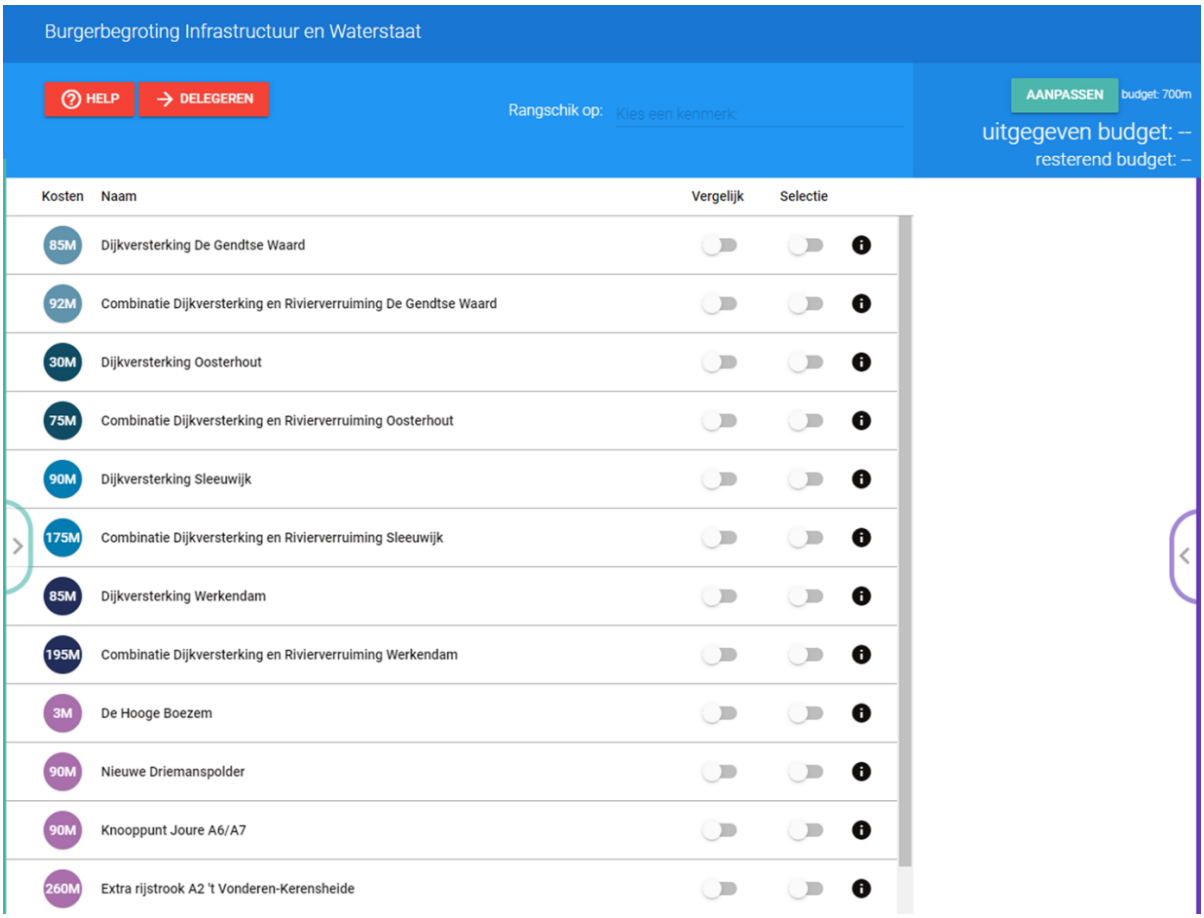

Figure 3-1: Online PVE tool, participant view

Afterwards, the participants are asked to motivate their choices and to answer some demographical and socioeconomical questions. These answers generate qualitative data that can give more insight into the de quantitative data generated by the PVE.

The creators of the method codified the qualitative data (Mouter, Koster, Dekker, & Borst, 2018) (Mouter, Koster, Dekker, & Borst, 2018) to explore why people made certain decisions. The quantitative data can also be used to gain insight into the behaviour and preferences of participants. (Dekker, Mouter, & Koster, 2019) For the quantitative data, they used the multiple discrete-continuous extreme value model (MDCEV) to calculate how important certain effects of projects are and how much they are willing to pay for this. The results of the MDCEV combined with the qualitative data can give more insight since sometimes people make choices based on information not present in the effects. The Data is used to calculate a top 10 optimal portfolios. A sensitivity analysis can show if changing certain effects or prices changes the top 10 portfolios to gain further insight.

3.2 Past use cases

The developers of the PVE method have published five case studies in which the PVE method was used. These will be explored to identify the benefits and drawbacks of PVE found by the authors in their studies.

3.2.1 Long term ambition for rivers case

The first case is the long term ambition for rivers in (Mouter, Koster, Dekker, & Borst, 2018) is described how the PVE method was used in a case for the Dutch ministry of infrastructure and water management. The Dutch ministry of infrastructure and water management makes sure the Dutch people are kept safe from the water of the rivers. In doing so they need to make decisions about dyke improvement and river widening. The Technical University Delft was asked to perform a PVE to gauge the preferences of the Dutch citizens on this subject.

2.900 people participated in the PVE for long term ambition for rivers. After the respondents made their decisions, they were asked to motivate their decisions. The results of the PVE were also compared with details of the respondents, for instance, their income, for which political party they vote and educational background. This gives insight into how and why people made certain decisions in the PVE. The qualitative data was codified so it could be used in comparisons. The data was analysed and optimal portfolios were created and given to the Dutch ministry of infrastructure.

3.2.2 Transport region of Amsterdam case

The second use case was for the transport region of Amsterdam in (Mouter, Koster, Dekker, & Borst, 2018) is described how the PVE method was used in a case for the transport region of Amsterdam. The transport region of Amsterdam wanted to know the preferences of local citizens on the different possible projects that could be realized. A PVE was conducted to see what projects and their effects are favoured or disliked.

In the first experiment, respondents had difficulties to motivate their decisions because they could not recall what choices they had made. In the second group, this was fixed by giving them the ability to do so. This resulted in more and better qualitative data. When asked to motivate their choices, part of the respondents looked only at the option they picked instead of making a comparison or giving an argument as to why they picked it over the other options. The respondents were asked to give their opinion on PVE. 1% of the people was very negative about the use of PVE and had the following arguments:

1. There is not enough information to make these decisions.
2. I'm am not an expert on the subject and therefore not fit to make these decisions.

3. Most citizens are not fit to make this decision.
4. Experts on the subject should be asked about their opinion.
5. People who live nearby should decide (this was therefore added in the second experiment)
6. I would like to add projects

2498 people participated in the PVE for the transport region of Amsterdam. The choices the participants made can be compared to information such as age, gender, education and income. With the results, an optimum portfolio was calculated. Again, participants were asked to motivate their answers, these motivations were codified and put into 21 categories. These motivations give insight into why participants choose certain options.

3.2.3 Heating transition Utrecht

This case was conducted for the municipality Utrecht. It explores the vision of the residents on the heating transition of 40.000 apartments away from the use of natural gas before 2030 (Mouter, et al., Bewoners kiezen aardgasvrije wijken, 2020). Participants had to distribute 100 points across the following four different approaches.

1. Housing cost doesn't rise.
2. Residents decide themselves how they transition away from gas.
3. Maximum CO2 reduction.
4. Neighbourhoods with the highest financial standing go first.

Participants had different perceptions on the subject and made diverse choices, but they all distributed their points across multiple approaches. From this the authors identified emergent uncertainties, which are uncertainties not at an individual level but on the collective level. These emergent uncertainties can hinder communication and debate between participants that have different perceptions. Identifying and addressing these uncertainties can remedy this problem.

The majority of the participants think that PVE is a suitable method of participation. Lower educated participants more than higher educated participants. Participants found the PVE an accessible but nuanced way to share their opinion. However, some participants did not like that the PVE assumes that the transition will take place and that they are forced to choose an option.

The authors explain that a recurring consideration in designing a PVE survey is the balance between inclusivity and complexity. Making the PVE more complex often makes it more accurate. However, making it more complex reduces the accessibility of the PVE for lower educated residents. But simplifying the PVE can reduce the accuracy of the results.

3.2.4 Energy policy Súdwest-Fryslân

1376 residents of the municipality Súdwest-Fryslân participated in this PVE on the future energy policy of the region (Kapitein, et al., 2020). In this PVE the participants also had 100 points to distribute across different options. The following 6 options were available:

1. The municipality takes charge and unburdens residents
2. Resident do it themselves
3. The market decides
4. Large scale energy production on a small number of places
5. Go for energy storage
6. Become an energy provider for the Netherlands

The options are not detailed plans but meant to get a reaction from the participants.

Again, the majority of the participants was positive about the use of PVE for participation. They appreciated clear information and the possibility to access more information and details. The help of visual aids such as videos or figures was also welcomed. Some participants noted that it was not an option to do nothing. Other participants noticed that not all technologies or saving energy were given as an option.

3.2.5 Corona intelligent lockdown exit strategy

When COVID-19 arrived in the Netherlands, the government took measures to prevent further transmission of the virus. This package of measures was called the intelligent lockdown. After the measures proved effective and the virus started receding, the government started considering which measures to relax. This PVE was done to gauge the preferences of citizens on which measures to lift or relax and how fast this should be done (Mouter, et al., Als eenheid uit de intelligente lock-down, 2020). 30.000 people participated, with participants across all age groups. The participants were given 8 different options to relax the measures. Each relaxation brought a given percentage of pressure on the healthcare system. The extra pressure was not allowed to exceed 50%.

80% of the participants found PVE a good method to involve citizens in the decisions made by the government on the relaxation of the COVID-19 measures. Again, the lower educated participants are more positive compared to the higher educated participants. 57% of the participants said they have become more aware of the decisions that the government must make.

3.3 Benefits and drawbacks found in previous cases

So far, the research has shown that there are benefits to using PVE in a government-citizen use case, namely:

1. Participation of the silent majority
2. Transmitting of local knowledge
3. Strong feeling of inclusion in participants
4. Awareness methodology

The participation of the silent majority is due to the low entry barrier of the method. The survey is online and takes 20 to 30 minutes to complete. Methods that include meetings usually take up a lot of time. The short time it takes to complete a PVE survey allows for more people to voice their opinion.

The qualitative data that is gathered with the questions at the end of the PVE survey helps to gain better insight into the preferences of the participants and their reasons for making decisions. This transmission of local knowledge can result in more in-depth information that can be taken into account while making decisions on behalf of the participants or used to substantiate a decision.

Participants see the feeling of inclusion they get from filling in the PVE as important and find this to be one of the positive effects of the method. They find the PVE to give them more awareness of the considerations that the government has to make. Giving them more knowledge of the positive and negative effects of the different options that are available.

A drawback that was found is that the entry barrier is higher for elderly people that do not know how to use the internet.

In the next chapter, the environment of the government-citizen PVE use case and the environment of a company PVE use case will be compared. This comparison will then be used to predict how the benefits and drawbacks found in this chapter will translate to a company environment PVE.

4. Environment comparison

To predict and explain the translation of benefits and drawbacks from the government-citizen environment to the company environment, the two environments need to be compared to see how they differ. This chapter will explore these differences between the government-citizen environment and the company environment. Agency theory predicts the behaviour of the agent and the principal based on their environment and relation. As explained in 2.2 both the government-citizen environment and the company environment have a principal-agent relation, however slightly different. In this chapter these differences will be identified, and Agency Theory will be used to make predictions on the translation of benefits and drawbacks. The predictions will also be used to see if the data gathered in the PVE survey is valid and gives logical results. Basing these predictions on a published and often researched theory will increase the validity of that test.

4.1 Principal agent theory

To compare the government-citizen environment and the company environment, agency theory will first be used to explore both environments. Agency theory describes the relation between a principal and an agent (Panda & Leepsa, 2017). The principal is a person or party that authorizes another person or party, the agent, to make decisions on their behalf. In certain circumstances the goals of the agent might not align with the goals of the principal, this could lead to a situation where the agent does not act in the best interest of the principal. This is called the principal-agent problem. To analyse this phenomenon, principal-agent theory was developed within agency theory. Depending on the environment and relation between the principal and the agent, the principal-agent theory predicts how the agent will behave. Principal-agent theory applies to both the company environment and the government-citizen environment. This allows for a structured and substantiated comparison between the two different environments.

Kathleen M. Eisenhardt did a review of the literature on agency theory (Agency Theory: An Assessment and Review, 1989) and summarised it in 10 propositions. All 1- propositions can be found in appendix B: Kathleen M. Eisenhardt's 10 propositions. Proposition 1, 5 and 6 will be used in this chapter:

> *Proposition 1: When the contract between the principal and agent is outcome-based, the agent is more likely to behave in the interest of the principal.*
>
> *Proposition 5: The risk aversion of the agent is positively related to behaviour-based contracts and negatively related to outcome-based contracts.*
>
> *Proposition 6: The risk aversion of the principal is negatively related to behaviour-based contracts and positively related to outcome-based contracts.*

During this chapter, these propositions will be used to explore the reasons for the benefits and drawbacks of using PVE that were found in previous government-citizen cases and to predict if these benefits and drawbacks apply to the environment in which PVE will be used during this research.

The more recent literature research of Panda and Leepsa (2017) Also made the distinction between three different types of agency problems.

Type 1: Principal-Agent problem. This describes the relation between the owners and managers in the organisation. Problems exist due to the separation of ownership and control.

Type 2: Principal-Principal problem. A problem that exists between a principal with a majority of the control and a principal with a minority of the control. Effectively giving the majority owners more power to make decisions in their benefit.

Type 3: Principal-Creditor problem. A conflict that arises between owners and creditors when shareholders want to invest in risky projects in the hope of high return. The owners will enjoy higher profits due to the higher risks, but creditors do not share in the higher profits, only the higher risks.

Both the government-citizen and the company environment covered in this thesis are of type 1. In both cases there a separation between the owner and the control. In the government-citizen environment seen in previous PVE cases, the Government has control but is not the owner. The government gets its control from the votes of the citizens (Gailmard, 2012). In the company environment case covered in this thesis. The control is given by the owners of the assets to employees with the expertise to do the job.

4.2 Indirect and direct mandate

To help differentiate between and to compare the environment of previous PVE cases and the environment in which PVE will be used during this research, a closer look is taken at indirect and direct mandates. In the comparison Freedom and assignment description, flow of information, and contract types will be used.

4.2.1 Differences in freedom and assignment description

An indirect mandate is a mandate where the agent is empowered by and acts on behalf of another party according to their own judgement. The agent has a lot of freedom to fulfil this task as they see fit. As an example, when citizens vote on who they want to represent them in the coming years they trust that person will make decisions that are beneficial to them. Once chosen this representative (the agent) has the freedom to do this how they see fit. Even if the principal makes decisions that are not in line with the requests of all citizens, there could be little the citizens (the principals) can do, except vote for a different person during the next elections (Asamoah, 2018).

In contrast, a direct mandate is more defined. For example, the employee-employer. The employer (the principal) hires an employee (the agent) to do a certain task for him. This task can be defined in multiple ways: the outcome and the process or behaviour. For instance, when the agent works at a large fast-food chain and their job is to prepare burgers, the outcome is defined as perfectly prepared burgers. However more likely than not, they also told the agent which machines to use and exactly the way that these machines should be used. If the agent chooses to behave in a way that does not fit the mandate, he will probably be fired and replaced by a different agent. The degree to which the process of a task is definable is called the task programmability. This task programmability is a large reason for the existence of the information asymmetry (Amagoh, 2009) that will be described in the next section.

4.2.2 Flow of information

In the indirect mandate, the flow of information is mostly from the principal to the agent. The agent then makes decisions that affect the principal. As an example, when the government needs to make decisions the representatives gather information on what the citizens that they represent want and then vote accordingly. A decision is made and rules or regulations that impact the citizens go into effect. Because of (social) media, internet, and the transparency of decisions in most governments there is little information asymmetry in favour of the agent and they will likely be held accountable if they act in self-interest (Asamoah, 2018). Although normally agency theory has an information asymmetry in favour of the agent this is not entirely the case here. Agency theorem still usable due to the power of the principal (Saam, 2007).

With a direct mandate such as the employee-employer relation, the flow of information is different. The employee acts on instructions that have been given by the employer, but the employee is the one

that is communicating most of the information to the employer. Especially when the task has very low task programmability (Stroh, Brett, Baumann, & Reilly, 1996), meaning the agents behaviour can't be precisely defined, and specialized employees are hired for their knowledge to do this task. For instance, results and reports. Within the direct mandate, the employee is allowed to make decisions, but the employer is the one making most decisions, decisions that can impact the employee. Especially in specialised jobs, the employee is often hired for his skills and knowledge. When the employee is hired to do a job that the employer has no or little understanding of, the direction of the information flow shifts even more from employee to employer (Amagoh, 2009).

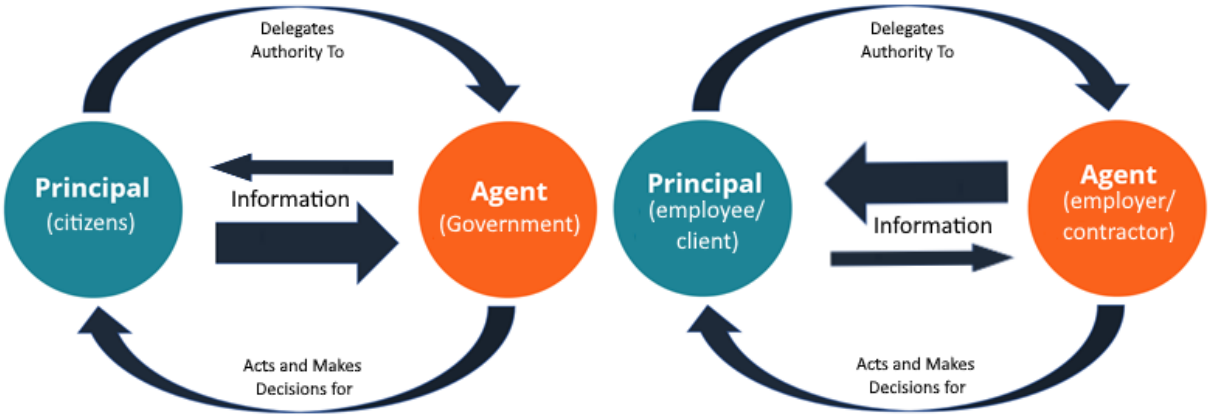

Figure 4-1: Flow of information for indirect mandate (left) and the direct mandate (right)

The flow of information and the authority to make decisions are different in these two cases. This is illustrated in Figure 4-1. So far, the environment in which PVE has been used can be categorised as the indirect mandate. The business environment in which PVE will be tested during this research more closely represents the direct mandate.

4.2.3 Contract types

Eisenhardt (1989) differentiates between two types of contracts. The outcome-based contract and the behaviour-based contract. In the outcome-based contract, the agent is rewarded based on their or the company's performance. Examples of this are paying the contractor after a job is completed in a satisfactory manner, payments in company stock, performance bonuses or sales commissions. In other words, the agent has a direct interest in his performance. In behavioural-based contracts, the principal buys the agent's time (Shapiro, 2005). The principal tells the agent what to do in this time and pays them an hourly wage. The agent has little to no interest in the results of their work, they do not gain any direct benefits from a positive outcome, especially if the outcome is hard to check for the principal.

For this research, the indirect mandate of governance is considered an outcome-based contract. The representatives in the government are judged by the citizens on the results of their decisions, and if those are considered to be positive, they are rewarded with votes for the next term.

In a company environment, there are of course different types of contracts. However, most employees are paid a regular salary (Gerhart, Minkoff, & Olsen, 1995). For this research, the assumption is made that employees in a business environment are paid a salary and are not rewarded with for instance company stock, performance bonus or sale commissions. This means that the direct mandate is a behavioural based contract.

The differences found between the indirect and the direct mandate are summarised in Table 4-1.

	Indirect mandate	Direct mandate
Freedom of the agent	More	Less
Flow of information	From principal to agent	From agent to principal
Contract type	Outcome-based	Behaviour-based

Table 4-1: Differences between the indirect and direct mandate

4.3 Participatory value evaluation benefits and drawbacks for the indirect mandate

This section will explore the benefits and drawbacks found in previous cases for the indirect mandate to see if they are also applicable to the direct mandate. The first three benefits; participation of the silent majority, transmitting of local knowledge and a strong feeling of inclusion have a very similar reason. The better and the more people the representative can please, the more likely they will get to serve another term. The participation of the local majority makes sure that the representative can make decisions that will please and benefit the most people. The transmitting of local knowledge gives the representative information or solutions that can help to choose the best solution, allowing the representative to better please the citizens. The strong feeling of inclusion in participants is also a form of pleasing the citizens, if they feel that their representative listens to them they are more likely approve of him, provided that they have the feeling something is done with their opinions (Corgnet & González, 2013).

The last benefit, awareness methodology, can help to show citizens that not all their requests are possible by making them aware of the methodology of the decision making process. Because of this, they might better understand if a decision is made that does not benefit them and be less upset with their representative. The drawback, the entry high barrier for elderly people that do not know how to use the internet, is true for all the same reasons. The elderly are also allowed to vote and therefore a part of the citizens that the representative would like to please.

Now that the benefits have been explored, let's look at the propositions by Eisenhardt. Proposition 1 shows that the representative would behave in a way that is in line with the citizens that they represent. PVE helps the principal because it is a tool that allows the principal to gather information.

4.4 Benefits and drawback predictions for the direct mandate

Do the same benefits apply to the direct mandate? As explained in paragraph 4.2 the flow of information and the authority to make decisions is different. In this case, the flow of information is from employee to employer and the employer makes the decisions. When the PVE is used in this flow of information, the principal will be the one to design the PVE and the agent to fill in the PWE.

The first advantage is the participation of the silent majority. Because the flow of information is reversed in the direct mandate, participation of the silent majority is a matter of asking the agent to participate. PVE could make it easier or faster to do this, or it could be a good tool to reach more departments, but it should not extend the range of participants as much as with the indirect mandate. The second advantage, strong feeling of inclusion, in this case, the agent that feels like he is being listened to and might therefore be more motivated to deliver results. The third advantage, transmitting of local knowledge, helps the principal to make better decisions by transferring knowledge from the agent to the principal. The last benefit, awareness methodology, can again help with the satisfaction and therefore productivity of the agents. Showing the agents that there is a budget cap and why not all options can be picked, can help with the understanding of why decisions that are not in their interest are made. Each of these benefits helps the principal in pursuing his goal, which is doing his job well. Two of these benefits align the agent's goals with his goals by motivating them to work. The drawback that the entry barrier could be too high should be less present for the direct mandate. In a working

environment, there are less elderly than in the indirect mandate situation and it is most likely expected from employees that they are capable of using email and the internet.

So in principle, the same benefits found in the indirect mandate could apply to the direct mandate, leading to the following predictions:

Prediction 1: The benefits of participation of the silent majority will be less pronounced with the direct mandate than with the indirect mandate.

Prediction 2: The benefits of transmitting of local knowledge will be similar with the direct mandate as in the indirect mandate.

Prediction 3: The benefits of the strong feeling of inclusion in participants will be similar with the direct mandate as in the indirect mandate.

Prediction 4: The benefits of awareness methodology will be similar with the direct mandate as in the indirect mandate.

Prediction 5: The drawback of a high entry barrier for certain groups of people will not be seen in the direct mandate.

However, the flow of information between the agent and the principal is reversed in these two different scenarios. To verify that the agents and principals are switched in this scenario, Proposition 5 and 6 will be used to make the following prediction.

Prediction 6: In the direct mandate, the agents will be more risk-averse than the principals

These predictions will be tested by conducting a PVE survey within Liander asset management. The next chapter will explore the life cycle design process that will be used as the subject of this PVE.

5. Life cycle design

In this chapter, the subject of the PVE will be explored. In consultation with Liander, it was decided to use decisions on the life cycle of the architectural component of a compact secondary substation as the subject. Liander uses life cycles as part of their asset management. The chapter will start by taking a closer look at what asset management is and why Liander uses it. Then it will be explained why this case was chosen before diving deeper into the details of the life cycle.

5.1 Asset management

Schneider, et al. (2006) describe asset management as "operating a group of assets over the whole technical life cycle guaranteeing a suitable return and ensuring defined service and security standards" in their paper on asset management for energy suppliers. They note how the bulk of the cost for energy suppliers are related to maintenance and capital depreciation. They show that asset management is used to decrease these costs by optimising the utilisation of the remaining life of the asset while considering the reliability of the service and distribution of the cost.

To accomplish this, Liander makes use of the ISO 55000 NEN norms (ISO, 2014). These norms require a company to create a strategic asset management plan (SAMP). The SAMP describes the approach to implementing the principals of the company on asset management. Within the SAMP a life cycle plan (LCP) is created that describes the decisions made in every step of the life cycle. In the development of the LCP trade-offs need to be made. As an example, when buying a car it is not possible to have the most reliable, safest, best looking, most specious, fastest, lightest and cheapest car. Some characteristics will come at the cost of other characteristics. Liander makes use of the reliability, availability, maintainability, and safety (RAMS) characteristics, life cycle costing (LCC) and risk assessment to design the SAMP. The Rams targets are defined by the vision or aim of Liander and will set the boundaries in which the LCP can be designed, the LCC will be used to calculate all involved costs over the life cycle and the risk factors will be used to see if the plan is within acceptable risks (Thaduri & Kumar, 2019).

In short, the vision and goals of the company, design and cost calculations of an asset, building, maintaining, using and discarding the asset, and all the risks involved in the process are all part of asset management. As a result, many people are involved or impacted by the decisions made in the LCP. Because of the various positions/departments of these people, they can have varying perspectives, opinions and ideas on the decisions made in the LCP and the risks that are a result of this. PVE is designed to map the preferences of many different people on a subject by letting the participants make decisions based on variables and resources. This subject would therefore be a good fit for the PVE. It gives the possibility to assess the preferences on budget, and acceptable risks between different departments. This also brings the opportunity to test PVE on different types of departments within a company.

5.2 Asset condition

Part of optimising the utilization of an asset is managing the condition of the asset. Assets are subject to degradation during their life cycle. To calculate how fast an asset degrades, Liander uses the NEN2767 norms (NEN, 2006). NEN2767 ranks the condition of an asset on a scale from 1 to 6, defined as followed:

Condition score	Description	Explanation
1	Excellent condition	Occasional minor flaws
2	Good condition	Occasional early ageing
3	Reasonable condition	Locally visible ageing, functional fulfilment of building and installation parts is not endangered
4	Moderate condition	Functional fulfilment of construction and installation parts is occasionally at risk
5	Bad condition	The ageing is irreversible
6	Very poor condition	Technically ripe for demolition

Table 5-1: Condition

The condition of an asset is modelled according to the following formula:

$$condition = 1 + \log_{0.5}\left(\frac{1 - age}{lifespan}\right)$$

Equation 1: Condition score calculation

The lifespan of an asset is influenced by the material it is made of.

The PVE survey will focus on the architectural part of a compact secondary substation. An example of a compact secondary substation is shown in Figure 5-1. The compact secondary substation is made up of an assortment of building parts. A compact secondary substation is made up of:

- Pavement
- Hinges and locks
- The door
- Roof construction
- Walls
- Cellar
- Grating

Figure 5-1: Example of a compact secondary substation

These various building parts can be made up of different materials and therefore have different lifespans. The lifespans of al building parts are listed in Table 5-2.

Building part	Material	Lifespan
Pavement	Stone tiles	35
Hinges and locks	Metal	50
Door	Metal	50
Roof construction	Concrete	75
Walls	Concrete	75
Cellar	Concrete	75
Grating	Metal	50

Table 5-2: Building parts

The degradation of these building parts can also have different consequences. For instance, a leaking roof can result in an outage, but it can also be very dangerous. In contrast, a wall with graffiti on it does not pose a risk to safety or the functioning of the installation, but if not cleaned it could harm the image of Liander because it is an eyesore for the residents of the area. This example demonstrates that there is more to creating a life cycle then the money involved and that the decisions made in the life cycle should also reflect the other values the company has.

To improve the condition of a building part, it can be repaired or replaced. With the help of experts witing Liander the following conditions were given to improvements: The first time a building part is repaired, the condition will improve to score 2. Every subsequent repair will improve the score 0.5 less. The second repair will improve the condition to score 2.5 and the third repair will improve the condition to score 3. This is done because in most cases repair can't last forever. At some point, it becomes more efficient to replace the item instead of repairing it. For instance, a bike tire. Bike tires will wear over time. The first leak can be repaired and probably the second and third one as well. But at some point has worn out so much that leaks will appear much more frequently. At this point, you would rather buy a new tire then repair it every few days. Once repaired the condition will improve to score 1.5. It is as good as new, but not as good as when the complete asset was new.

If the asset condition is the only thing that is considered, the ideal situation would lead to often replacing assets to maintain a perfect condition. However, there are costs involved. The next section will explore the different costs during the life cycle of an asset and their relation to the rest of the life cycle.

5.3 Life cycle costs

Budgeting is also a part of the life cycle. The DSO's have a limited budget and limited manpower. An effect of this is that they cannot do all the projects they would like to do. Due to the transition of the electrical grid, some projects are postponed or changed. Assets can have life spans of over 50 years. Plans made for these assets might not be relevant anymore and might need to be changed. Liander uses life cycle cost (LCC) to help them gain insight into the total costs of an asset over its lifetime (Norris, 2001). This is meant to help them make the decisions that relate to investing, repairing or replacing assets. During the life cycle of an asset, there are multiple types of costs. For instance:

- Development/design costs
- Acquisition costs
- Placement costs
- Inspection costs
- Repair costs
- Disposal/recycling costs

Liander categorises these moments and costs in three phases, the initial phase, the operation phase, and the disposal phase. During the life of an asset, events such as inspections, repairs and revisions

occur. In Figure 5-2 an imaginary example is given of these costs over the lifetime of an asset. Year 0 is the initial phase, year 1 till 24 the operational phase, in which repairs, and inspections occur. Lastly year 25 the Disposal phase. The expected lifespan of an asset is dependent on their use and material, in Table 5-1 some examples are given.

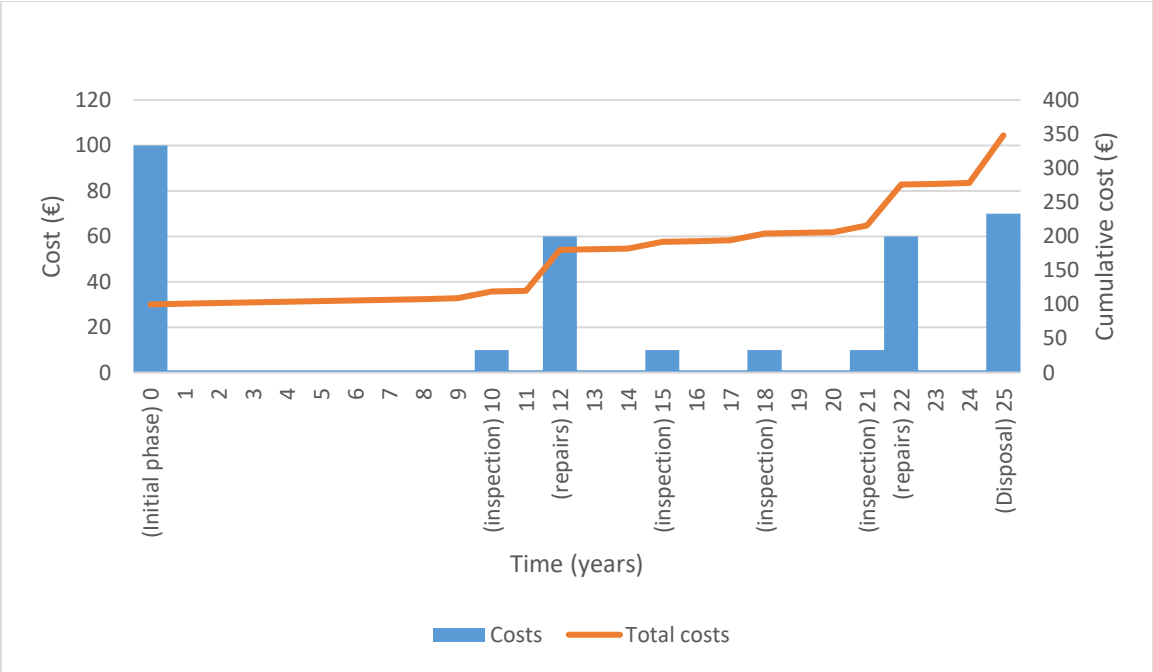

Figure 5-2: Asset life cycle costs 1

The total cost and cost per phase can vary depending on which choices are made. For instance, if more is invested in the initial phase, the cost could drop in other phases, or the asset could have a longer operational phase. An example of such a choice is given in Figure 5-3. This is the same imaginary asset as in Figure 5-2 but here the designers made the choice to go with a cheaper variant that is a little less reliable, to compensate for this they issued more inspections and smaller but more frequent repairs. This model also has more operational losses. These choices make for a very different looking life cycle but have very a similar total cost.

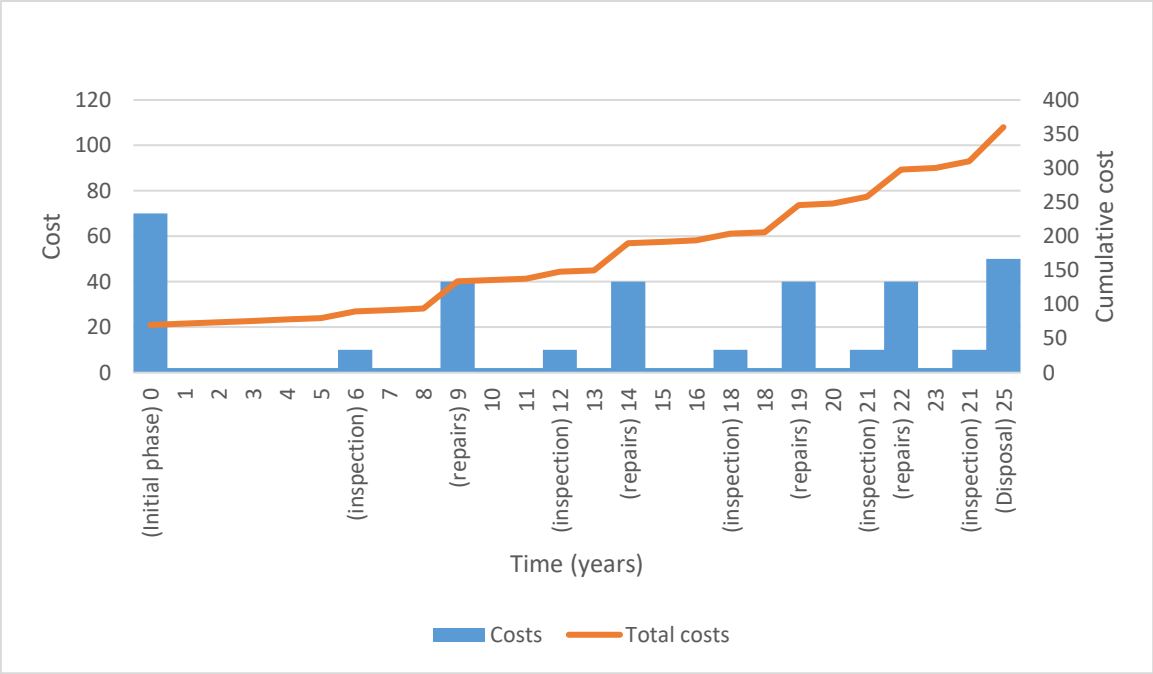

Figure 5-3: Asset life cycle costs 2

The information gained in 5.2 on the condition of an asset can be combined with the information on LCC to gain insight into the condition of an asset over time and the costs that come along with this. As briefly mentioned in 5.2 de degradation of some assets can have consequences such as shortages and outages. The next section will explore how these risks are taken into consideration while designing the life cycle.

5.4 Risk assessment

Liander uses three components in assessing the risk factors (Liander, 2017). Together these three components will lead to an outcome that is an acceptable risk or unacceptable risk. The three components used are:

- Company values
- Risk matrix
- Willingness to take risk

Figure 5-4:Strategic assetmanagement policy

The first component, company values, are the values that a company stands for and is willing to work towards. The company value model is a reflection of the interests of all Liander's stakeholders and built upon the ISO standards for asset management (ISO, 2014) and (ISO, 2019). The model is also used to objectively evaluate contradictory interests. Liander listed the following:

- Safety: measure in which people are protected or exposed to a threat to their lives or health in relation to the infrastructural network of Liander. The indicator for this value is the amount of injury that potentially can or will occur.
- Quality and supply: the extent to which Liander continuously supply their customers via their infrastructural network. The indicator for this value measures the size of the outage (amount of customers times the duration of the outage) expressed in System Average Interruption Duration Index (SAIDI) or storingverbruikersminuten in Dutch.
- Financial: the extent to which the financial objectives are met by the Asset Owner. The indicator for this value is the financial damage for the company.
- Law and regulation: promoting and supervising compliance with laws, external and internal rules and standards that are relevant to Liander's integrity and associated reputation. The indicator for this value is the possible impact of the noncompliance on the relation with the supervisor/authorities.
- Customer and Image: the extent of the impact that is made on the positive association that stakeholders of Liander have with dealing and/or the Liander network.
- Sustainability: the extent to which the actions of Liander raises their CO_2 emission, measured in CO_2 equivalents. The indicator for this value is the burden on the environment expressed in CO_2 equivalents.

The second component is the risk matrix. The risk matrix is used to translate the different types of risk from different company values to a uniform scale of risk levels. The risk level is determined by two variables. The chance of an event to happen and the severity of the consequences. Based on these two factors the risk is deemed to be, nil, low, medium, high, or very high. The risk matrix as shown in Figure 5-5. A larger version is depicted in appendix C: Risk matrix. The matrix can be thought of as a graph with the chance of occurrence on the X-axis, the severity of the consequences on the Y-axis and the

risk level as an output on the Z-axis. However, the scale of the risk matrix is logarithmic due to the chance of occurrence and the severity of the consequences multiplying by 10 with each following step.

Risicomatrix Liander Assetmanagement

Impact op bedrijfswaarden							Kans van voorkomen (per bedrijfswaarde)				
							Mogelijk	Waarschijnlijk	Geregeld	Jaarlijks	Maandelijks
							Wel eens van gehoord in de industrie	Meerdere malen gebeurd in de industrie / wel eens gebeurd binnen Liander	Meerdere malen gebeurd binnen Liander	Eén tot enkele malen per jaar binnen Liander	Eén tot enkele malen per maand binnen Liander
Categorie	**Veiligheid**	**Kwaliteit van levering**	**Klant & Imago**	**Wet- & regelgeving**	**Financieel**	**Duurzaamheid**	**Minder dan 1 keer per 100 jaar**	**1 keer per 100 jaar tot 1 keer per 10 jaar**	**1 keer per 10 jaar tot 1 keer per jaar**	**1 tot 10 keer per jaar**	**Meer dan 10 keer per jaar**
Rampzalig	Meerdere doden	≥ 10.000.000 vbm	Grootschalige zichtbaarheid in het publieke domein van lange duur.	Intrekking vergunning; Opeenstapeling van boetes; Strafzaak tegen directielid met gevangenisstraf tot gevolg; Structureel conflict met autoriteit(en)	Schade groter dan 10M euro	Uitstoot groter dan 500 kton CO_2	**M**	**H**	**ZH**	**ZH**	**ZH**
Ernstig	Ongevallen met dodelijke afloop of zeer ernstig letsel	1.000.000 tot 10.000.000 vbm	Grootschalige zichtbaarheid in het publieke domein van korte duur	Bestuurlijke boete en/of stille curator; Boete categorie 4, 5 en 6; Strafzaak tegen directielid (ongeacht veroordeling); Incidenteel conflict met autoriteit(en)	Schade van 1M tot 10M euro	Uitstoot van 50 tot 500 kton CO_2	**L**	**M**	**H**	**ZH**	**ZH**
Hevig	Ongevallen met ernstig letsel met verzuim	100.000 tot 1.000.000 vbm	Kleinschalige zichtbaarheid in het publieke domein van lange duur	Last onder dwangsom; Boete categorie 2 en 3; Rechtszaak namens meer dan 5000 klanten; Opeenstapeling problemen met autoriteit(en)	Schade van 100k tot 1M euro	Uitstoot van 5 tot 50 kton CO_2	**N**	**L**	**M**	**H**	**ZH**
Matig	Ongevallen met letsel met verzuim	10.000 tot 100.000 vbm	Kleinschalige zichtbaarheid in het publieke domein van korte duur	Bindende aanwijzing; Boete categorie 1; Rechtszaak namens meer dan 500 klanten; Incidenteel probleem met autoriteit(en)	Schade van 10k tot 100k euro	Uitstoot van 0,5 tot 5 kton CO_2	**N**	**N**	**L**	**M**	**H**
Klein	Bijna ongevallen, ongevallen met gering letsel / EHBO zonder verzuim	<10.000 vbm	Weinig tot geen zichtbaarheid in het publieke domein	Waarschuwing; Rechtszaak namens meer dan 50 klanten; Verschil van inzicht met autoriteit(en)	Schade kleiner dan 10.000 euro	Uitstoot kleiner 0,5 kton CO_2	**N**	**N**	**N**	**L**	**M**

Figure 5-5: Risk matrix

The last component is the willingness to take risk. The decision-maker looks at the company values, uses the risk matrix to translate those risks into a uniform scale and lastly on the bases of these two things has to decide if the risk presented is acceptable or not.

Combined these tools are used to assess risks. However, this is not a simple calculation, there is some judgement of the people that are working on the policies involved. They will design or judge a policy that will be influenced by their own perspective on the importance of company values.

5.5 Combining the life cycle and participatory value analysis

The PVE survey will have a similar structure to this chapter. The compact secondary substation will be split into its building parts. First, the participants will need to decide on the condition of the different building parts. They have a budget available to spend between the building parts. When they decided on a strategy the PVE tool will translate their decisions into a risk level with the help of the risk matrix. The participants can then decide if the risks are acceptable or not.

As mentioned in 3.2.3 in the Utrecht heat transition use case the author noted that there was a balance between inclusivity and complexity. If all relevant variables and factors of an LCP would be included the survey would be very realistic. However, it would be very time consuming and too complex for most participants to understand. Therefor factors from asset condition, LCC and risk assessment are included in the PVE but will be simplified. The inclusion of all three factors is important because as discussed in this chapter, when designing an LCP, these three factors need to be considered.

Therefore, the survey will include three of the six company values. Balancing all six values is difficult and can also be an overwhelming amount of information for participants. The decision was made to go with the following three company values:

- Safety: Because Liander as a company find this value the most important of all and is interested to see the different perspectives of employees on the importance of safety and their perceived safety.
- Quality of delivery: The main purpose of Liander is to deliver energy. The survey can explore if different how different departments see the relation between decisions made on the life cycle of building parts and the Quality of delivery.
- Financial risk: When something fails there are often financial consequences involved. This is added to see how the different departments value financial risk in relation to the other company values.

The LCC will include only costs that the participant can influence. Other costs such as development costs, placement cost and removal costs are not included in the budget. Because the participants can't influence these costs, they were removed for clarity.

The survey will include only the option to repair or replace a building part. There are other factors such as maintenance or the intensity of use that can be influenced in a real LCP but adding all these factors would be very difficult and certainly overwhelming for employees from departments that are not working on designing the life cycle. A set lifetime is also chosen and other variables such as condition degradation by outside factors such as traffic incidents are not included.

The next chapter will explore in more detail how the survey is designed.

6. Survey design

This chapter will describe the choices made in the design of the PVE survey. In the PVE, the participant will decide on how and when to maintain the seven architectural building parts listed in Table 5-2: Building parts. These decisions will result in a risk level for three different company values, safety risk, quality of delivery and financial risk.

6.1 Calculations

In consultation with asset managers from Liander, a 100-year life cycle is chosen. This life span gives more freedom of choice since concrete parts age slowly and therefore will not be relevant on smaller time scales. For each building part, a life cycle is calculated. For each year a condition score as listed in Table 5-1: Condition is calculated according to Equation 1. A repair will improve the condition to 2 and 0.5 higher for every successive repair made after the first one. A replacement of the building part will improve the condition to 1.5.

To calculate the risk, the risk matrix of Liander is used. The X-axis in the risk matrix is the change of an incident occurring, each step higher multiplies the change by 10. The Y-axis represents the severity of an incident, again each step higher multiplies the severity by 10. For each square, the expected value is calculated by multiplying the logarithmic average of both the X- and Y-axis. This can be seen in Figure 6-1.

Expected severity in points \ Expected frequency per year	0,00316	0,0316	0,316	3,16	31,6
36100000	114076	1140760	11407600	114076000	1140760000
3610000	11407,6	114076	1140760	11407600	114076000
361000	1140,76	11407,6	114076	1140760	11407600
36100	114,076	1140,76	11407,6	114076	1140760
3610	11,4076	114,076	1140,76	11407,6	114076

Figure 6-1: Expected values in the risk matrix

Each building part has three risk matrixes, one for each company value used. The condition codes for a building part are mapped in all three matrices so that any given condition represents a risk for each company value. These matrixes can be found in appendix C: Risk matrix. The total risk over the lifetime of the compact secondary substation for any given company value is calculated by taking the sum of the risk for each year of all the building parts.

6.2 Project options and budget

The participant has a total of 14 decisions to make. For each of the seven building parts, they need to decide two things. The first decision is on which condition they think action should be taken to improve

the condition. They can choose between condition 3, 4, 5 and 6. The second decision is what this action should then be taken. There are two options, repair and replacement. Because of repair becomes less effective each time, the participant is asked how many times they want to repair a part before they want to replace it. They get to choose between 0, 1, 2 and 3 times. 3 meaning that a part is repaired the first three times it reaches the chosen condition code and replaced the fourth time. 0 meaning that the part is never repaired but always directly replaced when it reached the chosen condition score. With these two decisions the life cycle, the number of repairs and replacements and the associated costs are calculated. Figure 6-2 shows the graph for a building part where the decision was made to undertake action on condition 4 and to repair the building part twice before replacing it. For each building part, a small description of the risk is given that can occur when the condition becomes very poor, or where necessary, a description of the repair or replacement options. The budget was set to 14500 euro. This budget was decided upon by letting the asset managers fill in the PVE form in a way that represented their views on how the life cycle is designed. Some extra budget was given to allow the participants more options.

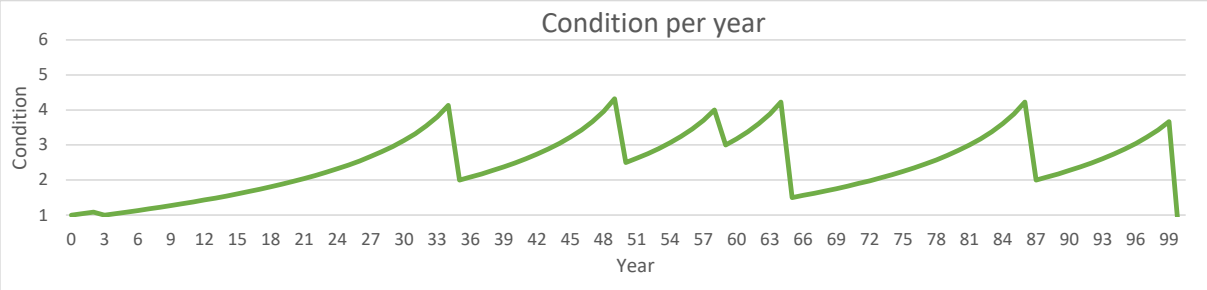

Figure 6-2: graph of the condition of a building part for each year

6.3 End of survey results and questions

The participants can see the effects of their decisions by observing the graphs that map the expected condition of the building part over time as seen in Figure 6-2. A total risk level for each company value is given. And graphs are shown that illustrate which building parts are responsible for this risk as shown in Figure 6-3.

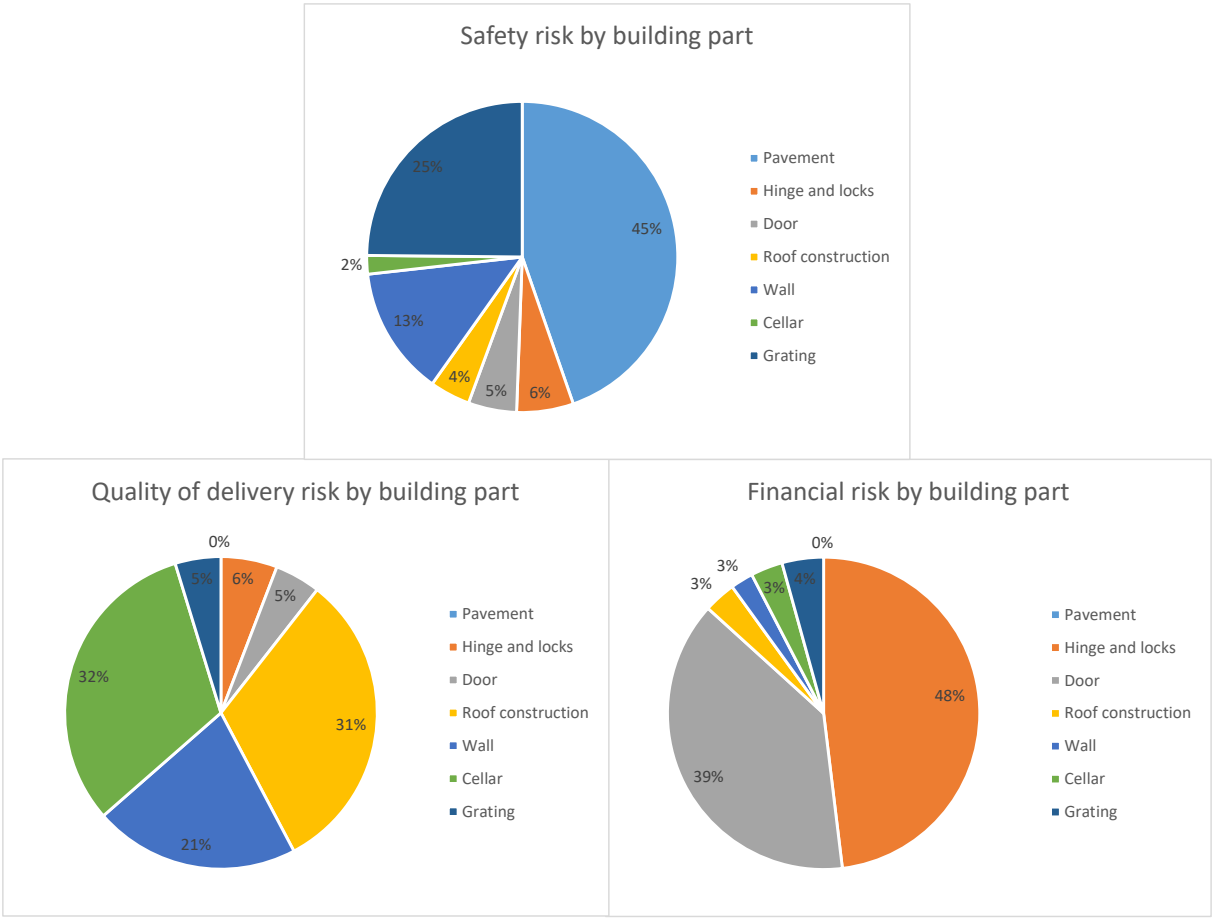

Figure 6-3: Risk by building part

Once satisfied with their decisions the participants are asked to answer two sets of questions, one set related to their decisions on the secondary substation and the results and one set related to PVE as a participation method within Liander. The full list of question is found in appendix D: post survey questions.

6.4 Survey tool

The subject of this PVE is different from the PVE surveys seen so far. The participants do decide what projects should be executed, but they make more detailed decisions on the project level. They make decisions on which building parts they want to maintain, but also for each building part what the maximum amount of degradation is acceptable and if they want to repair or replace the part. These decisions are then processed and result in a cost, in contrast to the clear costs of projects in previous PVE cases.

The existing online tool did not have the capabilities for the condition or cost calculations. Therefore, a new PVE tool has been developed in excel for this purpose. However, this makes the PVE more complicated to fill in, because it is no longer an online questionnaire, but an interactive Excel file. For this reason, a question was added about the clarity and ease of use of the PVE and the PVE went through multiple versions to test this. Pictures of the excel file can be found in appendix E: PVE survey excel.

6.5 Participants

The participants will be ordered in categories to aid the testing of prediction 6. The categories allow for insight into principal-agent relations on multiple abstraction levels. To categorise the participants,

part of the organizational structure of Liander needs to be explained. The functions involved with a secondary compact station can be divided into two different groups, the client and the contractors. The client is Liander asset management. The contractors are the parties that are hired by the client to do certain work. As discussed in 4.2 this would make Liander asset management the principal and the contractors the clients. Both groups have different departments and functions. The list below and Figure 6-4 summarize all relevant functions.

- Policy advisor: determines the framework for other decision-makers to build their policies around.
- Net architect: looks at the entire network and decides which areas need to expand or upgrade and by how much.
- Net planner: Is responsible for smaller parts of the network and for the more definitive design of the upgrades that are deemed necessary by the net architect.
- Operational asset manager: is responsible for commissioning and overseeing the plans made by the net planner. Guards the schedule and budget. Operational asset managers come in two different categories, construction and upkeep.

Three different contractors are relevant.

- Netcare: gains their contracts from the operational asset managers that are responsible for the upkeep, and are thus responsible for the upkeep of assets after they have been built. Within Netcare distinction is made between two functions. The Engineer/team leaders, who accept and prepare the work, and the operational personnel, who execute work.
- Architectural construction: gains their contracts from the operational asset managers that are responsible for construction, and are thus responsible for constructing new assets.
- Qirion: which is responsible for both construction and upkeep of high voltage assets.

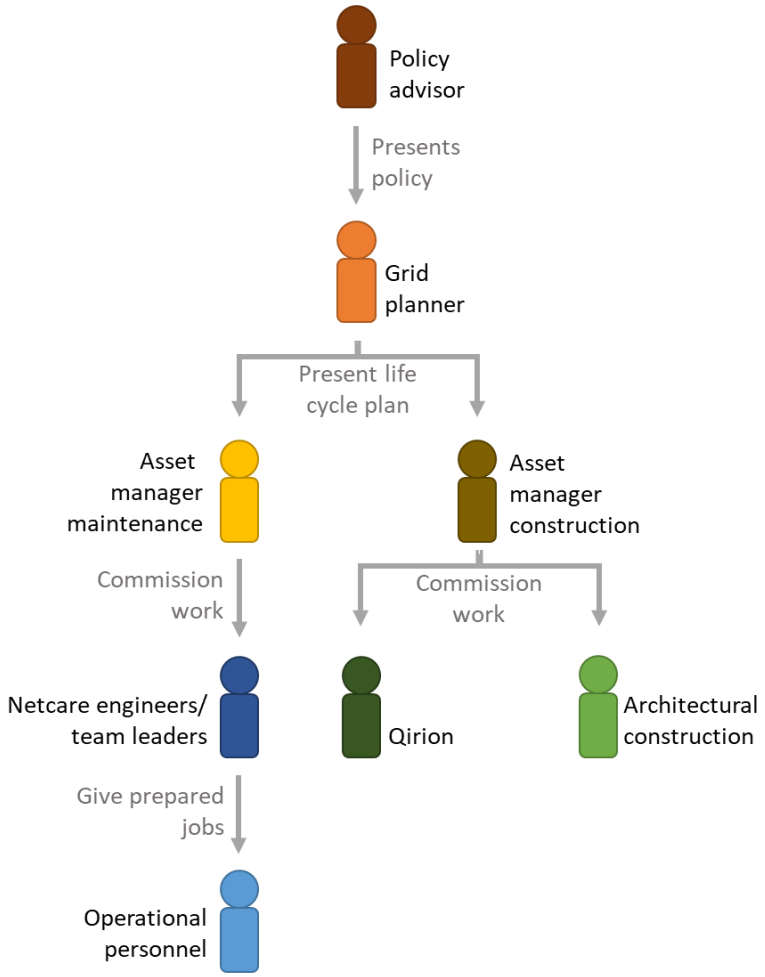

Figure 6-4: Organizational structure

Now that the organizational structure is clear, we can order the participants into categories. This categorization is depicted in Figure 6-5. While grouping the participants there are 3 abstraction levels.

The most abstract grouping divides the participants into two main groups, the contractors and the clients. The clients make plans and then hires contractors to execute these plans. This is depicted on the right side of Figure 6-5.

The second grouping, grouping by department, is less abstract. Contractors can be divided into two departments, directly involved contractors and indirectly involved contractors. The indirectly involved contractors are architectural construction and Qirion. The directly involved contractor is Netcare. Participants from Netcare are divided into engineers and team leaders, who plan and prepare the work, and operational personnel, who execute the work. Clients are also divided into two departments. The first group is the indirectly involved clients. This department consists of policy advisors and net planners. They are involved in the design of the plans, but they are not the parties that commission the work to the contractors. The second group is the directly involved clients. These are the operational asset managers. The construction operational asset managers and the upkeep operational asset manager. These four departments are depicted in the middle of Figure 6-5.

The last and least abstract grouping is grouping by function this groups all participants by the function they occupy. This grouping is depicted on the right side of Figure 6-5.

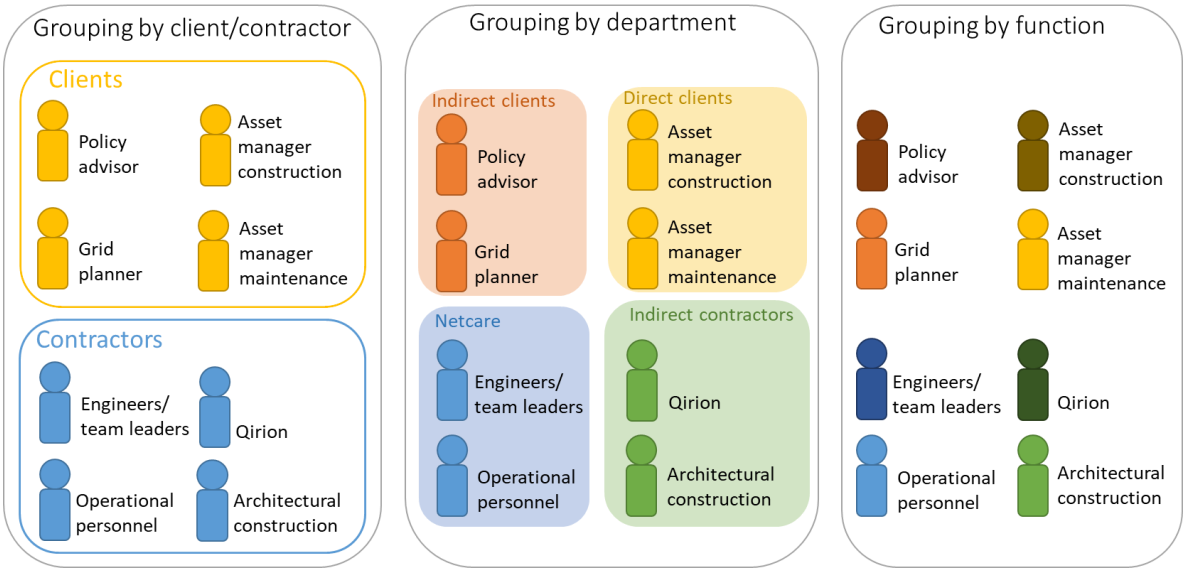

Figure 6-5: Grouping participants, most abstract grouping (left) to least abstract grouping (right)

When all of these groupings are shown in one figure and combine with Figure 6-4, Figure 6-6 emerges. In this figure, the functions on the bottom have the most hands-on experience with the asset while the functions on top are furthest away and are more strategy orientated functions.

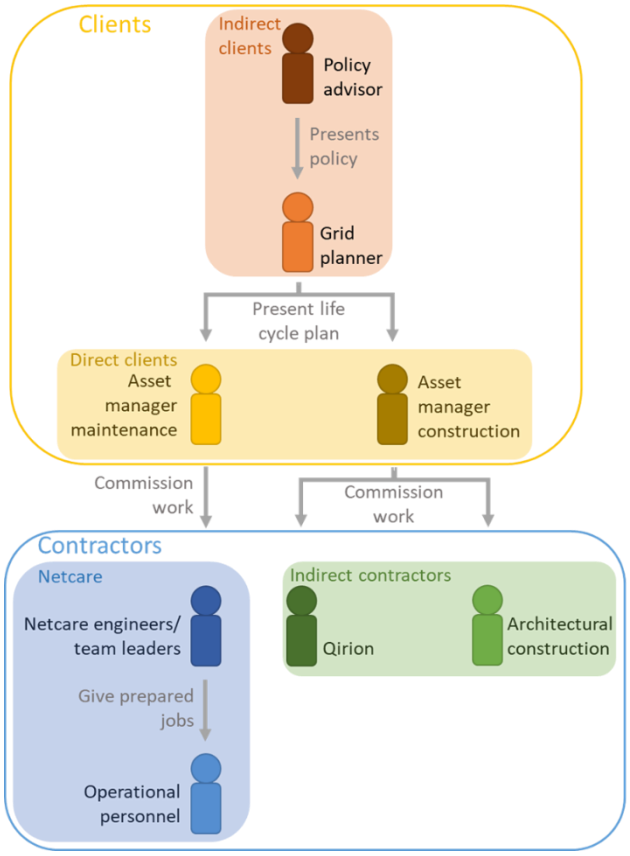

Figure 6-6: Grouping of participants

7. Survey results

During this chapter, the results of the PVE analysis will be explored. First, a small discussion on the validity of the data before the quantitative and qualitative data is analysed to help answer prediction 6.

7.1 Usability of the data

The risk matrix is designed as a tool to help evaluate and compare high and low risks so they could be prioritised and mitigated. It has limited options between these highest and lowest risk, so the resolution is very low, every option being 10 times the risk or frequent as the previous option. That said, the risk matrix was used for the PVE because it is the tool that Liander uses to evaluate risks. However, during the PVE participant disagreed on the amount of risk that decisions resulted in. Because of the logarithmic behaviour of the risk matrix, if a participant chooses a poor condition score for one of the building parts, the risk will multiply tenfold. Participants would leave one building part in a poor condition, in the assumption that it could not bring much risk and found that these risk would rise significantly and eclipse other risks. Only 10 out of 18 participants found the results a logical consequence of their choices. But when those 10 participants were later asked about why they took more risk in a certain area than another, 6 out of the 10 said they disagreed and say they did not even though the results that they deemed logical showed this. This leaves only 4 participants that found the results logical and agreed with them. Although the participants find the results unrealistic, only 5 of the participants would have made different decisions in real life. These 5 participants all provide a reason that did not relate to the risks calculated but rather to other limitations of the PVE such as total replacement or more budget. This would suggest that the participants did not use the calculated risk to influence their decisions but rather as a result afterwards. Around half of the PVE surveys were conducted during an interview, in which it was also observed that participants would make decisions on what they think is right. Afterwards, the participants looked at the results and noted that the calculated risk was not realistic or within acceptable limits but did not adjust their decisions based on these risks. Because of these observations, the budget spend, and the condition scores chosen will be used to estimate the risk the participants are willing to take.

The questions at the end of the PVE will be used to see how the participants rank the different risk areas, this, however, means that there is no way to quantify the risk for each category. Total spend budget will be used as a replacement for the amount of total risk the participant is willing to take.

The original plan was to conduct the survey during meetings of the departments. The model used in the PVE is best explained in person because of its complexity. However, this was not possible due to Covid-19 measures. Therefore, the survey was explained during a 1-on-1 video meeting and online screen sharing with each participant. Not all participants had access to this method of communication. These participants were called and the survey was conducted over the phone. As a result, participant 18 went 1.1% over budget. Because of the small number of participants and the small budget overrun, it was decided to still include this data in the analysis. Participant 16 went 28% over budget which is a much more significant amount, therefore the quantitative data of participant 16 is not included in the analysis. The qualitative data is still included because the participants insight is still valuable.

Participant 5 only spend 40% of the budget, this is an outlier as other low spenders still spend around 70% of the available budget. However, this is all within the survey rules and the participants made clear in the post survey questions that this is how he thinks it should be done. Therefore, this data is included in the analysis.

To see what effect these outliers have on the results, an analysis has been conducted with all participants, as well as an analysis without participant 16 and an analysis without participant 5 and 16. The graphs can be found in appendix F: Survey result graphs.

7.2 Total averages

The quantitative data will be used to gain insight into how much risk each group of participants is willing to take. First, a comparison between the different categories of participants is made with the help of the total budget spend and the average condition score. Secondly, the chosen condition scores for each building part along with the number of times participants are willing to repair building parts before replacing them, will be analysed to find the differences and the reasons for these differences between participants.

7.2.1 Average over all building parts

During the quantitative data analysis, the grouping of participants depicted in Figure 6-5 will be used to compare agents and principals. The full comparison including all details and comparisons between on a participant level can be found in appendix F: Survey result graphs. In this chapter, only the notable comparisons and data is presented.

Figure 7-1 shows that on average the clients spend more money and chose a worse condition score.

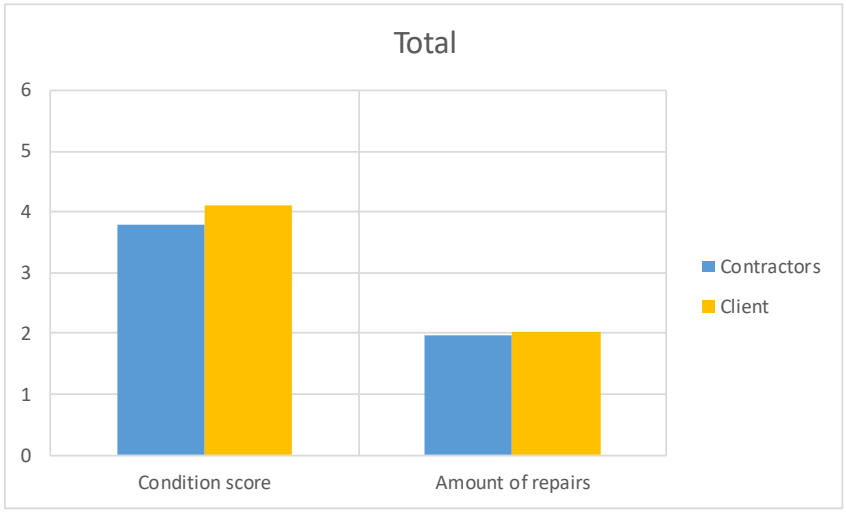

Figure 7-2 shows that the contractors on average also tend to repair a little less than the clients.

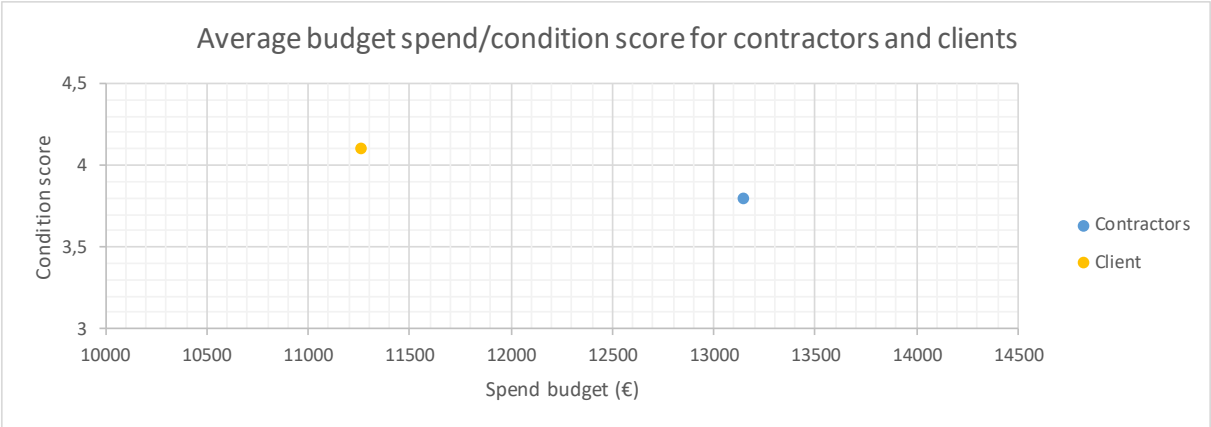

Figure 7-1: Scatter plot of average budget spend and average condition score for clients and contractors

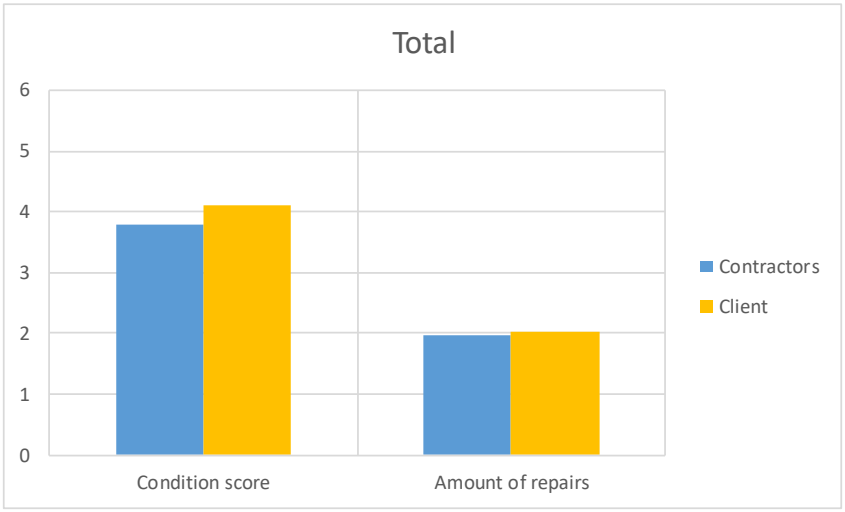

Figure 7-2: Average condition score and amount of repairs for clients and contractors

Figure 7-3 shows the different departments and indicates with an oval which of the departments are clients and which are the contractors. It shows that the indirect clients spend less and chose a lower condition score than the direct clients. The contractors are close to each other. Figure 7-4 shows that Netcare and the indirect contractors chose very similar condition scores, both lower than the direct and indirect clients. The trend continues in the number of repairs. However, Netcare, who is responsible for the actual repairs, chooses to do more repairs than the other departments.

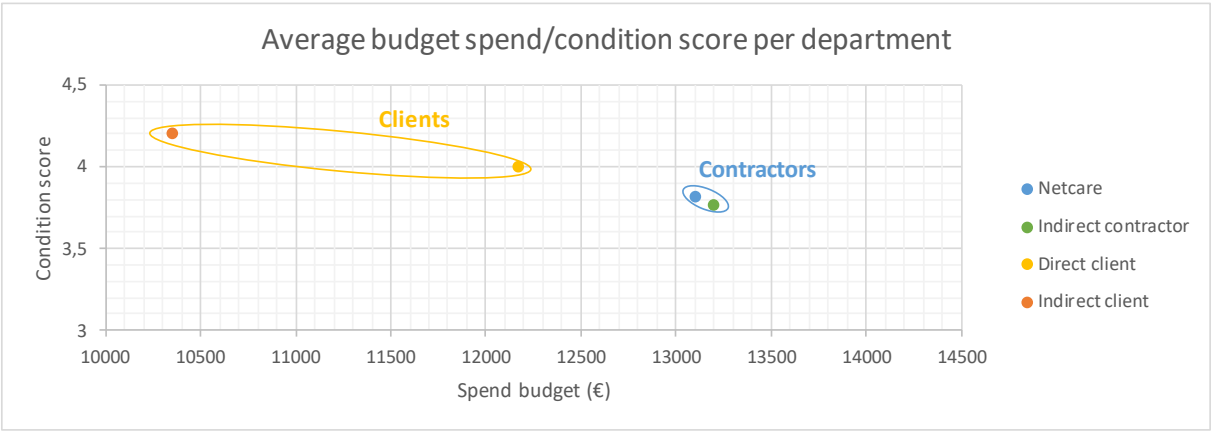

Figure 7-3: Scatter plot of average budget spend and average condition score per department

Figure 7-4: Average condition score and amount of repairs per department

In Figure 7-5 the functions of the participants are shown. The functions are grouped with opaque ovals to indicate from which department they are. Within the indirect clients, the policy advisors spend less and chose a worse condition score than the grid planners. The direct clients choose similar conditions but the asset managers for maintenance spend less. Within Netcare operational personnel spends significantly more money but on average pick a slightly worse condition code. Figure 7-6 shows that the Netcare engineers/team leaders choose to repair significantly more than Netcare operational personnel.

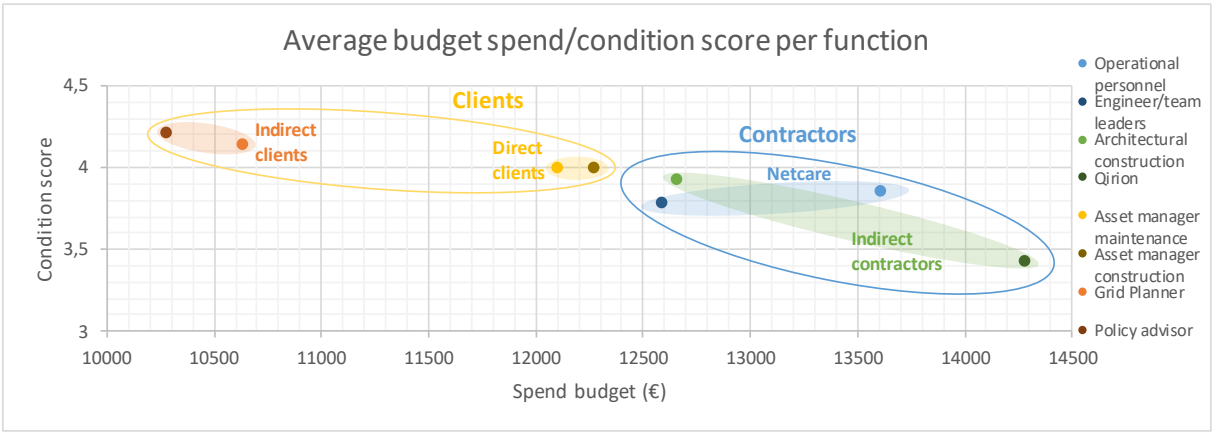

Figure 7-5: Scatter plot of average budget spend and average condition score for per function

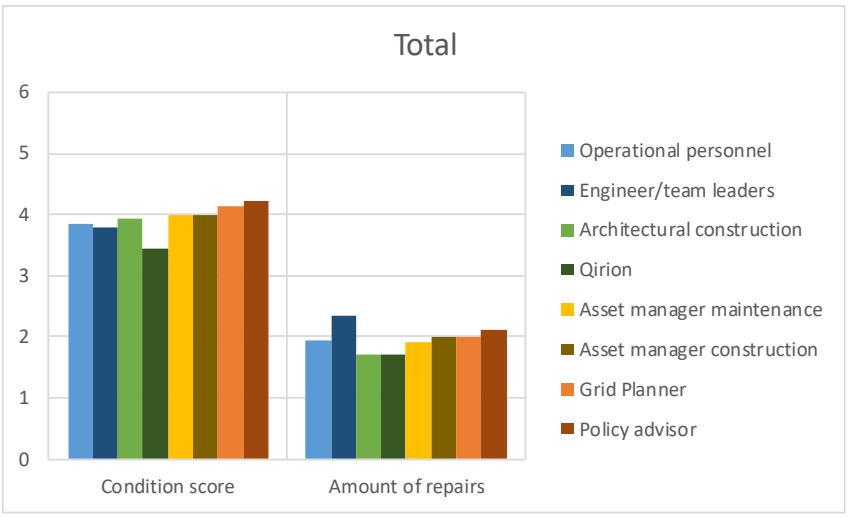

Figure 7-6: Average condition score and amount of repairs per function

Prediction 6 says that the agents will be more risk-averse than the principals. The budget spend and the condition score chosen by participants is an indication of this risk. The more budget a participant spends means that they are willing to invest more budget to reduce risk. The condition score is also a good indicator, the better (lower) the condition score is, the less risk a participant takes. In this situation, the contractor is the agent and the client is the principal. Figure 7-7 indicates the risk difference between the client and the contractor. The top left of the graph is the area where the most risk is taken, and the bottom right is where the least risk is taken. As can be seen, the client (principal) takes more risk than the contractor (agent), which is in line with prediction 6. This supports the theory that the role of the principal and the agent is switched.

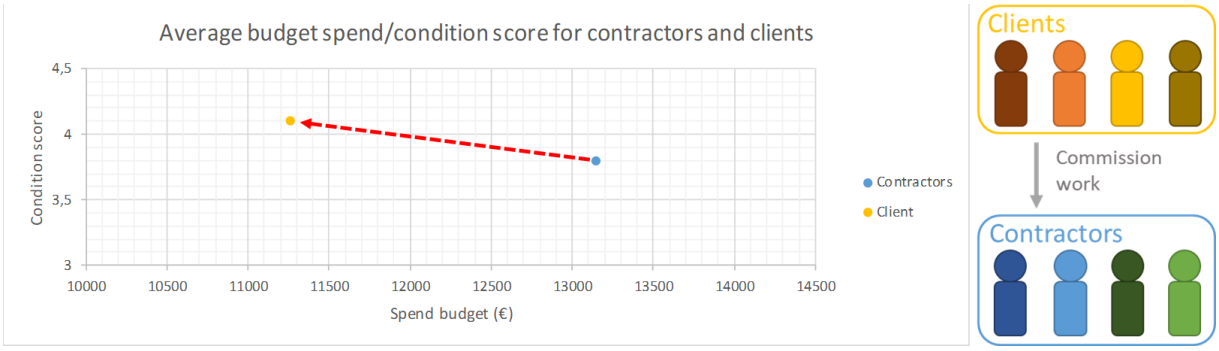

Figure 7-7: Risk difference on client/contractor level

However, the results show that prediction 6 also holds if the different grouping of participants are compared. Figure 7-8 shows the difference in risk taken if a comparison is made on the department grouping abstraction level. The direct client takes less risk than the indirect client. However, there is little difference between Netcare and the indirect contractors. As described in 6.5 the indirect clients create a plan, they then give this plan to the indirect client who makes sure that these plans are commissioned. So, there is a principal-agent relation in there. The indirect contractors are contractors that are involved in a different stage of the asset life cycle or are involved in the life cycle of different

assets then the compact secondary substation. They would get their contracts from one of the asset managers just like Netcare. This means that there is no principal-agent relation between them.

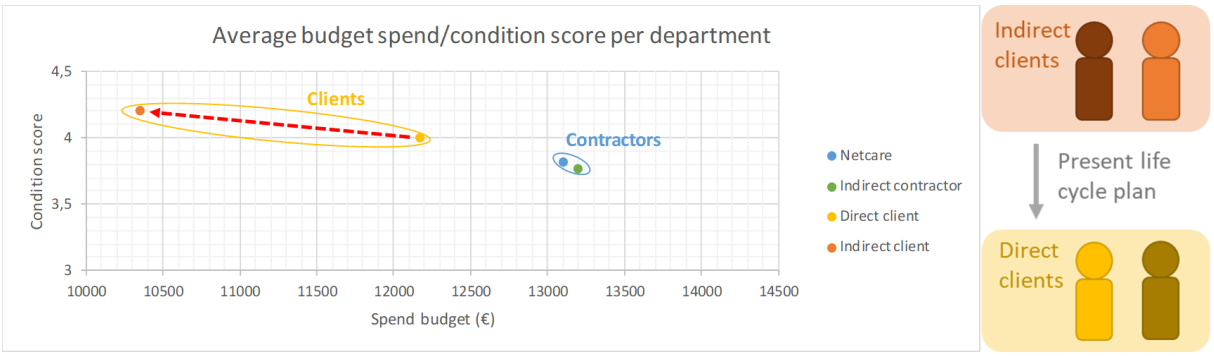

Figure 7-8: Risk difference on department level

Figure 7-9 Shows the difference in risk on a function level within the departments. The first difference in risk is between the policy advisor and the grid planner. The grid planner takes less risk than the policy advisor. The policy advisor makes boundaries in which the grid planner is supposed to plan. Which indicates a principal-agent relation.

There is a difference between the two different asset managers. The asset manager maintenance is willing to take more risk which could point to another principal-agent relation. However, the asset managers are both in charge of supervising the execution of the plans that the grid planner makes, but in different moments of the asset life cycle. They do not get their instructions from each other. So there is no principal-agent relation there.

Within Netcare the difference between the engineers/team leaders and operational personnel is visible. The operational personnel are willing to spend more budget. They do however pick a slightly worse condition score. The operational personnel get their instructions directly from the engineers/team leaders, meaning there is a principal-agent relation there. Where again the agent is more risk-averse.

There also is a large risk difference between Qirion and Architectural construction. Qirion works on a different type of assets than Architectural construction and they both get their contracts from clients, so there is no principal-agent relation there. However, it is interesting that Qirion takes very little risk compared to the other functions. This could have something to do with the type of assets that they work on, these are high voltage assets that are more expensive, dangerous and could affect the power supply of more people if the assets fail.

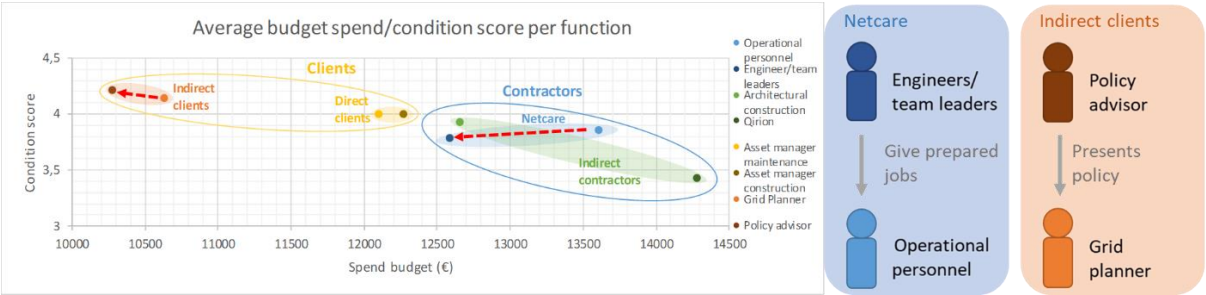

Figure 7-9: Risk difference on function level

The findings of this paragraph support prediction 6. This is also substantiated with the finding of more than one principal-agent relation all of which are in line with prediction 6. The following four principal-agent relations found are summarised in Table 7-1.

Principal	Agent
Clients	Contractors
Indirect clients	Direct clients
Policy advisor	Grid planner
Netcare engineers/team leaders	Netcare operational personnel

Table 7-1: Principal agent relations

7.3 Condition and repair choices per building part

The participant had to make two decisions for each building part. First, what the maximum acceptable condition is and second, the number of repairs before replacing the building part. The analysis of these decisions and the participant's substantiation on these decisions will be covered in the coming part.

To aid the comparisons between different participants/groups, four maintenance strategies are defined. These strategies are the result of the maximum allowed condition score and the number of repairs before replacement chosen by the participants. This will make it easier to understand the differences between the decisions made by the participants. The following four different life cycle strategies have been defined:

1. Perfect maintenance: In this strategy action is undertaken before the asset reaches a condition higher than 4, as defined in NEN2767 norms and building parts are replaced after at most 2 repairs. This is the least risky strategy.
2. Replacement based maintenance: Assets are repaired 2 times or less, and action will be taken on or after condition 4. So, an asset is placed, and little maintenance is done until it reaches a condition score of 4 or higher on which it is replaced.
3. Repair-based maintenance: For this strategy, action is undertaken at a condition of 4 or lower, at which the asset will be repaired. This will be done 2 or more times before it is replaced. This strategy involves a lot of maintenance but keeps the asset in good condition.
4. Run to fail: For this strategy, an asset is placed, when it reaches a condition of 4 or higher it will be repaired. This life of the asset will be extended by at least 2 repairs, making full use of the asset. This is the most risky strategy, the asset has a high chance of failing, resulting in outages.

These strategies will be shown in the condition/repair scatter plots.

7.3.1 Pavement condition divides contractors and clients

Figure 7-10 shows that for each type of grouping, the contractors prefer repair-based maintenance, and the clients prefer a run to fail strategy for the pavement. It also shows a lot of deviation between the different departments and functions in the condition. Except for the grid planner, all functions seem to be willing to at least repair the pavement two times before replacing it. The closer to the contractor/operational personnel the participant seems to be, the better the condition score they pick. The contractors and especially the operational personnel noted that it was important to keep this in good condition, as failures would often occur when it is dark or the weather is bad resulting in poor visibility. The clients did mention the safety of the operational personnel, but also argued that these stations were rarely visited or that the condition should just be good enough to walk on but not better, and was often given the worst condition code of all building parts. Operational personnel also mentioned that the subsidence of the pavement can expose cables, making it a safety risk.

Figure 7-10: Condition and repair choices for the pavement

7.3.2 Hinges and locks have mostly perfect maintenance but participants divided over repairs

Hinges and locks has the best average condition with little deviation across the participant groups with most results landing in the prefect maintenance strategy. However, the choice between repairing and replacing of the hinges and locks has a lot of deviation, shown in Figure 7-11. On client/contractor or department level, there does not seem to be a lot of deviation, this is because the deviation between and within functions seems to average out towards the middle. The qualitative data also shows that participants have very different ideas on the reparability of a lock. However, most participants wanted the locks to be in good condition because of the dangers of unauthorized access. Operational personnel is the only group to mention that a defective lock can be a hindrance in carrying out repairs creating longer failures. All the other participants only saw the lock as a way to keep people out, not as a way to gain access to the compact secondary substation.

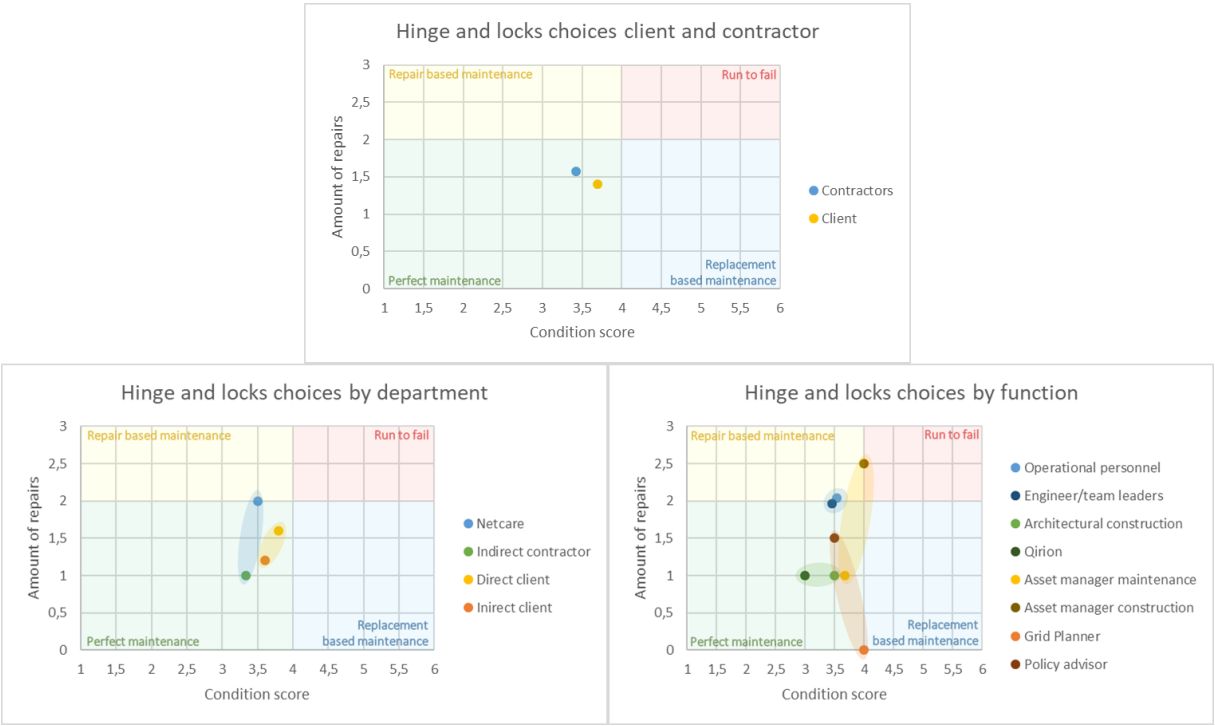

Figure 7-11: Condition and repair choices for the hinges and locks

7.3.3 Door has deviation due to confusion over function and material

The door saw some deviation in both condition and repairs, as seen in Figure 7-12. The cause of this seems twofold. First, some participants reasoned that the door is just as important to prevent unauthorized access as the hinges and locks are, while others did not. Second, there was a lot of confusion around the material of the door, which is important to the reparability of the door. However, operational personal especially choose to repair more often before replacing it. While operation asset management upkeep had the lowest amounts of repairs before replacement.

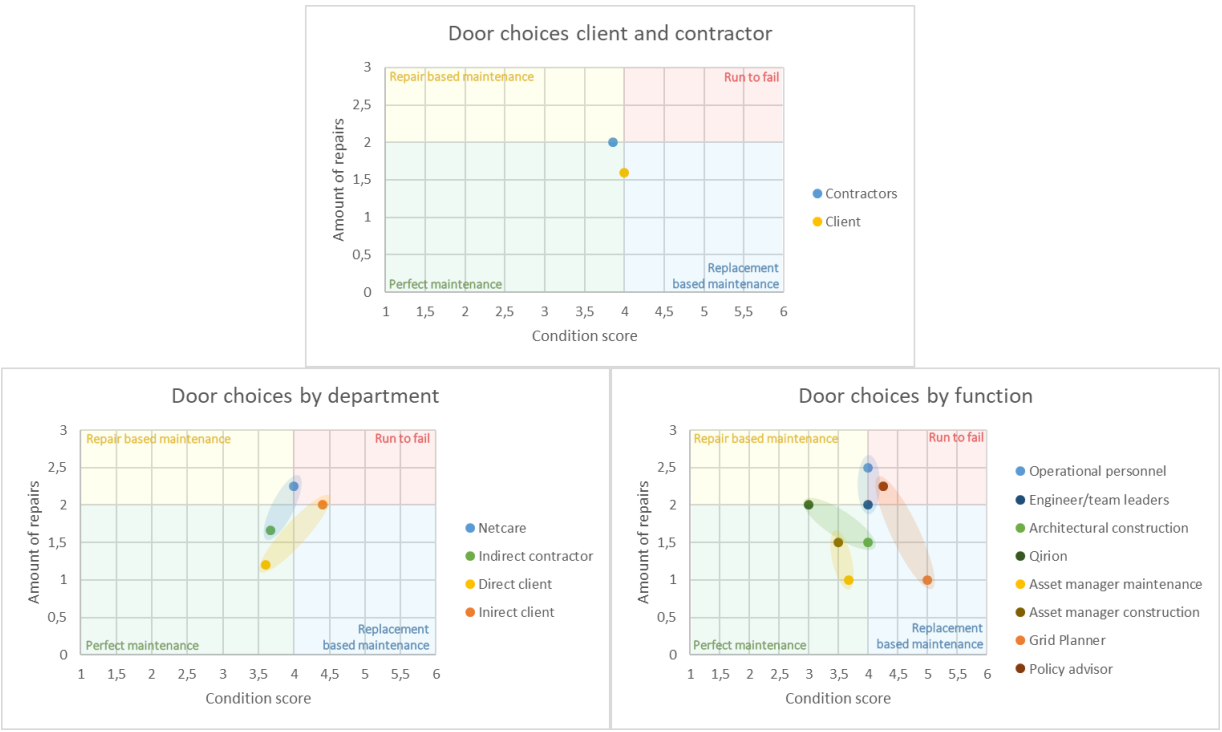

Figure 7-12: Condition and repair choices for the door

7.3.4 Confusion between participants on roof repair and replace possibilities

The roof construction saw very little deviation in the condition code the participants chose. The repair however, has a large amount of deviation between participants and functions, this deviation seems to average out on the department and client/contractor levels. This can be seen in Figure 7-13. The reason for this is not entirely clear, but it seems that there are different views on how often you could repair a roof and if you can or cannot replace it. Consequently, the results average out just between perfect maintenance and replacement-based maintenance. The only reasons mentioned to keep the roof in good condition by the participants is leakage and the risk of damage to the installation that leakage introduces.

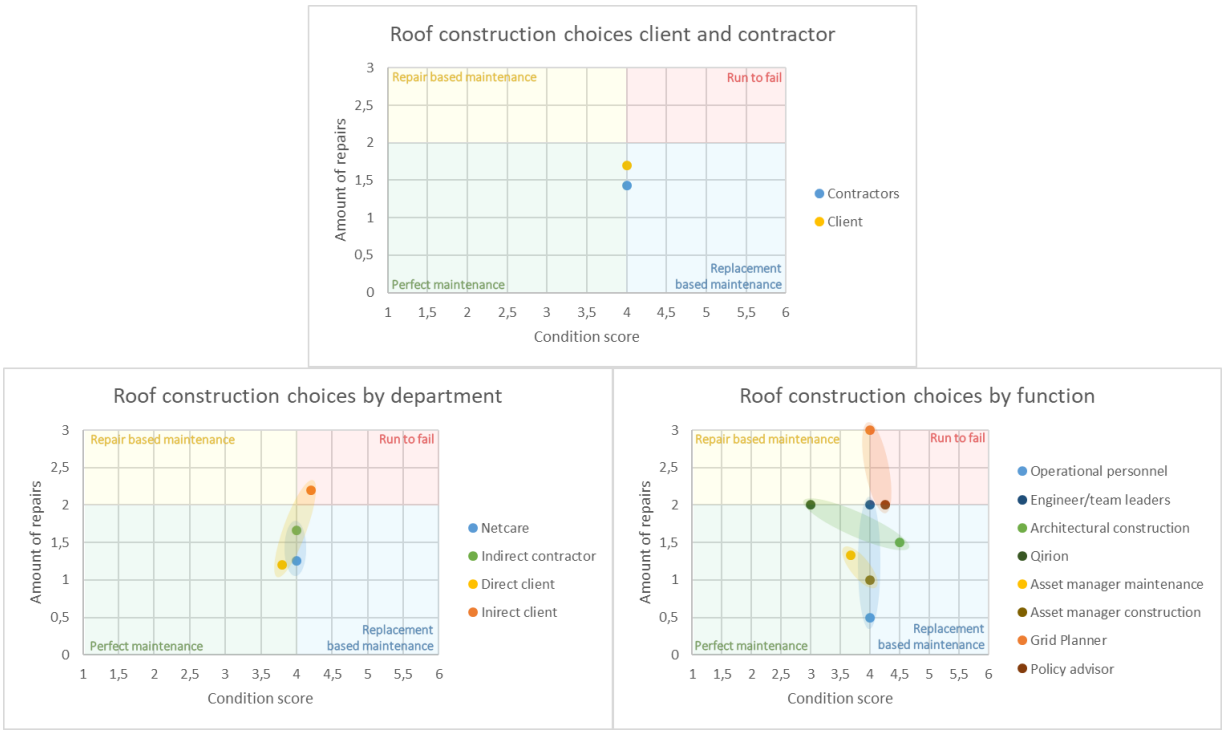

Figure 7-13: Condition and repair choices for the roof construction

7.3.5 Walls need little maintenance

Walls have the worst average condition score and the second most repairs of all building parts. There is a little deviation on both condition score and number of repairs. Most participants do not see much risk in the deterioration of the walls. Small repairs are easily made and mostly for visual benefit. Figure 7-14 shows that on all levels, the participants chose for a run to fail strategy.

Figure 7-14: Condition and repair choices for the walls

7.3.6 Cellar gives disagreement on importance and if it can or cannot be replaced

The cellar has one of the larger deviations in both the condition score and amount of repairs on the function level, shown in Figure 7-15. The participants that chose a better condition score argued that subsidence of the foundation leads to cables being exposed and therefore being a safety risk. Participants choosing worse condition scores argued that there was little risk involved, one participant said that cellars sometimes have pools of water in them. The replacement and repair of a cellar also divides participants. Some participants claim that there is little to repair and that it is impossible to replace without replacing the entire compact secondary substation. Other participants say that repair is possible and that the station can be lifted off the foundation so the foundation can be replaced.

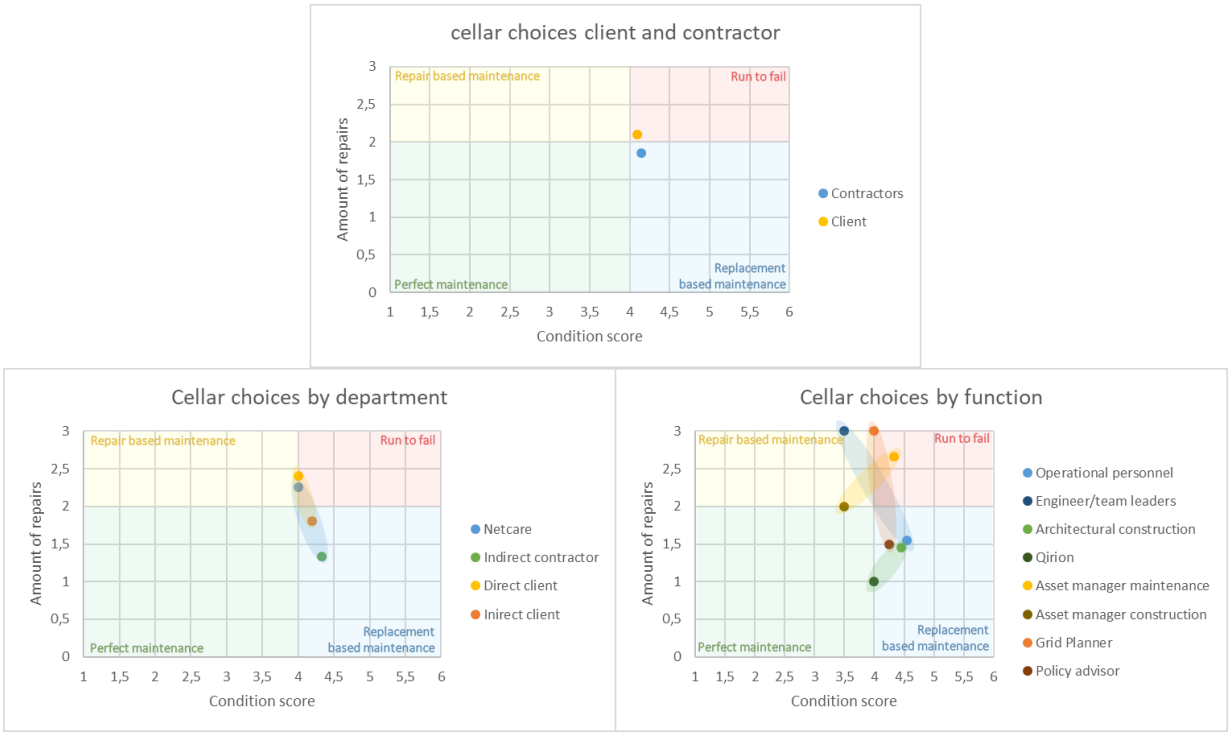

Figure 7-15: Condition and repair choices for the cellar

7.3.7 Grating has little deviation, but contractors repair a little earlier

Grating has little deviation on both condition score and number of repairs. The contractors chose to act on a lower condition score so they could prevent rust from damaging the building part to the point that it needs to be replaced. The results are shown in Figure 7-16.

Figure 7-16: Condition and repair choices for the grating

7.4 Conclusions

The results show that not all departments or functions have the same view on all building parts. This can be explained due to the different ways that each function looks at the life cycle. Operational personnel do not have the same goal as a policy advisor. The choice substantiation of the participants also showed that not all participants are aware of the same options or consequences. For instance, contractors all claim that safety is the most important value. However, they tend to spare costs on the pavement, thinking it is not important. In contrast, clients spend more on the pavement arguing that saving on the pavement brings safety risks. Other examples are the roof and the cellar. The participants have different ideas on the importance, repairability and replaceability of these building parts. This is not a difference that is only seen between different departments or functions but between all participants. The next chapter will explore the vision of the participants on the use of PVE within Liander. Chapter 9 will explore and explain the different views discussed at the start of this paragraph and the different visions of the participants found in chapter 8 more.

8. Participatory value evaluation review

In this chapter the participants experience with the PVE will be explored. At the end of the PVE, the participants were asked to answer some questions about their experience with the survey and to give their opinions on how they view the usability within Liander and for their function within Liander.

First, the questions on the ease of use and the amount of information will be explored. Secondly the questions on insight in life cycle design gained by the PVE. And lastly the view of the participants on participation in the decision-making progress and the possible role of PVE in this process.

8.1 Questions on the amount of information

Three questions were asked on the ease of use and the amount of information given in the PVE.

1. Do you find the PVE comprehensible and easy/quick to complete?
2. Do you like the amount of information?
3. Do you find maintenance of a compact secondary substation a suitable subject for a PVE?

The results are shown in Figure 8-1, Figure 8-2 and Figure 8-3.

Figure 8-1: Results for "Do you find the PVE comprehensible and easy/quick to complete"

Figure 8-1 Shows that 83% of the participants found the PVE comprehensible and easy/quick to complete. Participants who answered negatively or partially positive found it difficult to understand how the results were calculated. Participants on the client's side were more critical towards this.

Figure 8-2: Results for "Do you like the amount of information?"

Figure 8-2 shows that less than half of the participants liked the amount of information that was given during the PVE. Notable however, is that contractors were much more pleased with the amount of information than the clients.

The contractors often wanted more specific information on the location and type of compact secondary substation. They noted that a different environment or type of station had effects on how fast certain building parts would degrade. For instance, sea wind would have a negative impact on certain types of materials. The environment also mattered for the repair or replacement of certain building parts, arguing that cosmetic repairs would be unnecessary in places that people never visit, but they would be necessary for instance in the middle of a city. Lastly, the type of station also mattered for the repairs that can be made to building parts. Some doors for instance do not rust while others do, leading to different strategies.

The clients mentioned two other points. The first one is the ambiguity that some of the definitions gave. For instance, one participant gave the comment “What is incidental?” revering to the condition scores. The second point that the clients brought up was how difficult it was to understand exactly how the results were calculated and how their choices exactly affected this. During interviews, they asked more in-depth questions related to the mathematical model.

Figure 8-3: Results for "Do you find maintenance of a compact secondary substation a suitable subject for a PVE?"

Figure 8-3 shows that a little over half of the participants think that the maintenance of a compact secondary substation is a suitable subject for the PVE. Arguments for this mostly included gathering information easily. Participants noted that Liander has many compact secondary substations and that gathering more information on the life cycle would be helpful.

However, the participants that did not or partially agreed brought forward that this would be difficult because of the many different types of substations and circumstances. Another argument that multiple participants brought up was that these stations are prefab assets and that often they choose to replace the station instead of repairing parts. They proposed using the PVE for assets where more repair is done and where stations are more similar.

8.2 Questions on insight in the life cycle design

The participants were asked two questions that involved insight into the life cycle design.

1. Has the PVE given you more insight into the considerations involved in designing a life cycle plan?
2. Do you want more insight into the considerations involved in designing a life cycle?

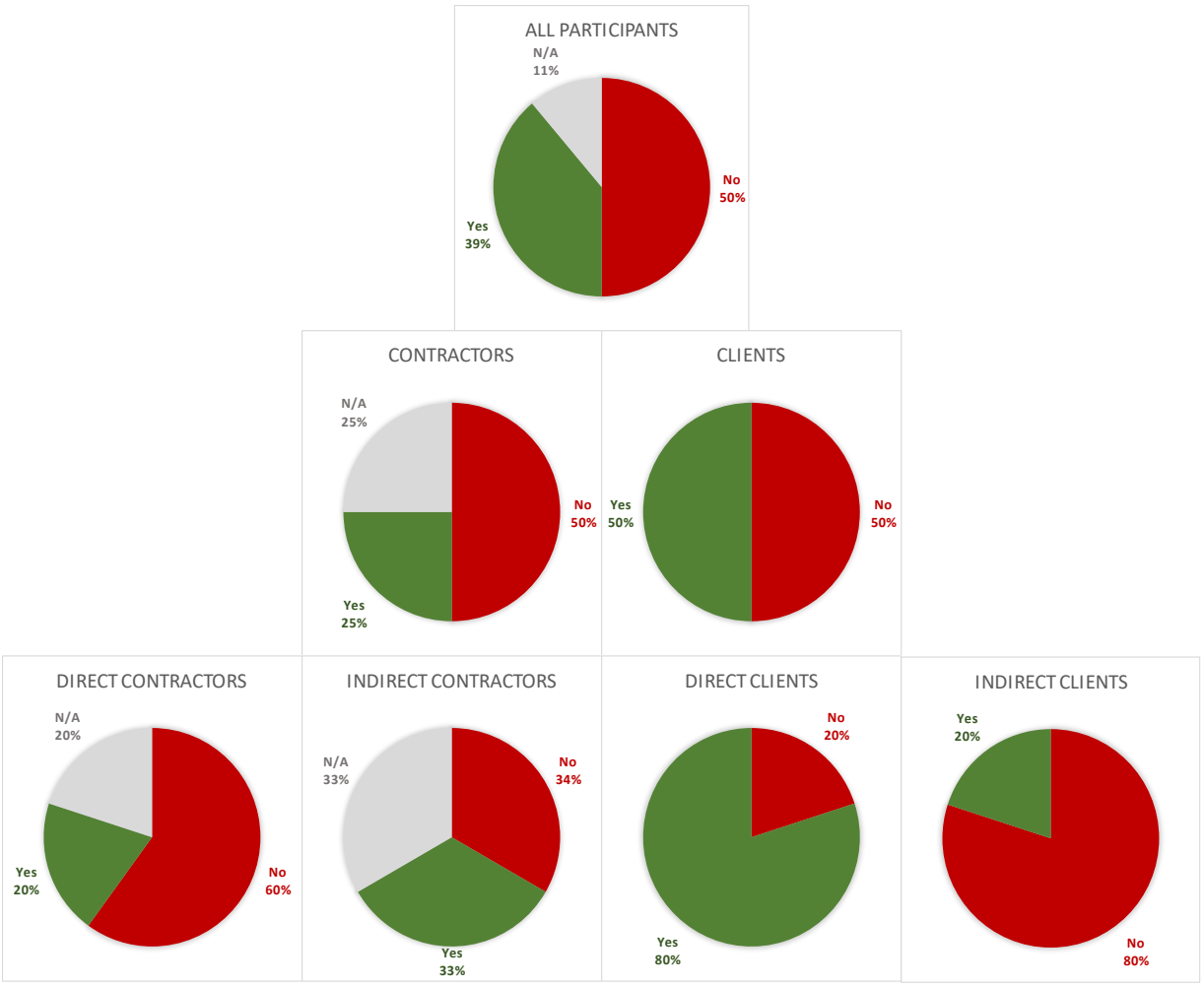

Figure 8-4: Results for "Has the PVE given you more insight into the considerations involved in designing a life cycle?"

Figure 8-4 shows that half of the participants did not gain any new insights into the considerations involved in designing a life cycle. The direct contractors mostly said that this is their daily job and that they already have the knowledge. One of the participants said that thinking/talking about it did give him new insights. Interesting however, is that the directly involved clients have gained the most insight because of the use of PVE while the indirect clients who are less involved, mostly gained no new insights.

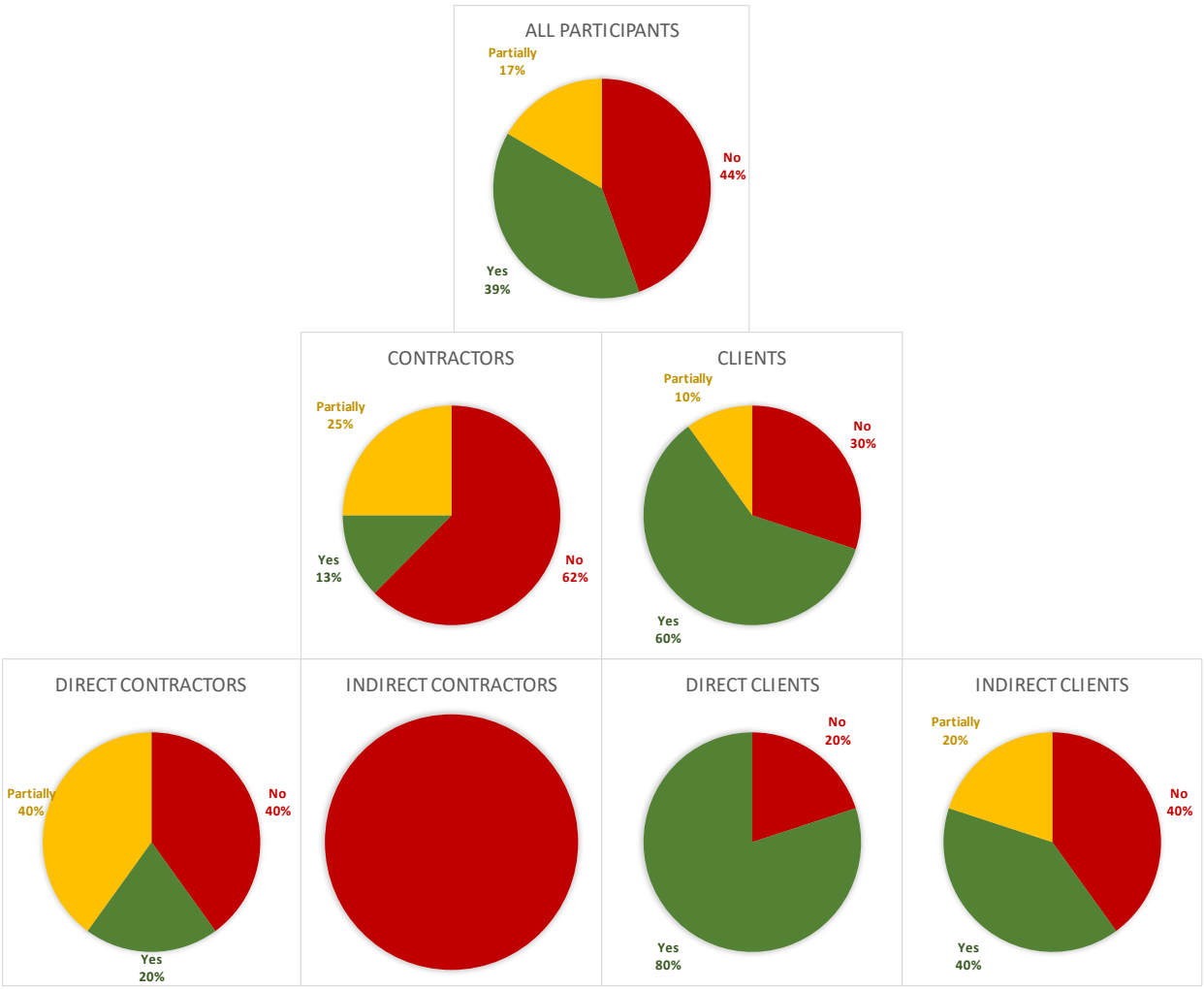

Figure 8-5: Results for "Do you want more insight into the considerations involved in designing a life cycle?"

Figure 8-5 shows that the contractors have little to no interest in gaining more insight into the design of a life cycle and the indirect contractors all have no interest. On the client-side, the direct clients are interested in gaining more insight into the design of a life cycle. The indirect clients are divided, the indirect clients who are not interested give the same reason as the indirect clients: it is not their job and it will cost them more time. Participants mentioned that they do see the use of PVE. This however mostly focuses on the mathematical model and the choices.

8.3 Question on participation in the decision-making progress

The participants were asked the following two questions on participation in the decision-making progress:

1. Do you want to participate in the decision-making progress?
2. Do you think PVE is suitable method for participation in the decision-making progress?

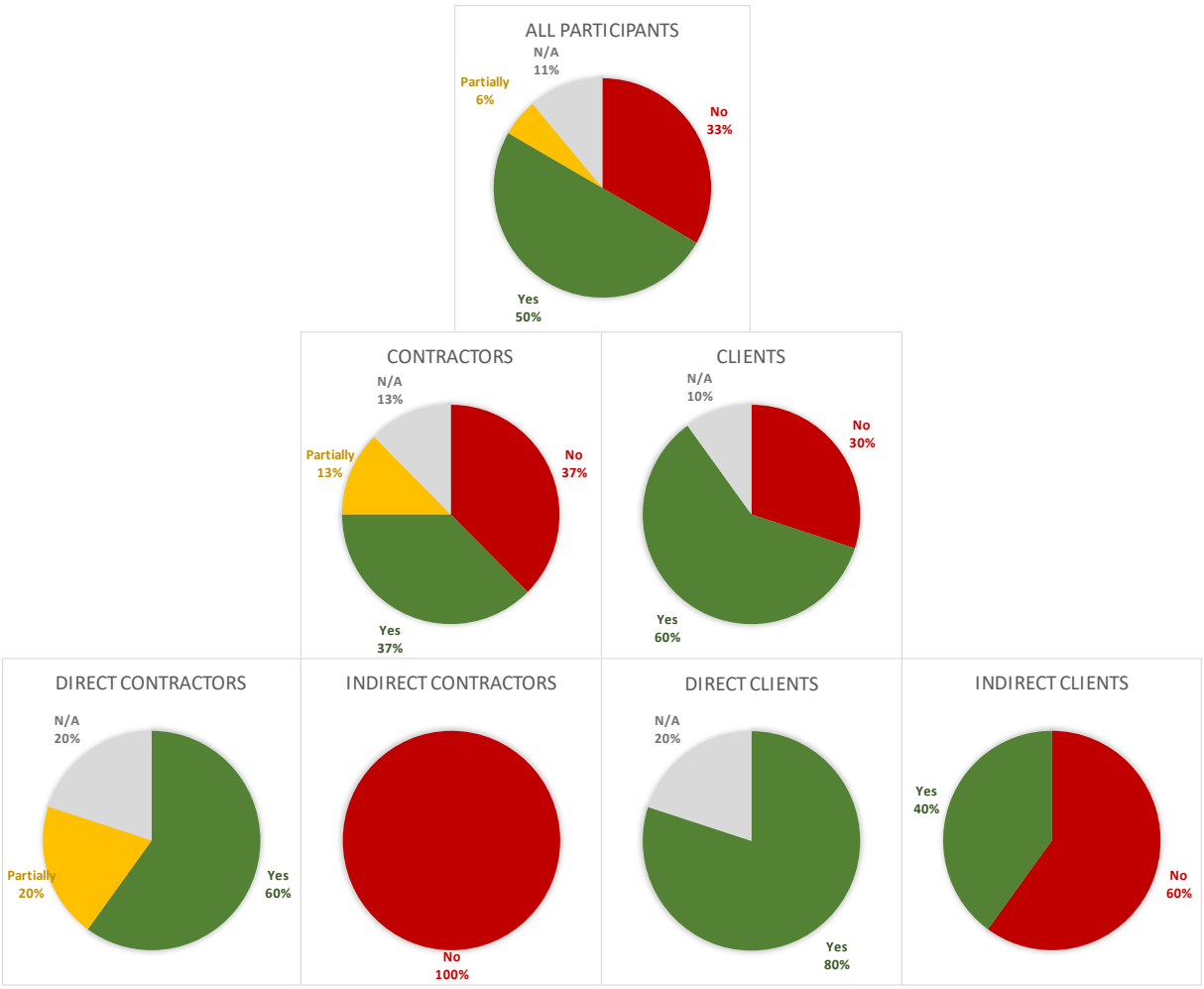

Figure 8-6: Results for "Do you want to participate in the decision making progress?"

As can be seen in Figure 8-6 most of the indirect clients and all of the indirect contractors do not have any interest in participating in the decision making progress. Those participants all argued that this is not part of their job. The indirect contractors consist of architectural construction and Qirion. Architectural construction builds assets and does not work on the maintenance of these assets. Qirion only works with high voltage assets and so do also not work on the compact secondary substations. One of the indirect clients mention that there is already a team working on this, other indirect clients give similar arguments.

The direct clients do want to participate. The asset manager construction, in contrast to Architectural construction who also only work on the construction of the asset and not on the maintenance of the asset, are interested in participating in the process. The direct contractors are interested as well. Operational personnel want to share the experience and knowledge they gain while maintaining the assets. The engineers and team leaders also want to participate with the goal to make maintenance cheaper and because they are responsible for the maintenance.

Figure 8-7: Results for "Do you think PVE is suitable method for participation in the decision making progress?"

Figure 8-7 shows that more than half of the participants think that PVE is a useful tool to support or facilitate participation in the decision-making progress. Only 11% of the participants do not think this will be a useful tool. The 22% of N/A votes are empty answers because the participants were not interested in participation and decided to not answer.

The participants that see PVE as a useful tool had the following arguments. On the contractor side, operational personnel sees PVE as an easy and quick way to share their experience and preferences. They noted that the PVE is much quicker and to the point than meetings are which they often found unproductive. The engineers and team leaders noted that it is a good way to build a database of experience and knowledge that is easy to access. On the client-side, the participants found it interesting that the PVE forces the participant to look at the consequences and impact of the decisions that are made, and that the PVE gives a quick way to look at this. They also noted that it is helpful to collect the views, opinions and wishes of different teams and different departments. It is also noted that to do this, the PVE would need to be as quick as possible to fill in.

Participants that do not see the PVE as a useful tool for participation in the decision-making process argued that the PVE gives a clinical view of reality and that it does not allow for the custom work and difference in individual cases while in reality, this is a large portion of the work. Another argument was that there is already a system in place with multidisciplinary teams where every department has a representative and thus there is no need for a PVE.

8.4 Different views on what a PVE should be

Three different observations were made on the use of PVE. The first observation is about the general use of PVE. Participants use PVE with two different goals. Some participants use the PVE to share their knowledge and experience while other participants use the PVE to gather information or data.

The second observation is that more than half of the indirect clients and all of the indirect contractors are not interested in participating in the decision-making process.

The last observation is that participants have different views on what the PVE should be and how it should be used. On the one end, participants want a quick and easy way to give their preferences or share their knowledge. On the other end, participants want a detailed and accurate mathematical model showing degradation and the effects of different types of maintenance. Interviews conducted in which the PVE was filled in showed a similar trend. Some participants asked detailed questions on how certain numbers are calculated and were very critical of the effects, continuously switching from the decision to result screen to see the effect that their choices had. Other participants filled in their decision and barely gave the result screen a look before moving on to the questions screen.

When this trend is further explored the following generalization can be made.

1. Operational personnel want an easy way to share their knowledge, experience and preferences.
2. Engineers and team leaders see the PVE as a way to build a knowledge base that can be easily accessed.
3. Asset managers see the method as a way to gain insight into the effects that different choices have and as a tool to aid in making decisions.
4. Policy advisors see PVE as a way to gather information from multiple departments and teams.

The following chapter will explore these different visions for PVE from the perspective of the participants, their function within Liander and how the information gathered in this chapter relates to the four different use cases found during this chapter.

9. Different perspectives

In this chapter, the observations of chapter 8 will be explored. These observations relate to two different levels of the use of PVE. First, the difference between gaining and sharing information via the PVE. And second, the different views within Liander on how PVE should be used and what it should be used for.

9.1 Information gathering or information sharing

During this experiment, all the participants, regardless of their function, participated in the same PVE. The original thought was that the PVE would be filled in by all departments and functions to gain insight into the different perspectives. However, some participants saw PVE as a possible tool to gain information while other participants saw PVE as a tool to share their experience and knowledge. The groups that saw PVE as a tool to gather information where the clients and the engineers/team leaders. The operational personnel wanted to use PVE as a tool to share their experience.

9.2 Different tasks create different needs

To explain why the different departments within Liander see different uses for PVE, a closer look needs to be taken at the workflow and interactions between the different departments and functions.

It starts with the policy advisor. The policy advisor creates a policy with the help of all the information that they have. This policy needs to be applicable to most cases and will need to cover risks from all sides. The asset managers will then be responsible for commissioning the plans to the contractors. The asset managers also monitor the budget and schedule. Within the direct contractors, the team/leaders and engineers prepare the work, and the operational personnel do the physical work. They work according to the policies that are set up by the policy advisor. When operational personnel encounter a situation in which they think following the policy is not desirable, they will first report their observations and experience to the engineers/team leaders. The engineers/team leaders will assess the situation and if necessary, contact the asset managers to ask for permission or advise. The asset managers and the contractors then talk about possible solutions while the asset manager also safeguards the budget. The asset manager evaluates the possible solutions and if the asset manager thinks a change needs to be made to the policy, they will present the situation and the change to the policy advisor. The policy advisor, if confined, will then update the policy. This flow of communication is illustrated in Figure 9-1:Flow of communication.

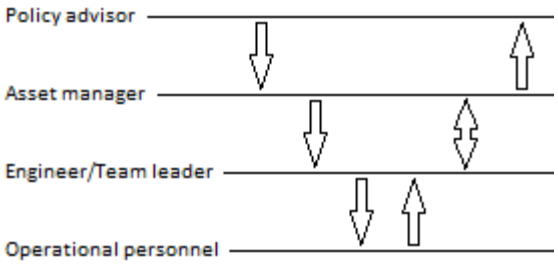

Figure 9-1:Flow of communication

The workflow shows that the discussion about deviating from the policy are being held between the asset managers and the contractors. The policy advisor who creates the policy is not present during these discussions around the details of specific situations.

Let's revisit the responsibilities and relevant tasks of each function. These are listed in Table 9-1.

	Responsibilities	Relevant tasks	Vision for PVE
Policy advisor	- Creating a general policy that is executable within budget	- Gather the necessary information to create a policy - Stay within budget - Cover risks from all sides	- Way to gather information from multiple departments and teams - Usable for all assets
Asset manager	- Commission work to contractors - Safeguard the budget	- Discuss possible solutions for exceptional situations with the engineers/team leaders	- Way to gain insight into the effects that different choices have and as a tool to aid in making decisions
Engineers/Team leaders	- Prepare and oversee work	- Create and discuss possible solutions for exceptional situations with the asset managers	- Way to build a knowledge base that can be easily accessed
Operational personnel	- Perform work	- Report situations where the policy is not desirable	- Easy way to share their knowledge, experience and preferences

Table 9-1: Responsibilities and relevant tasks of each function

When the relevant responsibilities and tasks for each function are compared to those of the other functions, it becomes clear why participants from different functions have a different vision for the PVE. First the policy advisor, they create a general policy. The policy advisor does not directly see the specific situations nor is the communicating party with the contractors who do see these situations. Instead, they have a more general view on the life cycle to cover off all general risks. Therefore, they do not deal with the small details and changes that operational personnel encounter. To create a policy the policy advisor needs a general view of all the parties that are relevant to the asset. With this information, they will create a policy that will fit most cases. Their vision for the PVE reflects this. They request a tool with which they can gather information from all parties. The PVE should be usable for all assets and cover all aspects, not only the architectural part, so a complete picture can be made. The policy advisor is given a budget within which the policy should be executable.

The asset managers are responsible for commissioning the work and safeguarding the budget. They are also the point of contact for the contractors to discuss other solutions for cases where the policy does not fit. The asset managers requested a tool that gives insight into the life cycle and the effects that these solutions or changes could have. A detailed model like this could help them in considering which solution is best suited for each case, making the risks and cost easily insightful. So, when they go into discussion with the contractor, they have a tool to analyse the solutions proposed by the contractors. This analysis will then help the asset managers in their discussion with the policy advisor about possible changes to the policy. The insight gained in long term effects, risks and costs, allows them to bring a more convincing and insightful proposal with relatively easy.

The engineers/team leaders are responsible for preparing the work for the operational personnel. Within the restrictions given to them by the clients (the policy), they make decisions on what maintenance needs to be done. They envisioned the PVE as a tool to build up a knowledge base on in-field experience that could easily be accessed later on. Making it a platform of experience that could help in finding the right solutions for each problem.

The operational personnel are responsible for performing the maintenance. They report their findings, and their opinion is asked by the engineers/team leaders when a new solution needs to be found. They feel that these meetings are often tedious and so they envision the PVE as a tool to share their experience easily and quickly.

This shows that each department has a different set of needs. Some are in need of sharing information and some are in need of gathering information. This information can also be very different depending on the department. The different goals and tasks create a different vision for a tool such as PVE which does not have a divined function within Liander. The different departments all found a different way of implementing PVE to help them with their own goals.

10. Comparing the results to the predictions

In section 4.4. six predictions were made. Prediction 1 through 5 were on the translation of benefits and drawbacks from a government-citizen environment. Prediction 6 made a prediction on the participants view on acceptable risk based on their function. This prediction was made with the help of the principal-agent theory to see if the survey gives logical results. This chapter will look back at these predictions and compare them to the experience of the participants and the results of the PVE and explore the findings.

10.1 There is no silent majority

The first prediction was on the participation of the silent majority.

Prediction 1: The benefits of participation of the silent majority will be less pronounced in the direct mandate than in the indirect mandate.

In section 4.4 it was argued that the flow of information was reversed in the company environment and is now mostly from agent to principal. The principal hires the agent for his specialized knowledge and the agent is expected to report on his work. Because of this, the principal can ask the agent to report and he is obligated to do so. Therefore, there should not be as much of a silent majority. However, the PVE could make this reporting easier.

During the survey, it was seen that while PVE was able to more easily reach a large number of employees, not all employees want to participate in a subject that they have very little to no involvement or interests in. Employees who do want to participate or work with the asset in question, are often already involved in one way or another. This shows that there was no silent majority of people that were relevant for the subject. However, some participants found the PVE easier to fill in compared to meetings that they currently partake in. So, prediction 1 is supported by the results.

10.2 Multiple parties seek local knowledge

The second prediction covers the transition of local knowledge, the transfer of information of experience between departments and functions.

Prediction 2: The benefits of transmission of local knowledge will be similar in the direct mandate as in the indirect mandate.

This prediction was made with the argument of the principal hiring agents for their specialized knowledge. And that this knowledge or experience on the subject might be transported to the principal through the PVE.

The transmission of local knowledge is also seen within the direct mandate. When looking at the requests for the type of implementation for PVE made by the participants it becomes clear that participants are looking for ways to easier collect information from other parties, mostly from their agents. And to store this information in a way that makes it accessible and usable to aid them in their own goals. While some participants see it as an opportunity to share information more easily. Where the indirect mandate saw one small party that needs information and one large party that shared information, the direct mandate has multiple smaller parties, most of which need information. The different parties all want different information which will require different/separate PVE forms. Prediction 2 is also supported in that PVE has benefits in transmitting local knowledge but with the side note that multiple parties are looking for information instead of one.

10.3 Feeling of inclusion not better than current methods

The third prediction is on the feeling of inclusion in the decision-making progress of the participants due to the PVE.

Prediction 3: The benefits of the strong feeling of inclusion in participants will be similar in the direct mandate as in the indirect mandate.

In chapter 1 it was shown that the participation of employees in the decision making progress is beneficial for both the company and the employee. Therefore, PVE should have a positive effect on the feeling of inclusion of the participants in a company environment.

The results here have similar reasons as the results of prediction 1. Parties that want to participate are often already participating in one form or another. The other parties that have little to no involvement in the assets that were the subject of the PVE also have no desire to be involved, arguing that it costs time and that it was not relevant for them. This does not mean that employee participation via PVE does not make the participants feel included, but that PVE has no added benefits in this regard compared to current methods of participation. Due to the lack of a silent majority, there was little to no benefit in this regard, so prediction 3 is not supported.

10.4 Agents learned little from the survey, but Principals did

The fourth prediction was based on the results of previous PVE cases. Arguing that it gave employees that are not part of the decision-making process more insight into why certain decisions are made.

Prediction 4: The benefits of awareness methodology will be similar with the direct mandate as in the indirect mandate.

39% of the participants said they gained more insight into the considerations involved in a life cycle design. Surprisingly, most participants that answered positively were direct clients. A department that was already closely involved. While contractors, who are further away from these decisions, mentioned that the PVE offered little to no new information. In contrast to the direct clients, the contractors also spend very little time during the interviews looking at the results. So, prediction 4 is supported. However, the benefits were seen in different groups than expected.

10.5 A more complex model led to an entry barrier

The fifth prediction was on the high entry barrier for certain groups.

Prediction 5: The drawback of a high entry barrier for certain groups of people will not be seen in the direct mandate.

The lack of people working for a company that do not know how to use the internet or a computer was the basis for this prediction.

The final survey was made in Excel, this program is more complex than the use of email and web pages on which the original prediction was based. It was observed that the more complex the results, questions, mathematical model or the graphs became, fewer participants were able to easily fill in the form. At a certain point, the survey becomes too complex to let all participants fill it in without explanation. Not all of the employees had a laptop with screen sharing software, making it more difficult to explain the survey. This resulted in an entry barrier. For the standard part of the PVE form (choosing the projects) where less complex graphs or results were shown, this was not observed. So, prediction 5 is also partly supported. For the standard PVE no drawback was seen, but for more complex PVE models an entry barrier began to arise for certain groups because an explanation was needed.

10.6 Agent a willing to take more risk

The sixth prediction is to verify that the survey results are valid by comparing the data with the predictions from agency theory.

Prediction 6: In the direct mandate, the agents will be more risk-averse than the principals

Due to environment and relation between the principal and the agent, agency theory predicts that the agents will be willing to take more risk than the principals in the company environment.

Chapter 7 showed that principal-agent relations were found on multiple levels. In total 4 principal-agent relations were found, listed in Table 7-1. In all these cases the agents on average took more risk than their principals. This means that all 4 principal agent relations support prediction 6.

11. Conclusion, discussion, and recommendations

This chapter will conclude the main research question, reflect on the research, discuss the main takeaways, implications, and the limitations of the research. At the end, recommendations will be given for future research and on the use of PVE in a business environment.

11.1 Conclusion

To answer the main research question:

"To what extend do the benefits of PVEs that are deployed in citizen to government context apply to the use of PVE within a company environment?"

In chapter 10 the predictions on benefits and drawbacks were explored in detail. The results showed that two of the four benefits found in previous PVE cases, the participation of the silent majority and feeling of inclusion among the participants, had no additional benefits over the current method of participation in decision making in the company environment. The benefits of awareness methodology and transmission of local knowledge were seen to translate during the survey. Potential for more transmission of local knowledge was identified. Finally, the entry barrier drawback was also found to a smaller extent, but only when the survey became more complex.

In short: benefits that related to communication and knowledge transmission translate to the company environment. However, the benefits that relate to the inclusion of more employees do not translate to the company environment. The drawback of the entry barrier translates to a lesser extent. Therefore, PVE as used in this experiment translates some but not all benefits and drawbacks from a government-citizen use case to a company use case.

The main reason that not all benefits translated is that in this company use case within Liander, all employees that are relevant to the decision-making process, or employees that are willing to spend time to be part of the decision making progress, are already participating. Whereas in previous use cases the government wanted information from all citizens, in the company environment multiple parties need information. Most of these parties need information from smaller groups of people, and they give another kind of information to a different party. There are more layers embedded in a company than in the government-citizen use case. These different layers have different interests, tasks, and expertise. This could also be true for a government-citizen use case, but in past PVE use cases, the survey had a subject that all participants were affected by or could relate to on a similar level. In the company environment, employees are very specialized and not all employees of a company are affected by, can relate to, or understand every subject. In other words, the specialised environment does not ideally lend itself to mass participation. As an example, the PVE executed in this survey tried to include as many employees as possible. To accomplish this, the PVE and the model included was not to complex nor was it to simplified. This led to participants from some departments skipping over information that was supposed to guide their decisions while participants from other departments found the model not realistic enough and wanted more complexity so the results would be more useable and realistic.

However, based on the feedback from participants and the experience of designing the PVE within a company environment, it is concluded that there are opportunities for PVE to fill different needs within the company environment. As discussed in chapter 9, each department has different responsibilities and tasks. They however all found envisioned a way to integrate PVE into their work so that they could benefit from it. An example of this is using PVE for simple gathering data from employees in the field, storing this data and being able to access it in the future. Another example was using PVE in combination with a simulation of a life cycle so that the results of different plans could be compared

and argued for or against. One department wanted to use the PVE as a less time-consuming replacement for meetings. The last example was gathering the preferences and opinions from different departments so they could all be included in the policy. The participants found opportunities in the ease in which information could be gathered from the source that they needed it.

This points to the need for different types and complexities of PVE. There is not one single way PVE can improve to work perfectly within a company environment. The environment varies too much. The departments should be able to take the parts of PVE that suit their needs and expand upon this. As well as being able to integrate PVE into their workflow so they can make their PVE survey a good fit for the specific environment that they are in.

11.2 Main takeaways and implications

It was found that two of the four benefits translated from a government-citizen environment PVE to a company environment PVE. The main reason for this is the specialized knowledge of the employees. In chapter 4 the literature showed that the programmability of the agents task is an important factor in the information asymmetry between the employee and employer. Because Liander employees are hired for their knowledge the direction of information is reversed. This is in contrast with the government-citizen use case where information asymmetry was shown to be in the principal's favour. Instead of one-party needing an answer to one question from thousands of citizens, many small groups of employees have many different questions to other groups of employees. However, the drawback found is also less present in the company PVE, if the PVE survey does not become too complex. The results of the PVE survey have been validated by comparing them to results predicted by agency theory. This showed that the PVE survey delivered valid results. There were also more principle-agent relations found then originally predicted with the help of agency theory.

The increased complexity of this PVE compared to previous PVE cases can be explained by the detailed/operational level on which this PVE survey was executed. Previous PVE surveys as explored in chapter 3 focused on the use of PVE for general/strategy decisions. The PVE in this survey was used to explore details in the execution of an already existing strategy. Due to this context the PVE gets more complex and people with knowledge on these non-generalisable parts are needed. This might be comparable to the government asking a neighbourhood about the safety problems of a specific road crossing close to a school. There are few people that have knowledge of the situation and it might not be generalisable to other crossings due to the specific situation. A PVE survey in such a scenario would not have the same size of a silent majority as the thousands of people that voted in the previous PVE surveys. Depending on the amount of people affected, other methods such as calling the neighbour or going door to door to ask for their opinion would lead to the same amount of people participating without the effort of creating a PVE survey. Going to a more specific situation in government-citizen PVE for this comparison would however not solve the problem of the entry barrier for people that are not capable of using the internet. Which would suggest that the drawback of the entry barrier in a company environment would be less present even if the PVE surveys would be of a similar operational/strategic level.

When participants were asked about their view on PVE and what they would change, all participants saw benefits in using PVE in their work. Participants proposed changes to PVE so that it could help them with the tasks they are working on or helps them to solve a problem that they have. These changes varied leading to simple but also very complex ways to use or design PVE surveys.

These findings imply that PVE is suitable for use within a company environment. Not all benefits would apply but the results are valid. The results also provided new insight into principal-agent relations, showing that agency theory could be applicable on more layers within company structure than

previously used. Most of the changes that participants suggested would not be possible with the existing PVE tooling. This could limit companies their willingness to implement PVE within their workflow.

11.3 Limitations

The research done during this thesis should be viewed as exploratory research. PVE is a novel method and was taken out of the environment it was designed for, to explore how well it would fit a company environment. The research in this thesis was done at Liander. No other company environments were used to test the predictions or to verify the results. The company environment within Liander might not be reflective of all other company environments nor will this PVE subject be reflective of all other subjects that PVE could be used for within a company environment. Therefore, as with other exploratory research, the results of this thesis should not be applied to other environments without any further consideration. It serves as an indication as to what can be, and it gives a first glance at the possibilities of PVE within a company environment and the obstacles that will have to be solved.

It is also important to note that a limited number of 18 employees participated in the PVE survey. The results are therefore not significant enough to draw any conclusions with certainty based on the data provided by the participants.

Liander does operate more like a private company when compared to the government-citizen relation from previous cases, but it should be taken into consideration that they operate in a regulated environment with limited competition when compared to companies in the open market. This could influence the priorities of the company or the decision-making process.

This does not mean that there is no value for the results found in this thesis outside of Liander. The lessons learned on how a company environment can differ compared to a government-citizen use case is certainly interesting. The translation of the benefits and drawbacks give an indication as to what is possible within company environments.

11.4 Recommendations for future research

The usability of PVE within company environments has shown promise in this exploratory research. To further explore this, more cases could be executed to gain more information on the possible use cases for companies. This PVE survey was executed on a very detailed/operational level when compared to previous PVE cases, which were on a more general/strategic level. Exploring more cases can give a better picture if PVE is also suited for these operational level surveys or if this was a consequence of the context of this thesis. PVE could also be tested within a company environment in a different context. For instance, the relation between the board of a company and the company's shareholder could more closely mimic the government-citizen relation and is also worth looking exploring.

Further research into how a PVE tool can be designed to allow companies to adapt the PVE to their needs. Participants mentioned functions such as incorporating more complex models/simulations, collecting, and retrieving the data. Currently, the PVE tool does not allow for any form of calculations of functions that would be required for this purpose. Interacting with the current database of the companies for uploading and downloading data to and from the PVE could also be helpful for the function of the PVE envisioned by the participants. As an example, the models/simulations same calculations would often be made on different assets/data. To make this easier a PVE tool can be designed to be more easily integrated with current databases and workflows. The use of for instance an API could be considered.

Further research can be done into the use of PVE as a replacement for meetings. Participants with functions that mostly participated in meetings to contribute in the form of a report saw PVE as a

method of replacing meetings that they found long and boring. Research into the viability of PVE for this function could help identify an increase in the productivity of these employees.

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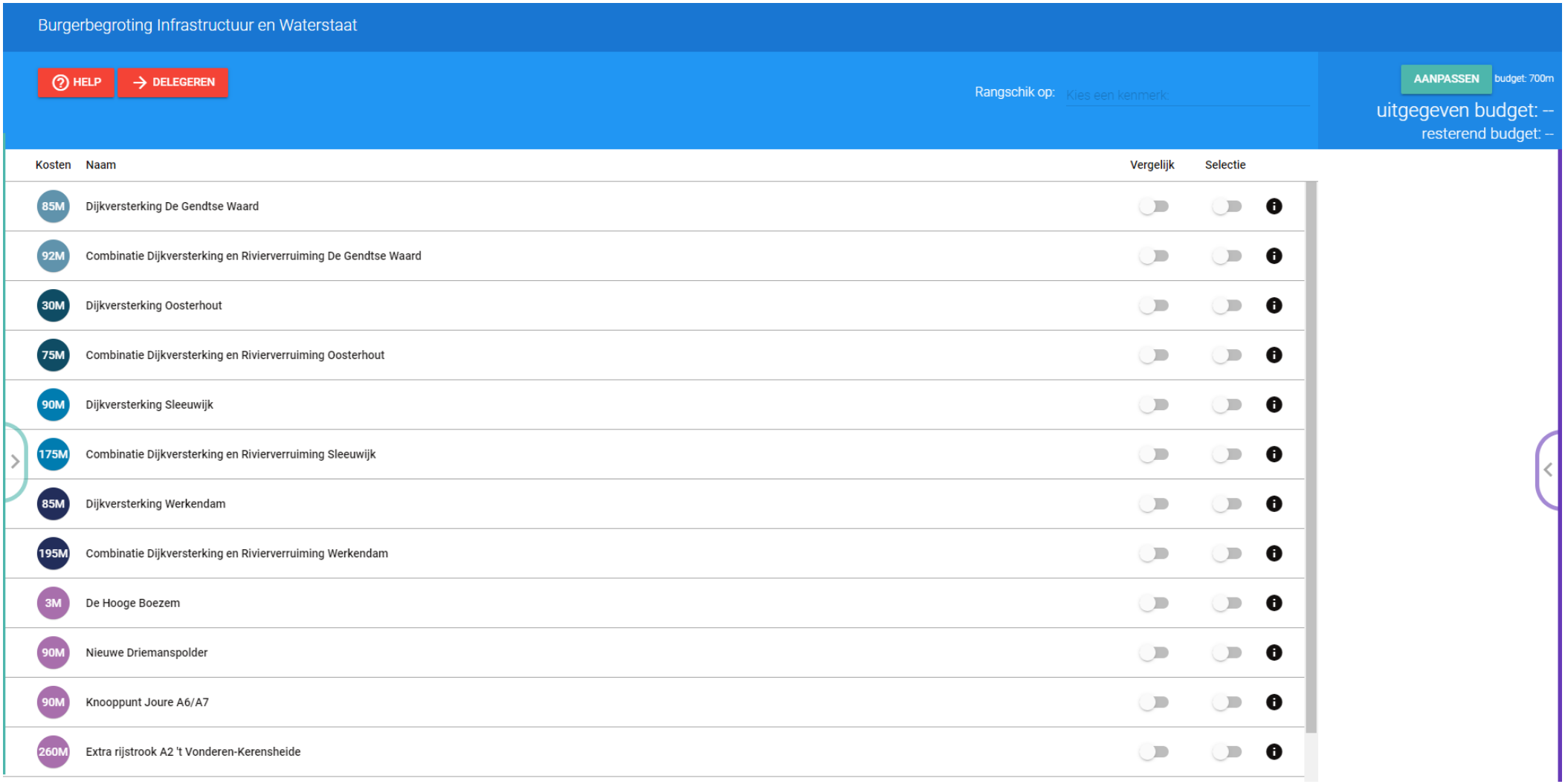
Appendix

A: Online PVE tool



B: Kathleen M. Eisenhardt's 10 propositions

Proposition 1: When the contract between the principal and agent is outcome-based, the agent is more likely to behave in the interest of the principal.

Proposition 2: When the principal has information to verify agent behaviour, the agent is more likely to behave in the interest of the principal.

Proposition 3: Information systems are positively related to behaviour-based contracts and negatively related to outcome-based contracts.

Proposition 4: Outcome uncertainty is positively related to behaviour-based contracts and negatively to outcome based-contracts.

Proposition 5: The risk aversion of the agent is positively related to behaviour based contracts and negatively related to outcome-based contracts.

Proposition 6: The risk aversion of the principal is negatively related to behaviour-based contracts and positively related to outcome based contracts.

Proposition 7: The goal conflict between principal and agent is negatively related to behaviour-based contracts and positively related to outcome-based contracts.

Proposition 8: Task programmability is positively related to behaviour-based contracts and negatively related to outcome-based contracts.

Proposition 9: Outcome measurability is negatively related to behaviour-based contracts and positively related to outcome-based contracts.

Proposition 10: The length of the agency relationship is positively related to behaviour-based contracts and negatively related to outcome based-contracts.

C: Risk matrix

Original risk matrix

Risicomatrix Liander Assetmanagement											
							Kans van voorkomen (per bedrijfswaarde)				
Impact op bedrijfswaarden							Mogelijk	Waarschijnlijk	Geregeld	Jaarlijks	Maandelijks
							Wel eens van gehoord in de industrie	Meerdere malen gebeurd in de industrie / wel eens gebeurd binnen Liander	Meerdere malen gebeurd binnen Liander	Eén tot enkele malen per jaar binnen Liander	Eén tot enkele malen per maand binnen Liander
Categorie	**Veiligheid**	**Kwaliteit van levering**	**Klant & Imago**	**Wet- & regelgeving**	**Financieel**	**Duurzaamheid**	**Minder dan 1 keer per 100 jaar**	**1 keer per 100 jaar tot 1 keer per 10 jaar**	**1 keer per 10 jaar tot 1 keer per jaar**	**1 tot 10 keer per jaar**	**Meer dan 10 keer per jaar**
Rampzalig	Meerdere doden	≥ 10.000.000 vbm	Grootschalige zichtbaarheid in het publieke domein van lange duur.	Intrekking vergunning; Opeenstapeling van boetes; Strafzaak tegen directielid met gevangenisstraf tot gevolg; Structureel conflict met autoriteit(en)	Schade groter dan 10M euro	Uitstoot groter dan 500 kton CO_2	**M**	**H**	**ZH**	**ZH**	**ZH**
Ernstig	Ongevallen met dodelijke afloop of zeer ernstig letsel	1.000.000 tot 10.000.000 vbm	Grootschalige zichtbaarheid in het publieke domein van korte duur	Bestuurlijke boete en/of stille curator; Boete categorie 4, 5 en 6; Strafzaak tegen directielid (ongeacht veroordeling); Incidenteel conflict met autoriteit(en)	Schade van 1M tot 10M euro	Uitstoot van 50 tot 500 kton CO_2	**L**	**M**	**H**	**ZH**	**ZH**
Hevig	Ongevallen met ernstig letsel met verzuim	100.000 tot 1.000.000 vbm	Kleinschalige zichtbaarheid in het publieke domein van lange duur	Last onder dwangsom; Boete categorie 2 en 3; Rechtszaak namens meer dan 5000 klanten; Opeenstapeling problemen met autoriteit(en)	Schade van 100k tot 1M euro	Uitstoot van 5 tot 50 kton CO_2	**N**	**L**	**M**	**H**	**ZH**
Matig	Ongevallen met letsel met verzuim	10.000 tot 100.000 vbm	Kleinschalige zichtbaarheid in het publieke domein van korte duur	Bindende aanwijzing; Boete categorie 1; Rechtszaak namens meer dan 500 klanten; Incidenteel probleem met autoriteit(en)	Schade van 10k tot 100k euro	Uitstoot van 0,5 tot 5 kton CO_2	**N**	**N**	**L**	**M**	**H**
Klein	Bijna ongevallen, ongevallen met gering letsel / EHBO zonder verzuim	<10.000 vbm	Weinig tot geen zichtbaarheid in het publieke domein	Waarschuwing; Rechtszaak namens meer dan 50 klanten; Verschil van inzicht met autoriteit(en)	Schade kleiner dan 10.000 euro	Uitstoot kleiner 0,5 kton CO_2	**N**	**N**	**N**	**L**	**M**

Pavement condition codes mapped in the risk matrix

Bestrating

Veiligheid	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Meerdere doden					
Ongevallen met dodelijke aflop of zeer ernstig letsel					
ongevallen met ernstig letsel met verzuim		4	5	6	
ongevallen met letsel met verzuim	2	3			
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	1				

Kwaliteit van levering	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
≥ 10,000,000 vbm					
1,000,000 tot 10,000,000 vbm					
100,000 tot 1,000,000 vbm			nvt		
10,000 tot 100,000 vbm					
< 10,000 vbm					

Financieel	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Schade groter dan 10M euro					
Schade van 1M tot 10M euro					
Schade van 100k tot 1M euro			nvt		
Schade van 10k tot 100k euro					
schade kleiner dan 10,000 euro					

Hinge and locks condition codes mapped in the risk matrix

Hang en sluitwerk

Veiligheid	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Meerdere doden			6		
Ongevallen met dodelijke aflop of zeer ernstig letsel			5		
ongevallen met ernstig letsel met verzuim		4			
ongevallen met letsel met verzuim		3			
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	1	2			

Kwaliteit van levering	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
≥ 10,000,000 vbm					
1,000,000 tot 10,000,000 vbm					
100,000 tot 1,000,000 vbm					
10,000 tot 100,000 vbm					
< 10,000 vbm	1,2	3	4	5	6

Financieel	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Schade groter dan 10M euro					
Schade van 1M tot 10M euro					
Schade van 100k tot 1M euro				5	6
Schade van 10k tot 100k euro		1,2	3,4		
schade kleiner dan 10,000 euro					

Roof construction condition codes mapped in the risk matrix

Dakconstructie

Veiligheid	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Meerdere doden					
Ongevallen met dodelijke aflop of zeer ernstig letsel					
ongevallen met ernstig letsel met verzuim		4	5	6	
ongevallen met letsel met verzuim	2	3			
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	1				

Kwaliteit van levering	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
≥ 10,000,000 vbm					
1,000,000 tot 10,000,000 vbm					
100,000 tot 1,000,000 vbm					
10,000 tot 100,000 vbm			3	4	5,6
< 10,000 vbm		1,2			

Financieel	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Schade groter dan 10M euro					
Schade van 1M tot 10M euro					
Schade van 100k tot 1M euro					
Schade van 10k tot 100k euro		3	4	5	6
schade kleiner dan 10,000 euro	1,2				

Door condition codes mapped in the risk matrix

Deur

Veiligheid	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Meerdere doden			6		
Ongevallen met dodelijke aflop of zeer ernstig letsel			5		
ongevallen met ernstig letsel met verzuim		4			
ongevallen met letsel met verzuim		3			
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	1	2			

Kwaliteit van levering	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
≥ 10,000,000 vbm					
1,000,000 tot 10,000,000 vbm					
100,000 tot 1,000,000 vbm					
10,000 tot 100,000 vbm					
< 10,000 vbm	1,2	3	4	5	6

Financieel	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Schade groter dan 10M euro					
Schade van 1M tot 10M euro					
Schade van 100k tot 1M euro				5	6
Schade van 10k tot 100k euro		1,2	3,4		
schade kleiner dan 10,000 euro					

Wall condition codes mapped in risk matrix

Wand

Veiligheid	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Meerdere doden					
Ongevallen met dodelijke aflop of zeer ernstig letsel	4	5	6		
ongevallen met ernstig letsel met verzuim	3				
ongevallen met letsel met verzuim	2				
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	1				

Kwaliteit van levering	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
≥ 10,000,000 vbm					
1,000,000 tot 10,000,000 vbm					
100,000 tot 1,000,000 vbm				5	6
10,000 tot 100,000 vbm	2	3	4		
< 10,000 vbm	1				

Financieel	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Schade groter dan 10M euro					
Schade van 1M tot 10M euro					
Schade van 100k tot 1M euro		4	5	6	
Schade van 10k tot 100k euro		3			
schade kleiner dan 10,000 euro	1,2				

cellar condition codes mapped in the risk matrix

Kelder

Veiligheid	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Meerdere doden					
Ongevallen met dodelijke aflop of zeer ernstig letsel			5	6	
ongevallen met ernstig letsel met verzuim		4			
ongevallen met letsel met verzuim	3				
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	1,2				

Kwaliteit van levering	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
≥ 10,000,000 vbm					
1,000,000 tot 10,000,000 vbm					
100,000 tot 1,000,000 vbm					6
10,000 tot 100,000 vbm				4	5
< 10,000 vbm	1	2	3		

Financieel	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Schade groter dan 10M euro					
Schade van 1M tot 10M euro					
Schade van 100k tot 1M euro					
Schade van 10k tot 100k euro					
schade kleiner dan 10,000 euro	1,2	3	4	5	6

Grating condition codes mapped in the risk matrix

Rooster

Veiligheid	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Meerdere doden		6			
Ongevallen met dodelijke aflop of zeer ernstig letsel		5			
ongevallen met ernstig letsel met verzuim		3,4			
ongevallen met letsel met verzuim	2				
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	1				

Kwaliteit van levering	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
≥ 10,000,000 vbm					
1,000,000 tot 10,000,000 vbm					
100,000 tot 1,000,000 vbm					
10,000 tot 100,000 vbm				5	6
< 10,000 vbm	1,2	3	4		

Financieel	minder dan 1 keer per 100 jaar	1 keer per 100 jaar tot 1 keer per 10 jaar	1keer per 10 jaar tot 1 keer per jaar	1 tot 10 keer per jaar	meer dan 10 keer per jaar
Schade groter dan 10M euro					
Schade van 1M tot 10M euro					
Schade van 100k tot 1M euro		4	5	6	
Schade van 10k tot 100k euro		3			
schade kleiner dan 10,000 euro	1	2			

D: post survey questions

	Vragen over de gemaakte keuze	**Questions about the choices made**
1.	Vind je de resultaten een logisch gevolg van de keuzes die je gemaakt hebt?	Do you think the results are a logical consequence of the choices you have made?
2.	Zou je in het echt andere keuzen gemaakt hebben? Welke, en waarom?	Would you have made other choices in real life? If so which, and why?
3.	Je vindt veiligheid minder/meer belangrijk dan Kwaliteit van levering. Klopt dit? Kan je deze keuze onderbouwen?	You think safety is more/less important than the quality of delivery. Is this correct? Can you substantiate this choice?
4.	Je vindt financieel minder/meer belangrijk dan veiligheid. Klopt dit? Kan je deze keuze onderbouwen?	You think finances is more/less important than safety. Is this correct? Can you substantiate this choice?
5.	Je vindt kwaliteit van levering minder/meer belangrijk dan financieel. Klopt dit? Kan je deze keuze onderbouwen?	You think the quality of delivery is more/less important than finances. Is this correct? Can you substantiate this choice?
6.1.	Bij bestrating heb je gekozen om op conditie x actie te ondernemen en om x keer te herstellen voor vervanging. Waarom heb je deze keuze gemaakt?	At pavement you have chosen to take action on condition x and to repair x times before replacing. Why did you make this decision?
6.2.	Bij hang en sluitwerk heb je gekozen om op conditie x actie te ondernemen en om x keer te herstellen voor vervanging. Waarom heb je deze keuze gemaakt?	At hinge and locks you have chosen to take action on condition x and to repair x times before replacing. Why did you make this decision?
6.3.	Bij de deur heb je gekozen om op conditie x actie te ondernemen en om x keer te herstellen voor vervanging. Waarom heb je deze keuze gemaakt?	At door you have chosen to take action on condition x and to repair x times before replacing. Why did you make this decision?
6.4.	Bij dakconstructie heb je gekozen om op conditie x actie te ondernemen en om x keer te herstellen voor vervanging. Waarom heb je deze keuze gemaakt?	At roof construction you have chosen to take action on condition x and to repair x times before replacing. Why did you make this decision?
6.5.	Bij wand heb je gekozen om op conditie x actie te ondernemen en om x keer te herstellen voor vervanging. Waarom heb je deze keuze gemaakt?	At walls you have chosen to take action on condition x and to repair x times before replacing. Why did you make this decision?
6.6.	Bij kelder heb je gekozen om op conditie x actie te ondernemen en om x keer te herstellen voor vervanging. Waarom heb je deze keuze gemaakt?	At cellar you have chosen to take action on condition x and to repair x times before replacing. Why did you make this decision?
6.7.	Bij rooster heb je gekozen om op conditie x actie te ondernemen en om x keer te herstellen voor vervanging. Waarom heb je deze keuze gemaakt?	At grating you have chosen to take action on condition x and to repair x times before replacing. Why did you make this decision?
7.	Voor welke afdeling werk je?	For which department do you work?

	Vragen over PWE als participatie methode	**Questions on PVE as a participation method**
1.	Vind je de PWE begrijpelijk en makkelijk/snel in te vullen?	Do you find the PVE comprehensible and easy/quick to complete?
2.	Vind je de hoeveelheid informatie goed, of had je behoefte aan meer of minder details?	Do you like the amount of information, or do you want more/fewer details?
3.	Heeft de PWE je meer inzicht gegeven in de afwegingen die gemaakt moeten worden bij het ontwerpen van levensloop plan?	Has the PVE given you more insight into the considerations involved in designing a life course plan?
4.	Is dit iets waar je behoefte aan hebt? Zo ja, denk je dat PWE een gischikte methode hiervoor kan zijn? Waarom wel of niet?	Is this something you want? If so, do you think PVE could be a suitable method for this? Why/why not?
5.	Vind je onderhoud van een compactstation een geschikt onderwerp voor een PWE? Waarom wel of niet?	Do you find maintenance of a compact secondary substation a suitable subject for a PVE? Why/why not?
6.	Heb je behoefte aan participatie in de besluitvorming? Waarom wel of niet?	Do you want to participate in decision making? Why/why not?
7.	Zo ja, vind je PWE een geschikte methode hiervoor? Waarom niet/wel?	If so, do you think PVE is a suitable method for this? Why/why not?
8.	Zijn er nog verbeteringen voor PWE die je graag zou willen zien?	Are there any improvements for PVE you would like to see?

E: PVE survey excel

Choice screen

PWE Compactstation

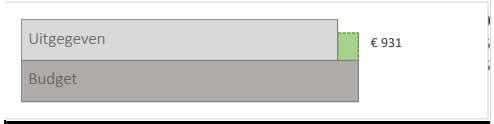
Budget	€	15.000
Uitgegeven	€	14.069
Resterend	€	931

Conditiescore	Omschrijving	Toelichting
1	Uitstekende conditie	Incidenteel geringe gebreken
2	Goede conditie	Incidenteel beginnende veroudering
3	Redelijke conditie	Plaatselijk zichtbare veroudering, functievervulling van bouw- en installatiedelen niet in gevaar
4	Matige conditie	Functievervulling van bouw- en installatiedelen incidenteel in gevaar
5	Slechte conditie	De veroudering is onomkeerbaar
6	Zeer slechte conditie	Technisch rijp voor de sloop

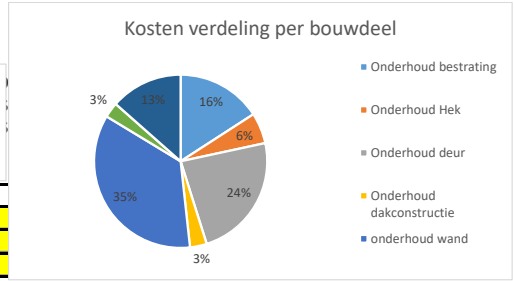
Bestrating	**€**	**2.232**	
Herstellen of vervangen als conditie de volgende staat bereikt:		4	Verslechtering van de bestrating leid tot scheefliggende, lossen en gebroken tegels waar mensen over kunnen struikelen. Herstel is het opnieuw rechtleggen van de tegels, en bij vervanging zullen alle tegels worden vervangen.
Aantal keer herstellen voor vervanging		1	
Hang en sluitwerk	**€**	**810**	
Herstellen of vervangen als conditie de volgende staat bereikt:		4	Slechte conditie kan leiden tot het open staan van een deur. Dit geeft onbevoegde toegang tot de ruimte met als mogelijk gevolg elektrocutie. Dit kan ook leiden tot onderbreking van stroom. of een schade claim.
Aantal keer herstellen voor vervanging		2	
Deur	**€**	**3.308**	
Herstellen of vervangen als conditie de volgende staat bereikt:		4	Slechte conditie kan leiden tot het open staan van een deur. Dit geeft onbevoegde toegang tot de ruimte met als mogelijk gevolg elektrocutie. Dit kan ook leiden tot onderbreking van stroom. of een schade claim.
Aantal keer herstellen voor vervanging		1	
Dakconstructie	**€**	**440**	
Herstellen of vervangen als conditie de volgende staat bereikt:		4	Bij verslechtering van het dak is er lekkage mogelijk in de ruimte. Hierdoor kan de installatie uitvallen, elektrocutie optreden of zelfs een explosie plaatsvinden.
Aantal keer herstellen voor vervanging		2	
Wand	**€**	**4.980**	
Herstellen of vervangen als conditie de volgende staat bereikt:		4	Verval heeft als gevolg dat er gaten in wand optreden. Hier kunnen mensen dingen doorheen steken. Ook kan dit in mindere maten leiden tot lekkage.
Aantal keer herstellen voor vervanging		1	
Kelder	**€**	**400**	
Herstellen of vervangen als conditie de volgende staat bereikt:		4	Bij een slechte conditie van de kelder kan er verzakkingen optreden, waardoor kabels losgetrokken worden met als mogelijk gevolg elektrocutie voor de monteur.
Aantal keer herstellen voor vervanging		2	
Rooster	**€**	**1.898**	
Herstellen of vervangen als conditie de volgende staat bereikt:		4	Bij verval van de roosters kan er een ook een mogelijkheid ontstaan dat er mensen toegang krijgen tot de ruimte, met als mogelijk gevolgen elektrocuties, uitval en schade claims.
Aantal keer herstellen voor vervanging		1	

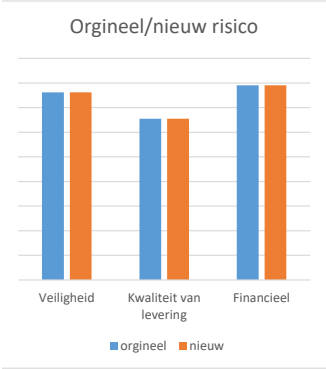
Result screen

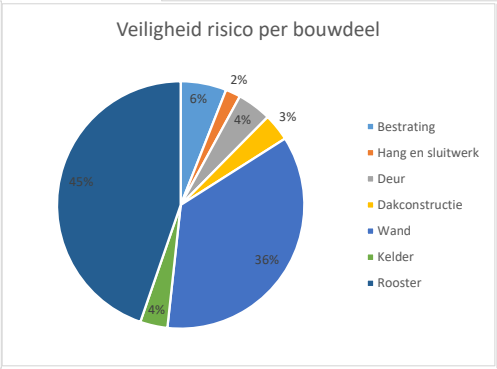
Resultaten

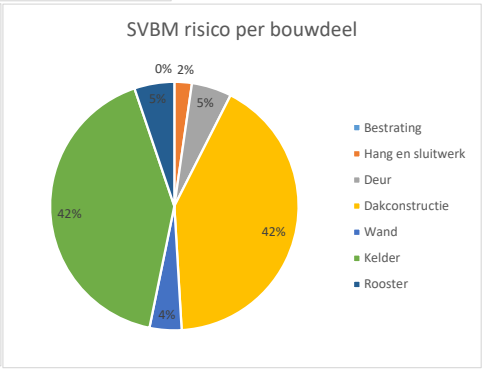


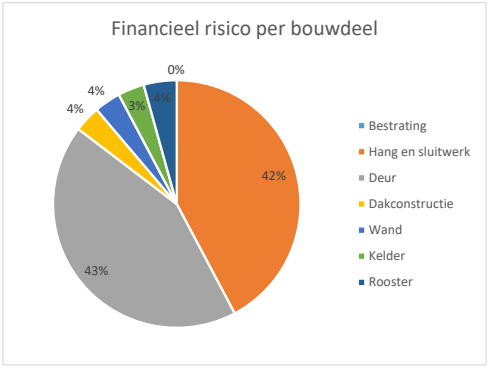
Risico over de hele compactstation populatie	
Veiligheid risico	**Laag**
Kwaliteit van levering risico	**Laag**
Financieel risico	**Laag**









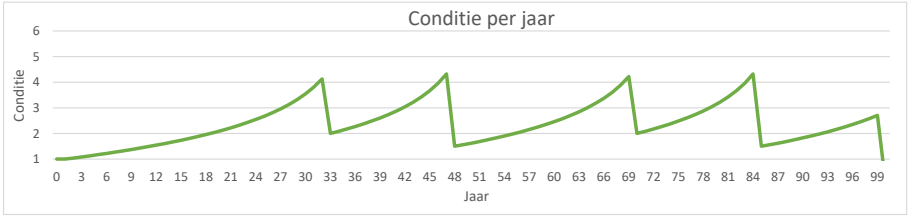


Gedetaileerde resultaten

Bestrating	**Totaal kosten:**	**€ 2.232**
	aantal	Totaal
Aantal keer herstel (€328 per keer)	2	€ 657
Aantal keer vervanging gedaan (€788 per keer)	2	€ 1.576

Gemiddeld risico veiligheid	**Nihil**
Gemiddeld risico kwaliteit van levering	**Nihil**
Gemiddeld risico financieel	**Nihil**

Aantal jaar op risico niveau			
	V	**KvL**	**F**
ZH			
H			
M			
L	4		
N	96		



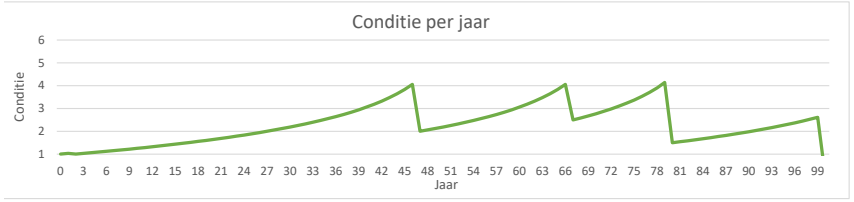
Totaal verwacht risico over 100 jaar bestrating			
Veiligheid		**SVBM**	**Financieel**
Meerdere doden	0,0	-	€ -
Ongevallen met dodelijke afloop of zeer ernstig letsel	0,0	**Situatie beschrijving**	
ongevallen met ernstig letsel met verzuim	0,4	Verslechtering van de bestrating leid tot scheefliggende, lossen en gebroken tegels waar mensen over kunnen struikelen. Herstel is het opnieuw rechtleggen van de tegels, en bij vervanging zullen alle tegels worden vervangen.	
ongevallen met letsel met verzuim	0,0		
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	0,0		
Totaal punten	**228.266**		

Hang en sluitwerk

Totaal kosten:	€	810
aantal	Totaal	
Aantal keer herstel (€130 per keer)	2	€ 260
Aantal keer vervanging gedaan (€550 per keer)	1	€ 550

Gemiddeld risico veiligheid	Nihil
Gemiddeld risico kwaliteit van levering	Nihil
Gemiddeld risico financieel	Laag

Aantal jaar op risico niveau			
	V	KvL	F
ZH			
H			
M			3
L			18
N	100	100	79



Totaal verwacht risico over 100 jaar hang en sluitwerk			
Veiligheid		SVBM	Financieel
Meerdere doden	0,0	74.571	€ 1.669.730
Ongevallen met dodelijke afloop of zeer ernstig letsel	0,0		
ongevallen met ernstig letsel met verzuim	0,0		
ongevallen met letsel met verzuim	0,4		
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	0,0		
Totaal punten	74.571		

Situatie beschrijving

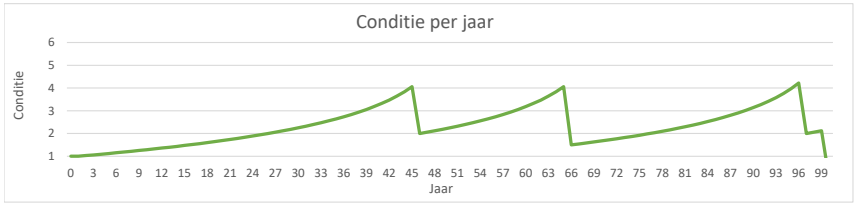
Slechte conditie kan leiden tot het open staan van een deur. Dit geeft onbevoegde toegang tot de ruimte met als mogelijk gevolg elektrocutie. Dit kan ook leiden tot onderbreking van stroom. of een schade claim.

Deur

Totaal kosten:	€	3.308
aantal	Totaal	
Aantal keer herstel (€326 per keer)	2	€ 652
Aantal keer vervanging gedaan (€2656 per keer)	1	€ 2.656

Gemiddeld risico veiligheid	Nihil
Gemiddeld risico kwaliteit van levering	Nihil
Gemiddeld risico financieel	Laag

Aantal jaar op risico niveau			
	V	KvL	F
ZH			
H			
M			3
L	3	3	19
N	97	97	78



Totaal verwacht risico over 100 jaar deur			
Veiligheid		SVBM	Financieel
Meerdere doden	0,0	170.361	€ 1.703.611
Ongevallen met dodelijke afloop of zeer ernstig letsel	0,0		
ongevallen met ernstig letsel met verzuim	0,0		
ongevallen met letsel met verzuim	0,4		
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	0,0		
Totaal punten	170.361		

Situatie beschrijving

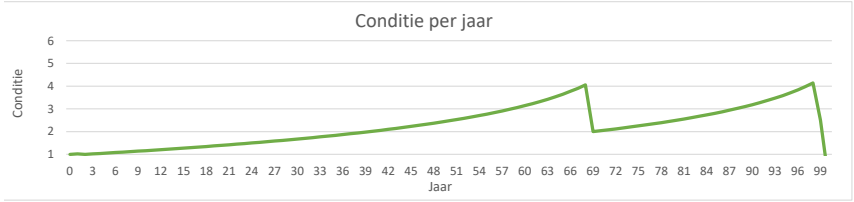
Slechte conditie kan leiden tot het open staan van een deur. Dit geeft onbevoegde toegang tot de ruimte met als mogelijk gevolg elektrocutie. Dit kan ook leiden tot onderbreking van stroom. of een schade claim.

Dakconstructie

Totaal kosten:	€	440
aantal	Totaal	
Aantal keer herstel (€220 per keer)	2	€ 440
Aantal keer vervanging gedaan (€900 per keer)	0	€ -

Gemiddeld risico veiligheid	Nihil
Gemiddeld risico kwaliteit van levering	Laag
Gemiddeld risico financieel	Nihil

Aantal jaar op risico niveau			
	V	KvL	F
ZH			
H			
M		2	
L	2	19	2
N	98	79	98



Totaal verwacht risico over 100 jaar dakconstructie			
Veiligheid		SVBM	Financieel
Meerdere doden	0,0	1.361.725	€ 136.173
Ongevallen met dodelijke afloop of zeer ernstig letsel	0,0		
ongevallen met ernstig letsel met verzuim	0,0		
ongevallen met letsel met verzuim	0,1		
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	0,3		
Totaal punten	136.173		

Situatie beschrijving

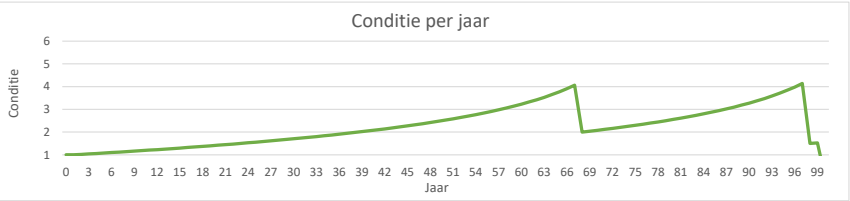
Bij verslechtering van het dak is er lekkage mogelijk in de ruimte. Hierdoor kan de installatie uitvallen, elektrocutie optreden of zelfs een explosie plaatsvinden.

Wand

Totaal kosten:	€ 4.980
aantal	Totaal
Aantal keer herstel (€600 per keer)	1 € 600
Aantal keer vervanging gedaan (€4,380 per keer)	1 € 4.380

Gemiddeld risico veiligheid	Laag
Gemiddeld risico kwaliteit van levering	Nihil
Gemiddeld risico financieel	Nihil

Aantal jaar op risico niveau			
	V	KvL	F
ZH			
H			
M	2		
L	19	2	2
N	79	98	98



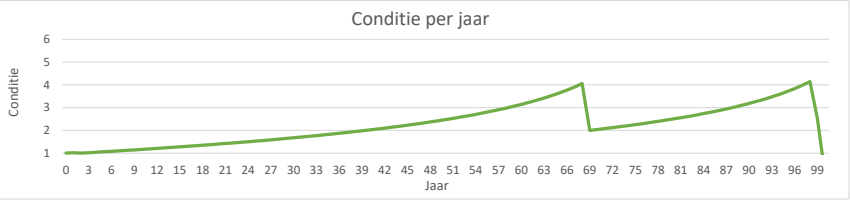
Totaal verwacht risico over 100 jaar wand			
Veiligheid		SVBM	Financieel
Meerdere doden	0,0	136.173	€ 136.173
Ongevallen met dodelijke afloop of zeer ernstig letsel	0,0	Situatie beschrijving	
ongevallen met ernstig letsel met verzuim	0,0		
ongevallen met letsel met verzuim	0,0	Verval heeft als gevolg dat er gaten in wand optreden. Hier kunnen mensen dingen doorheen steken. Ook kan dit in mindere maten leiden tot lekkage.	
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	0,4		
Totaal punten	1.361.725		

Kelder

Totaal kosten:	€ 400
aantal	Totaal
Aantal keer herstel (€200 per keer)	2 € 400
Aantal keer vervanging gedaan (€1.460 per keer)	0 € -

Gemiddeld risico veiligheid	Nihil
Gemiddeld risico kwaliteit van levering	Laag
Gemiddeld risico financieel	Nihil

Aantal jaar op risico niveau			
	V	KvL	F
ZH			
H			
M		2	
L	2	19	2
N	98	79	98



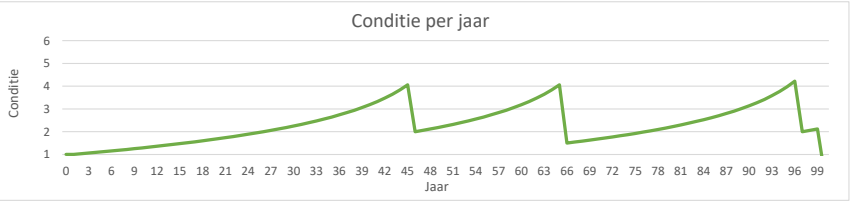
Totaal verwacht risico over 100 jaar kelder			
Veiligheid		SVBM	Financieel
Meerdere doden	0,0	1.361.725	€ 136.173
Ongevallen met dodelijke afloop of zeer ernstig letsel	0,0	Situatie beschrijving	
ongevallen met ernstig letsel met verzuim	0,0		
ongevallen met letsel met verzuim	0,0	Bij een slechte conditie van de kelder kan er verzakkingen optreden, waardoor kabels losgetrokken worden met als mogelijk gevolg elektrocutie voor de monteur.	
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	0,4		
Totaal punten	136.173		

Rooster

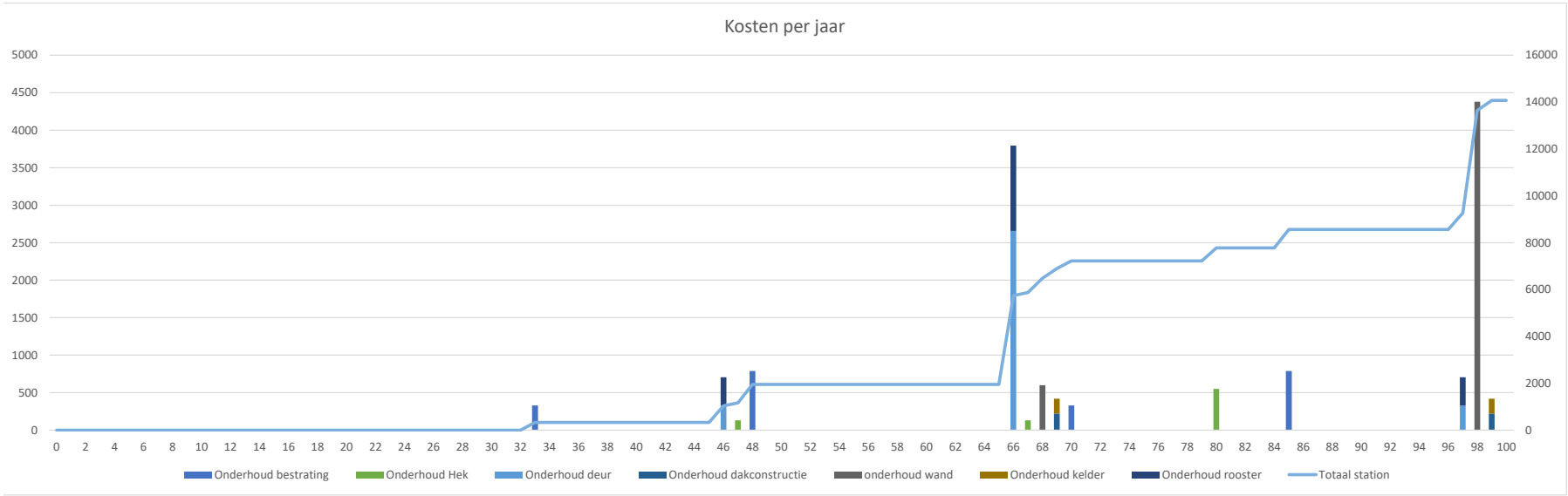
Totaal kosten:	€ 1.898
aantal	Totaal
Aantal keer herstel (€380 per keer)	2 € 759
Aantal keer vervanging gedaan (€1,139 per keer)	1 € 1.139

Gemiddeld risico veiligheid	Laag
Gemiddeld risico kwaliteit van levering	Nihil
Gemiddeld risico financieel	Nihil

Aantal jaar op risico niveau			
	V	KvL	F
ZH			
H			
M	3		
L	19	3	3
N	78	97	97



Totaal verwacht risico over 100 jaar rooster			
Veiligheid		SVBM	Financieel
Meerdere doden	0,0	170.361	€ 170.361
Ongevallen met dodelijke afloop of zeer ernstig letsel	0,0	Situatie beschrijving	
ongevallen met ernstig letsel met verzuim	0,0		
ongevallen met letsel met verzuim	0,4	Bij verval van de roosters kan er een ook een mogelijkheid ontstaan dat er mensen toegang krijgen tot de ruimte, met als mogelijk gevolgen elektrocuties, uitval en schade claims.	
Bijna ongevallen, ongevallen met gering letsel/EHBO zonder verzuim	0,0		
Totaal punten	1.703.611		


Kosten per jaar
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
16000
14000
12000
10000
8000
6000
4000
2000
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100
Onderhoud bestrating
Onderhoud Hek
Onderhoud deur
Onderhoud dakconstructie
onderhoud wand
Onderhoud kelder
Onderhoud rooster
Totaal station

Question screen

Vragen over de gemaakte keuze

1. Vind je de resultaten een logisch gevolg van de keuzes die je gemaakt hebt.

2. Zou je in het echt andere keuzen gemaakt hebben? Welke, en waarom?

3. Je vindt veiligheid minder belangrijk dan Kwaliteit van levering. Klopt dit? Kan je deze keuze onderbouwen?

4. Je vindt financieel minder belangrijk dan veiligheid. Klopt dit? Kan je deze keuze onderbouwen?

5. Je vindt kwaliteit van levering meer belangrijk dan financieel. Klopt dit? Kan je deze keuze onderbouwen?

6.1. Bij bestrating heb je gekozen om op conditie 4 actie te ondernemen en om 1 keer te herstellen voor vervanging
Waarom heb je deze keuze gemaakt?

6.2. Bij hang en sluitwerk heb je gekozen om op conditie 4 actie te ondernemen en om 2 keer te herstellen voor vervanging
Waarom heb je deze keuze gemaakt?

6.3. Bij de deur heb je gekozen om op conditie 4 actie te ondernemen en om 1 keer te herstellen voor vervanging
Waarom heb je deze keuze gemaakt?

6.4. Bij dakconstructie heb je gekozen om op conditie 4 actie te ondernemen en om 2 keer te herstellen voor vervanging
Waarom heb je deze keuze gemaakt?

6.5. Bij wand heb je gekozen om op conditie 4 actie te ondernemen en om 1 keer te herstellen voor vervanging
Waarom heb je deze keuze gemaakt?

6.6. Bij kelder heb je gekozen om op conditie 4 actie te ondernemen en om 2 keer te herstellen voor vervanging
Waarom heb je deze keuze gemaakt?

6.7. Bij rooster heb je gekozen om op conditie 4 actie te ondernemen en om 1 keer te herstellen voor vervanging
Waarom heb je deze keuze gemaakt?

7. Voor welke afdeling werk je?

Vragen over PWE als participatie methode

1. Vind je de PWE begrijpelijk en makkelijk/snel in te vullen?

2. Vind je de hoeveelheid informatie goed, of had je behoefte aan meer of minder details?

3. Heeft de PWE je meer inzicht gegeven in de afwegingen die gemaakt moeten worden bij het ontwerpen van levensloop plan?

4. Is dit iets waar je behoefte aan hebt? Zo ja, denk je dat PWE een gischikte methode hiervoor kan zijn? Waarom wel of niet?

5. Vind je onderhoud van een compactstation een geschikt onderwerp voor een PWE? Waarom wel of niet?

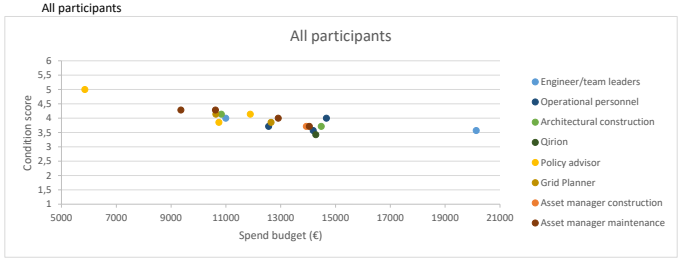
6. Heb je behoefte aan participatie in de besluitvorming? Waarom wel of niet?

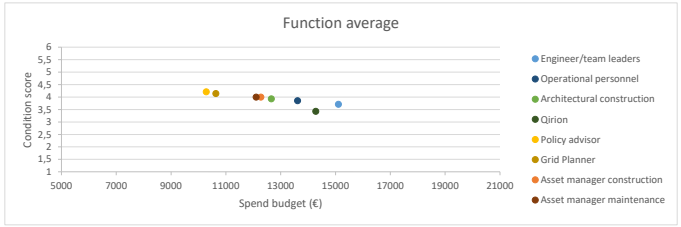
7. Zo ja, vind je PWE een geschikte methode hiervoor? Waarom niet/wel?

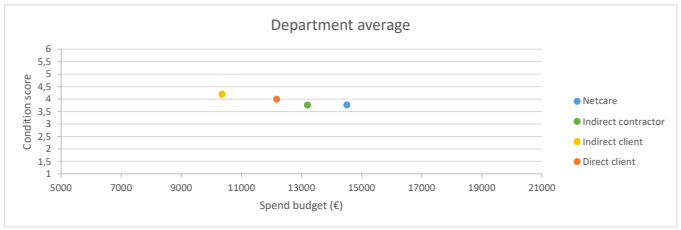
8. Zijn er nog verbeteringen voor PWE die je graag zou willen zien?

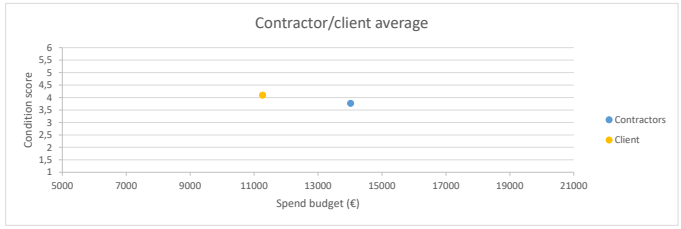
F: Survey result graphs

All participants

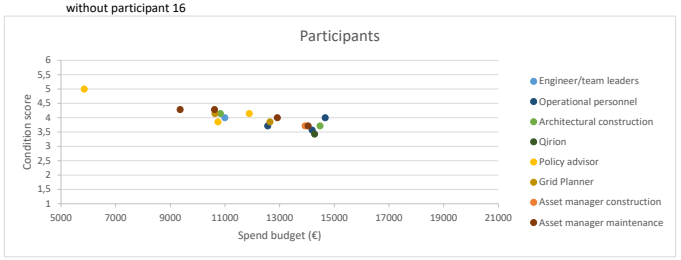


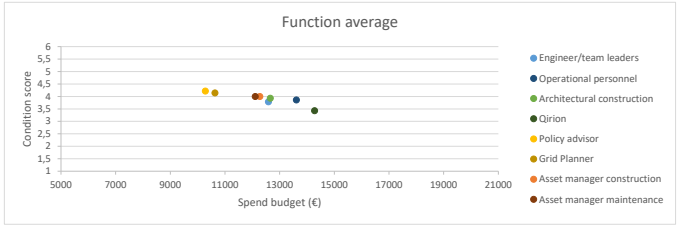


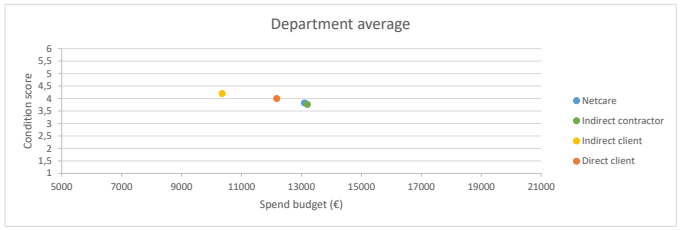


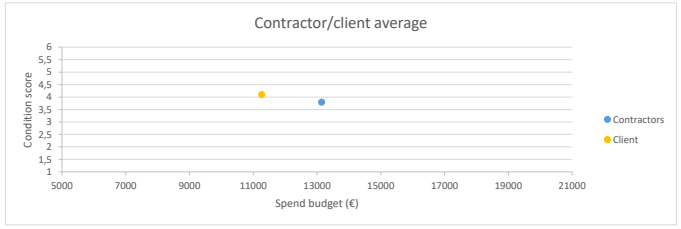


without participant 16

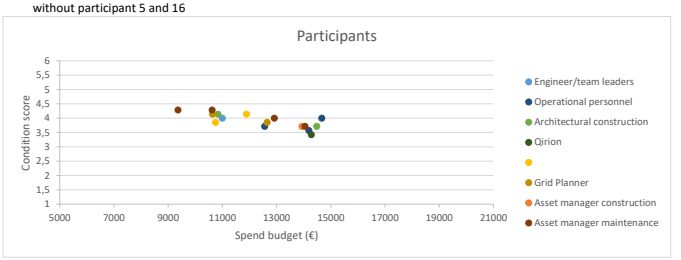


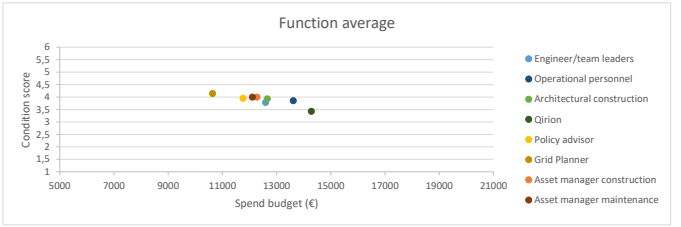


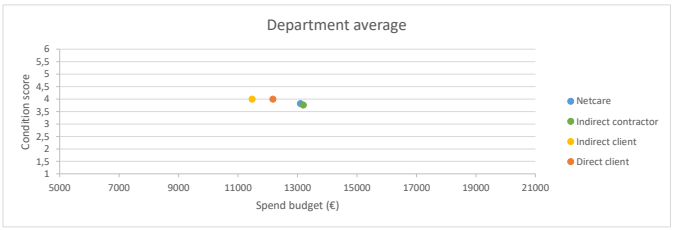


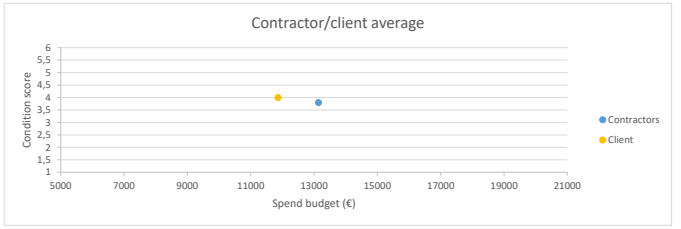


without participant 5 and 16

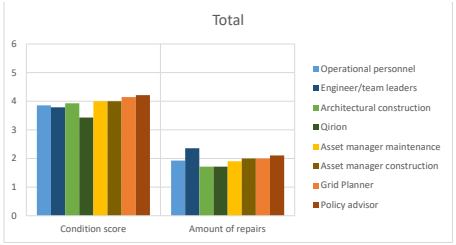


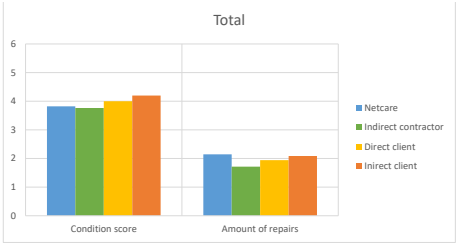


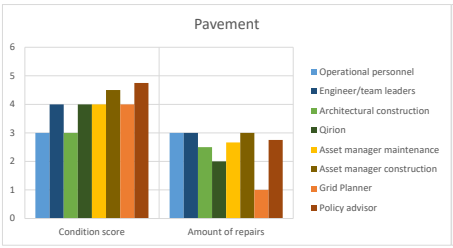


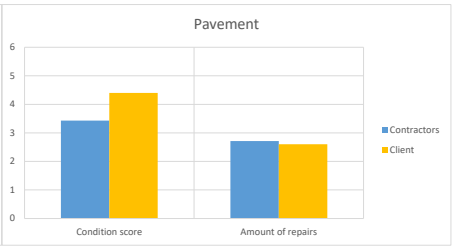


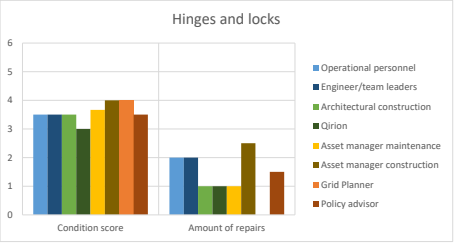
Condition and repair choices by groupings

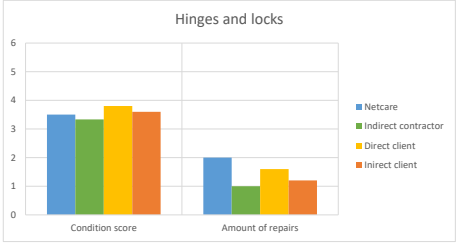


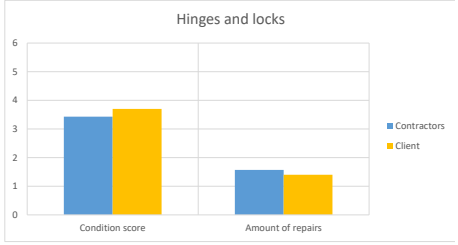


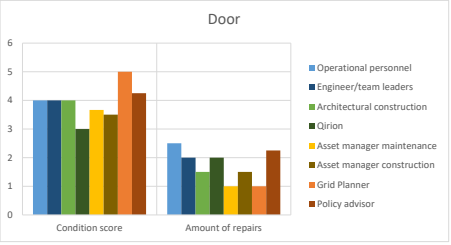


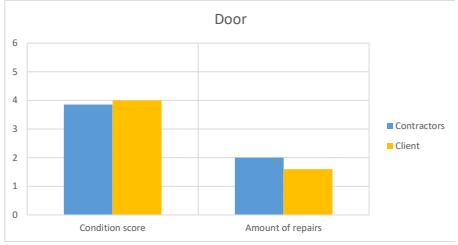


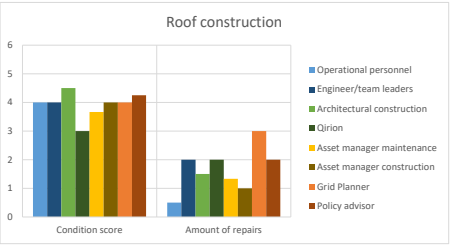


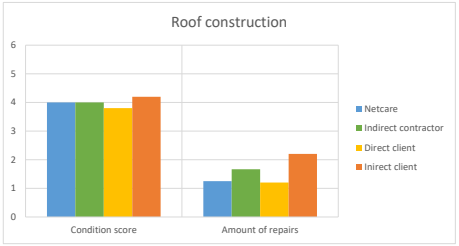


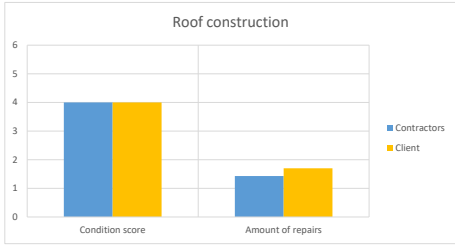


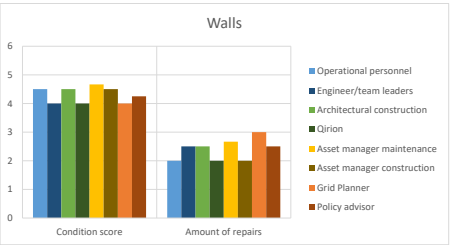


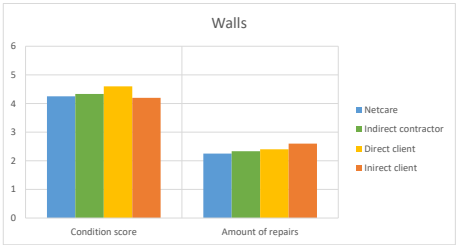


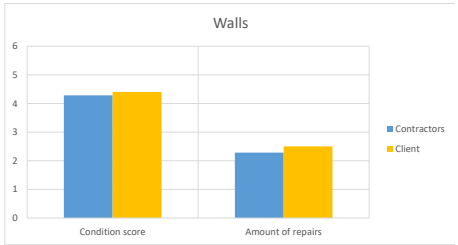


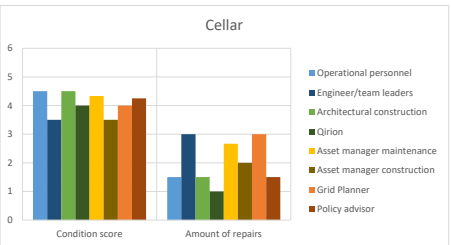


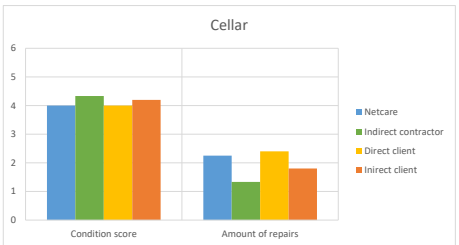


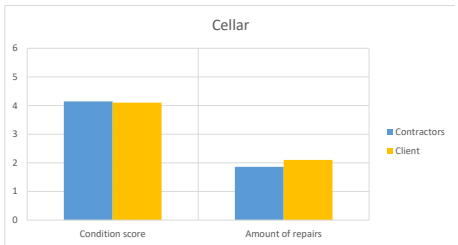


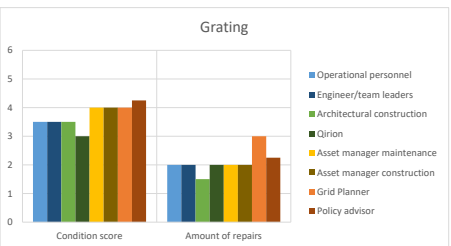


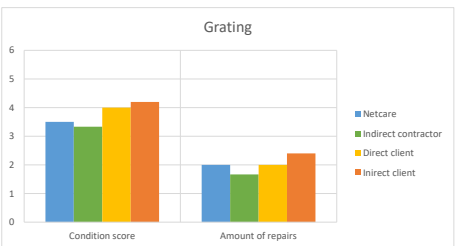


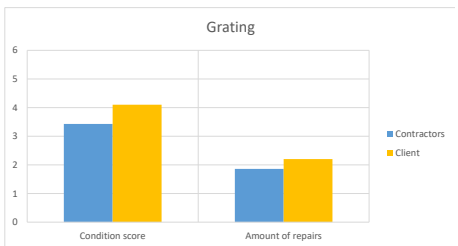




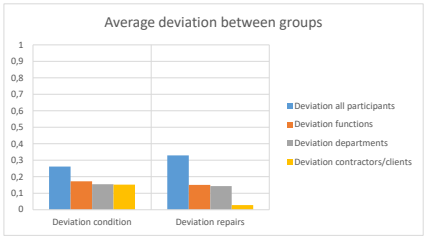


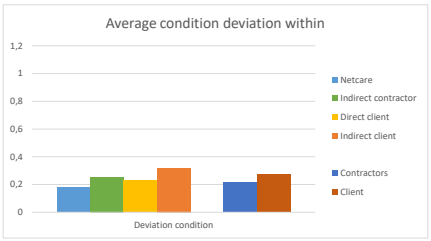


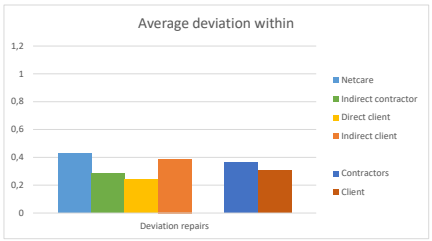


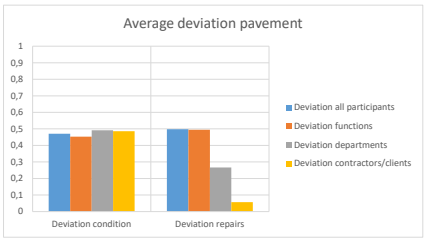


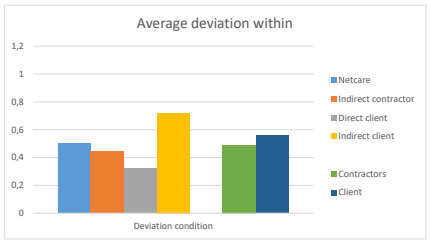
Deviation between groups for condition and repair choices, average deviation within groups for condition choices and average deviation within groups for repair choices

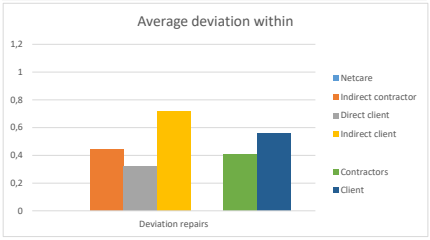


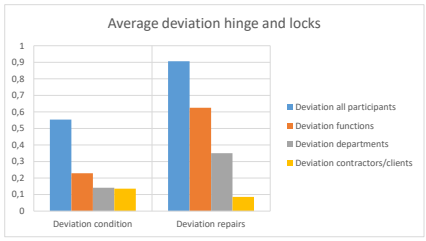


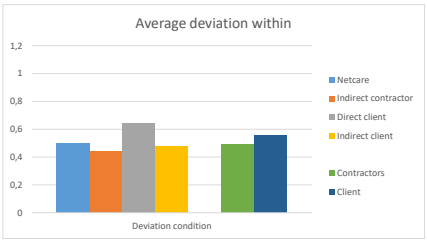


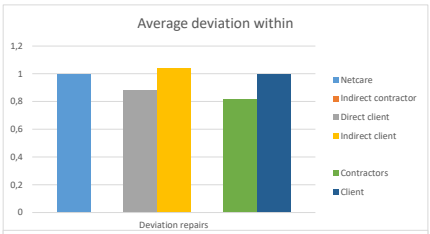


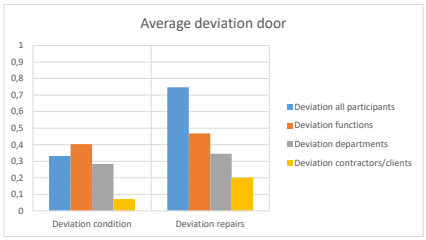


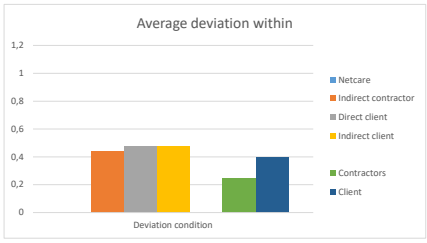


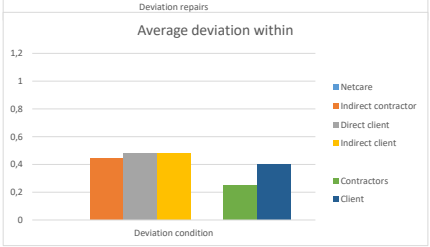


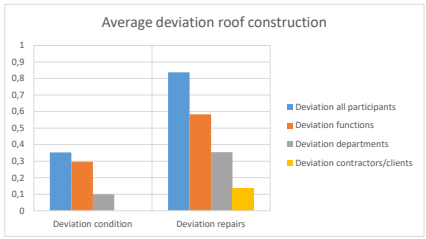


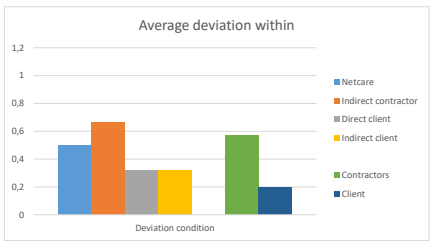


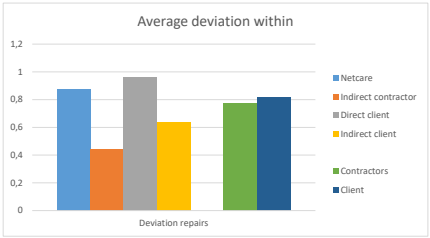


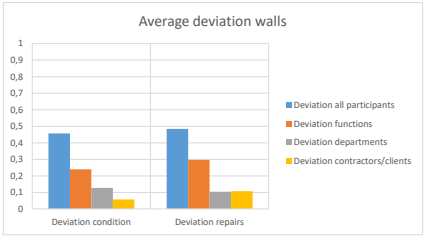


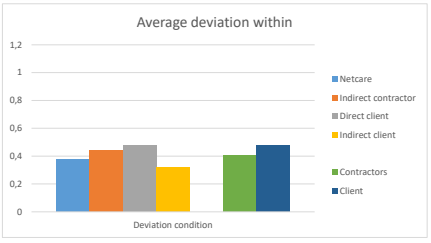


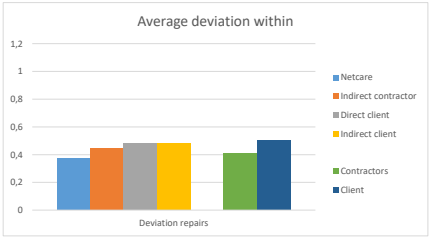


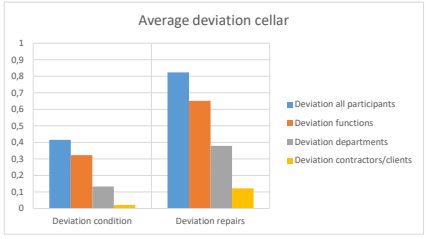


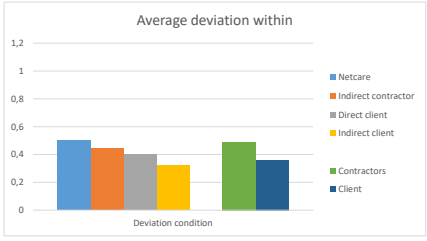


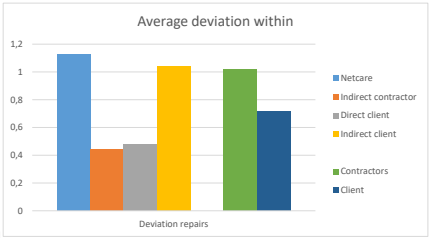


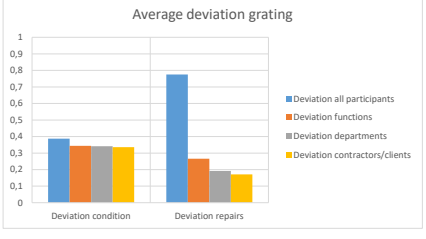


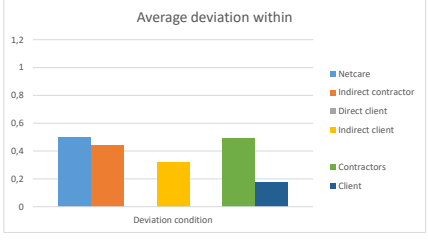


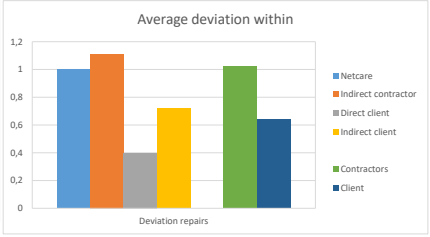




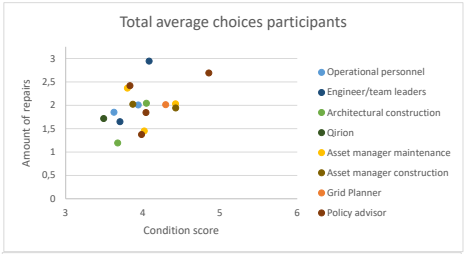


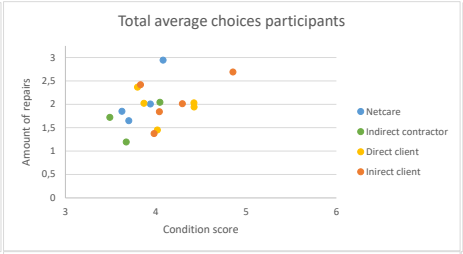


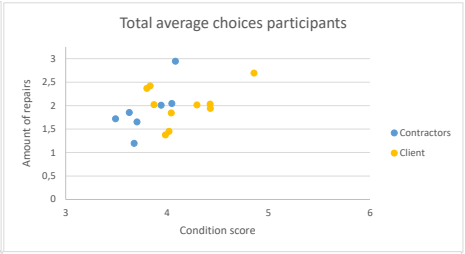


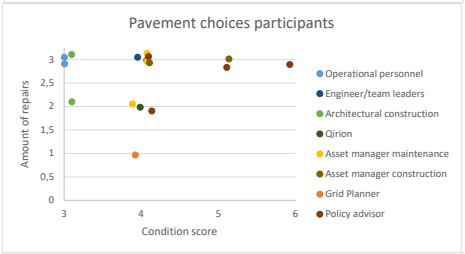


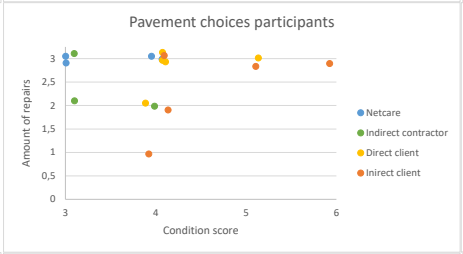
Scatter plots for condition and repair choices for all participants coloured by different groupings

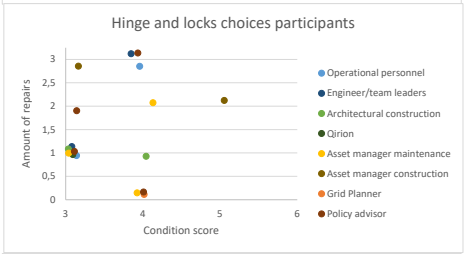


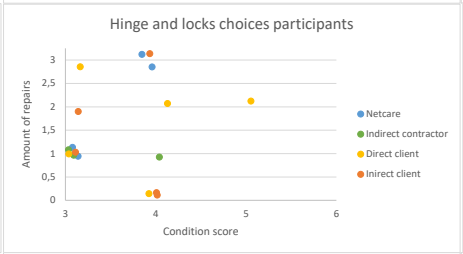


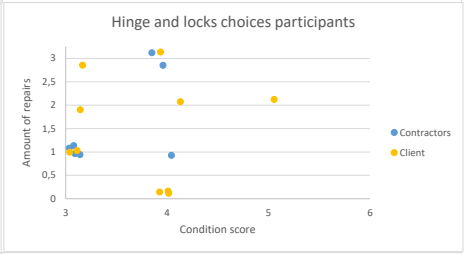


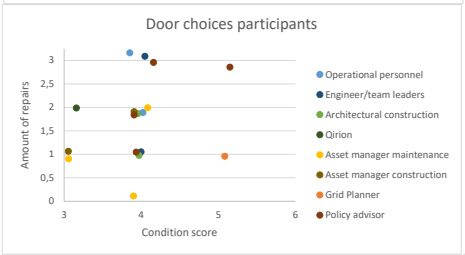


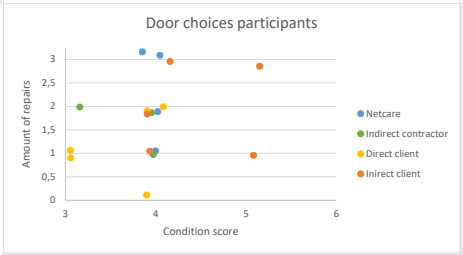


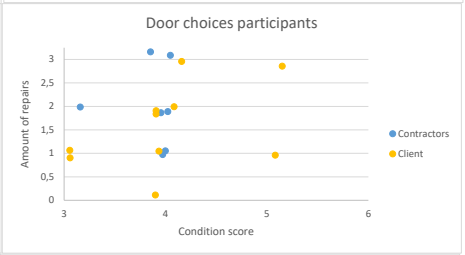


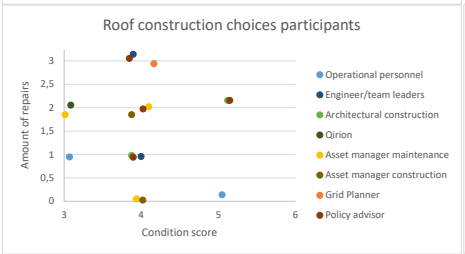


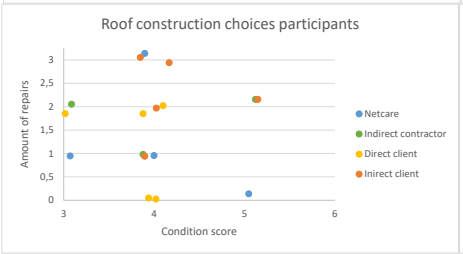


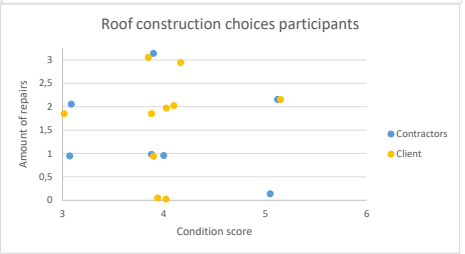


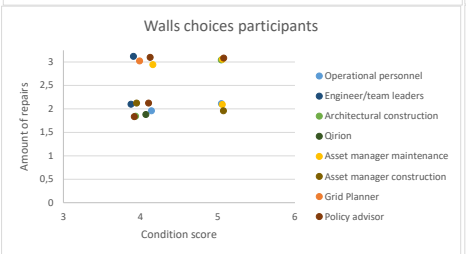


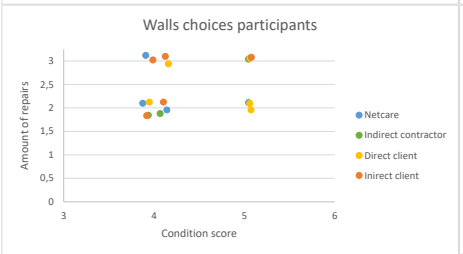


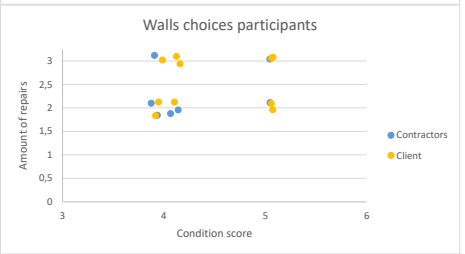


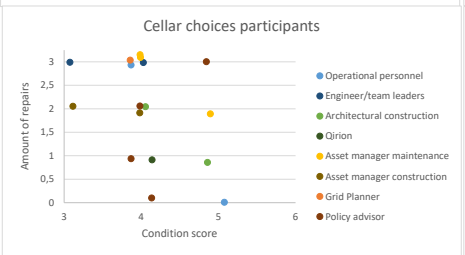


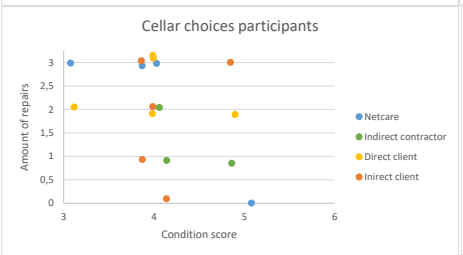


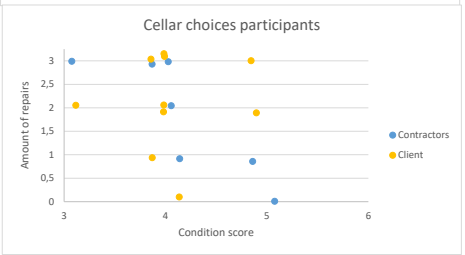


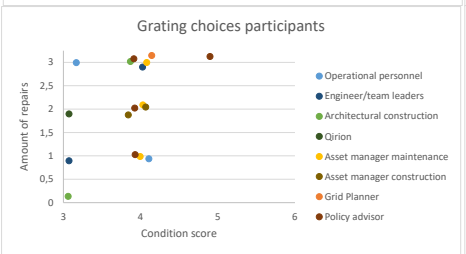


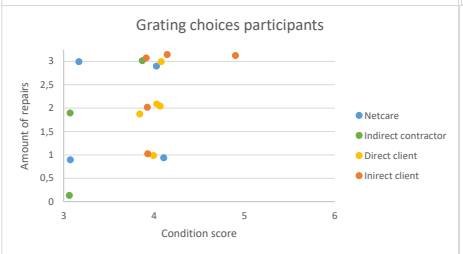


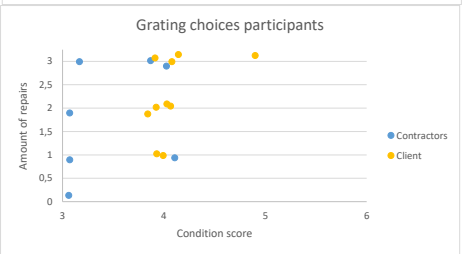












Scatter plots for condition and repair choices group averages