Managing uncertainties in the collaboration process of integraal programmeren

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MASTER THESIS

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Managing uncertainties in the collaboration process of integraal programmeren

GROENLICHT

TU Delft

Executive summary

The energy system is changing and is becoming more important in the spatial-economic development of the Netherlands. The current energy planning system is insufficiently equipped to deal with these changes. Therefore transmission and distribution system operators, provinces and municipalities have come together in the process of integraal programmeren to aid in making democratic legitimate decisions on energy infrastructure investments. The process of integraal programmeren has the aim to design an energy system coordinated with spatial development and sectorial plans on energy demand and supply. The process of integraal programmeren can play a role in mitigating uncertainties in the energy system by accumulating knowledge on developments, drawing up an energy vision and assisting in making decisions. Market parties are now minimally involved in the process, while they are essential in the realisation of sustainable developments. This dependency can lead to uncertainties in the process of integraal programmeren.

This research aims to construct the contours of design guidelines which could serve as a basis for the collaboration process for integraal programmeren to better suit the uncertainties in the process. The corresponding research question is:

How can uncertainties that occur in the development of long-term collaboration for integraal programmeren be managed given the characteristics and context of these uncertainties?

This research is exploratory of nature and scopes down along the way, to best suit the ongoing developments in the process of integraal programmeren. A theoretical framework and a case study are used to analyse both theoretical and practical perspectives on integraal programmeren. The theoretical framework is composed to generate design guidelines for a collaborative process in an uncertain environment and define different kinds of uncertainties. And three case regions are used to collect the experiences and ideas of the actors in the process of uncertainties and mitigation measures. Finally, the theoretical and practical insights are combined and validated in a focus group. The goal of the focus group is to discuss design guidelines and share ideas on how these can help to deal with uncertainties.

The analytical framework consists of two pillars, the first aimed at composing design guidelines for the collaboration process and the second at defining uncertainties. For the first pillar, four theories have been explored:

- Anna Bergek's work on innovation systems.
- Elinor Ostrom's IAD framework.
- Ernst ten Heuvelhof and Hans de Bruijn's work on management in networks.
- Bart Nooteboom's work on trust.

These theories have led to overarching categories of principles for collaboration in an uncertain environment:

- Trust and reciprocity norms
- Knowledge development and accumulation
- Governance and decision making

- Boundaries and context
- Communication
- Institutions
- Resources

The exploration of uncertainties has led to two kinds of groupings. First, based on the nature of the uncertainty and second, based on the location of the uncertainty relative to the process. The theoretical framework results in design guidelines that can improve the management of uncertainties in the process of integraal programmeren by defining the uncertainties and guiding the interactions they influence.

The conceptual analysis of integraal programmeren concluded that integraal programmeren is a process mainly between provinces, municipalities and system operators of electricity, heat and hydrogen. The actors work together in a network of interdependencies and work together to achieve shared goals. In addition, there is a big interdependency between the actors in the process and market parties e.g. information provision and investments. Market parties can have the role of energy demanders, suppliers, non-regulated system operators and flex providers. Market parties have thus far not been actively involved in the process of integraal programmeren. This can be explained by the fact that the cycle of integraal programmeren has only just begun and the main focus is now on testing the steps and setting up a collaboration process between provinces, municipalities and system operators. Likewise, the process does not have a legal status yet and actors work from their existing mandates.

The focus of the actors has mostly been on the uncertainties in the process itself since it is all very new. However, it is recognised that uncertainties stemming from the uncertainties with market parties can eventually have a big, unforeseen influence on the regional energy system. Therefore it is important to take them into account. The following uncertainties which highly depend on market parties are deemed as the most ambiguous:

- Sustainability plans of (scattered) industries and business parks
- Sustainability plans for heavy transport
- Use and development of hydrogen
- Reactions of market parties on state decisions (e.g. wind-at-sea, nitrogen policy), leading to consequences for the regional energy infrastructure
- Development of heat networks

Based on the interviews, it can be concluded that uncertainties among market parties can be dealt with in the process of integraal programmeren in two ways. 1.) By obtaining more information about it, or in the case when this information does not exist or is unavailable, 2.) by formulating a shared vision. Involving market parties, more actively than they are involved now, can help with these mechanisms. Involving market parties in the process of integraal programmeren can reduce uncertainties because their compliance leads to 1.) more information about subjects that are now still uncertain in the process and; 2.) a wider endorsed energy vision.

The focus group aimed to validate design guidelines and gather ideas on how to implement them in the process of integraal programmeren, with the goal of reducing uncertainties. The group discussed four categories of design guidelines: governance and decision-making, communication,

trust and reciprocity norms, and knowledge development and accumulation. In terms of governance and decision-making, it was agreed that market parties can play a role, but their involvement should be well-defined to avoid strategic behaviour. Transparency and knowledge sharing are crucial to increase acceptance and collaboration. Trust-building varies between market parties and regional governments/system operators and requires transparency and stable courses of action. Lastly, the process requires combining knowledge from different actors and reducing the cognitive distance to facilitate collaboration.

In conclusion, uncertainties in the process of integraal programmeren origination from market parties can be managed through collaboration with market parties. Involving new actors in the process leads to more complexity and new process rules are needed. Designing a process such as integraal programmeren is not a linear process, during the process, the design requirements can change based on new situations and ideas and thus it calls for flexibility, while still keeping its credibility. This research described a novel relationship between uncertainties and process design. Further research could lead to more insight into which factors influence the perception of uncertainties and call for a change in the collaboration process design.

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Tisja Kuiper

Den Haag, May 2023

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Abbreviations

PMIEK – Provinciaal Meerjarenprogramma Infrastructuur Energie en Klimaat

RES – Regionale Energie Strategie

CES – Cluster Energie Strategie

TSO – Transmission System Operator

DSO – Distribution System Operator

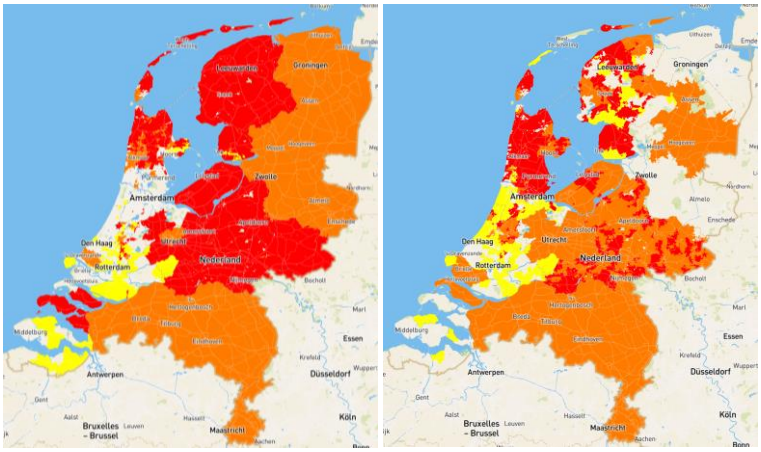
ACM - Authoriteit Consument & Markt

1. Introduction

1.1 Research problem

1.1.1 Problem introduction

The Climate Agreement is an important part of Dutch policy to become more sustainable (Government of the Netherlands, 2019). This policy affects all sectors and likewise puts pressure on the energy sector to become more sustainable. Consequently, the Dutch government stimulates the use of renewable energy sources, like solar and wind, to replace fossil sources. The energy system's demand side is changing and growing. There is a growth in energy users with high demand like datacentres and industrial areas (Werkgroep Integraal Programmeren, 2022). Additional pressures of, for example, electrification in mobility and industry induce an even more important role of the energy system in the spatial-economic development of the Netherlands. Because of these developments, the ways of generating, using, and transporting energy are changing. This calls for an energy system that is more flexible and diverse, and the current energy planning system is insufficiently equipped to adequately deal with these changes (Cowell, 2017; Muller, 2022). The system operators of the Dutch energy system are each responsible for maintaining and constructing their own network. Since 2020 every regulated system operator is obligated to publish an investment plan every two years in which the investments for new and replacing infrastructure are described (TenneT, n.d.).



Figures 1 & 2. Map of capacity shortage on the electricity grid in the Netherlands on 21-4-2022. Both new supply (left) and demand (right) can not get a connection to the electricity grid in many regions. (Netbeheer Nederland, n.d.).

Rapid energy infrastructure development is a key condition for achieving the goals set by the Dutch government for the energy transition. However, the realization of new energy infrastructure is slow because labour, money, and materials are limited to develop the infrastructure and the investments are long-term, capital-intensive, and irrevocable, which makes the process quite inflexible (Lane et al., 2016). The ongoing changes in the energy system are already causing capacity shortages on the electricity grid (Figures 1 &2) (Netbeheer Nederland, n.d.). This has unwanted consequences and obstructs sustainable development in the Netherlands. In some regions, projects like new solar parks or industrial parks cannot be connected to the electricity grid and are delayed due to net scarcity (Braat et al., 2021). Transmission and distribution system operators and local and regional governments have come together to solve this pressing matter and to take more control of the energy system by designing a new process to assist in making democratic legitimate decisions on energy

infrastructure investments, called "integraal programmeren" (figure 3) (Muller, 2022; Werkgroep Integraal Programmeren, 2022).

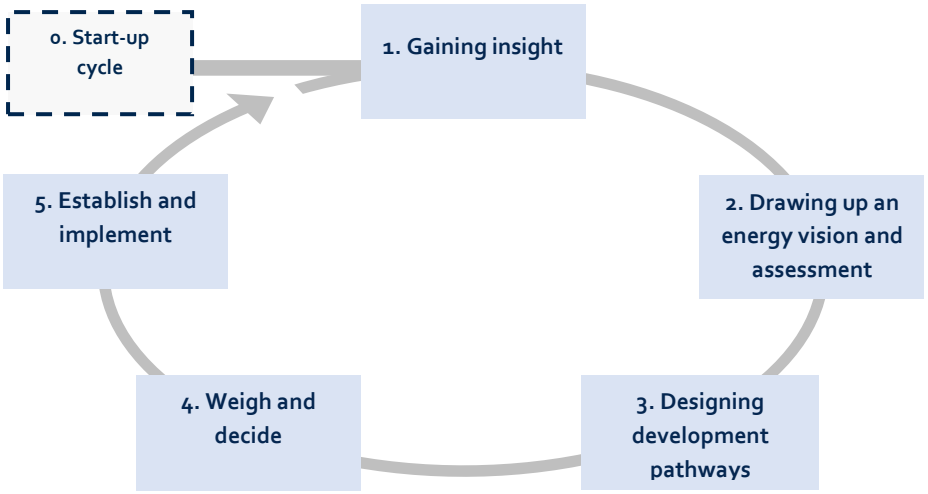


Figure 3. Integraal programmeren: the process that is being developed by governments and system operators to aid in making decisions on energy infrastructure planning.

The process of Integraal programmeren aims to design an energy system coordinated with the developments in all sectors with a claim on the energy network (industry, mobility, built environment, energy supply, and agriculture) (Werkgroep Integraal Programmeren, 2022). Therefore, programs from sectors, like, for example, the "Regionale Aanpak Laadinfrastructuur" (RAL), "Cluster Energie Strategie" (CES), and "Regionale Energie Strategie" (RES), are used as input for integraal programmeren. The energy transition is a complex problem with many uncertainties, especially because of the coherence with different sectors and interdependencies between actors (Yeşilgöz-Zegerius & Blok, 2021).

Integraal programmeren comes across different kinds of uncertainties that influence each other, both in the process and its environment, which makes it a complex situation. The process of integraal programmeren can play a role in mitigating uncertainties in the energy system by accumulating knowledge on developments, drawing up an energy vision and assisting in making decisions. However, uncertainties are still insufficiently addressed in the process, largely because of the novelty of the process. The uncertainties can influence choices in the process and likewise decisions on energy infrastructure. Thus, not taking uncertainties into account could lead to problems in the form of costly, wrong investments, further delays and discontent of actors (Jetten, 2022a). This research aims to analyse the current process regarding integraal programmeren and formulate design guidelines to further develop the design of the current collaboration process to better accommodate uncertainties.

1.1.2 Scope

The process of integraal programmeren is a broad concept, currently covering a whole bunch of processes. A national and a regional approach are being developed simultaneously (Werkgroep Integraal Programmeren, 2022). This thesis will focus on the regional process of integraal programmeren that is being set up in each province, resulting in a program called PMIEK (Provinciaal Meerjarenprogramma Infrastructuur Energie en Klimaat). In this process, the province, distribution

system operator (DSO) and municipalities work together, in which the province has a supervising role. A national working group guides the provinces by tackling overarching issues in the regions.

This thesis will focus on the development of the collaborative process of integraal programmeren between the province, DSO, TSO, and municipalities. The first run-through of the process is happening at the same time as this research is being carried out. This first run-through is aimed at trying out this way of working and setting up a collaboration process, therefore the focus on the collaboration process is very fitting to the current situation.

It has been agreed on nationally that the main actors in the regional process are the province, DSO, and municipalities, but the exact collaboration will vary between provinces. In July 2022, each province agreed to start the first cycle of the process (Werkgroep Integraal Programmeren, 2022). Because of the current scarcity of the electricity network, there was pressure to start the process fast. Therefore, the process has started while still under development. In the first cycle, only the essential steps are taken, so the cycle can be finished in spring 2023 (Werkgroep Integraal Programmeren, 2022). As a consequence, the actors work from their existing mandates. However, integraal programmeren is seen as a long-term solution, which may require different forms of collaboration in the future and the involvement of different actors. Market parties are now not or minimally involved in the process, while they are essential in the realisation of the energy transition. This dependency can lead to uncertainties in the process of integraal programmeren, especially if you look further into the future. Therefore, this thesis will look at how the uncertainties stemming from the dependencies with market parties influence the integraal programmeren process and how the collaboration process can be advanced to better handle these uncertainties.

1.2 Theoretical background

The energy system is a type of socio-technical system, both technological and social aspects are needed for its functioning (Bauer & Herder, 2009). Socio-technical systems are particularly complex due to technical and social complexity and the combination of both (Herder et al., 2008). The concept of social aspects can cover a range of things. De Bruijn & Herder (2009) define it as "networks of interdependent actors", which includes dependencies and interactions between the actors. But it can also refer to an institutional structure that shapes the behaviour of actors in the system (J. Koppenjan & Groenewegen, 2005). Part of what makes the system complex is that socio-technical systems inherently are multi-actor systems involving both private and public parties which means both market forces and government regulation influence the system (J. Koppenjan & Groenewegen, 2005).

A system consists of multiple sub-systems that are dependent on each other and all influence the functioning of the overall system (Bruijn & Herder, 2009b; Herder et al., 2008). Often the technical and social aspects are analysed independently since they are covered by different disciplines (Bruijn & Herder, 2009b). However, these aspects are interdependent in a socio-technical system and therefore the development of their designs should be interlaced (Bauer & Herder, 2009; Hassannezhad et al., 2019). Designing in socio-technical systems, therefore, requires integral methods that capture both the social and technical characteristics (Baxter & Sommerville, 2011; Hassannezhad et al., 2019).

De Bruijn & Herder (2009) discuss two different perspectives that need to be taken into consideration when solving problems in socio-technical systems: the system perspective and the actor perspective. The technical, system perspective divides the system into subsystems that all need to function well

for the overall system to function as intended. The social, actors perspective looks at a system as a network of interdependent actors, that need each other to reach their goals. The difference between these perspectives is how they perceive their components. The system perspective approaches components as mechanical things while the actor perspective looks at components as actors that have the ability to learn (de Bruijn & Herder, 2009). Although De Bruijn & Herder (2009) conclude that both perspectives should be integrated in order to solve problems, they also declare that complete integration is impossible and they must be used alongside each other. Baxter & Sommerville (2011) agree that combining social and technical methods is important, however, in practice, they see these are rarely used, most likely because of their complexity. The scope of a socio-technical system is inherently too broad to analyse as a whole, which means design decisions are often made without a clear understanding of the consequences (Bauer & Herder, 2009). Therefore analyses and models will often not lead to one right answer but give a range of different design options (Bauer & Herder, 2009).

What also makes socio-technical design complex is that it is not only about the design itself but also about the coordination of people involved in the design process, which can also impact the success of the design (Hassannezhad et al., 2019). Designs are established in an interactive process between actors, which can be messy and unstructured (J. Koppenjan & Groenewegen, 2005). Therefore, a process design is needed in addition to a technological and social design. The process design, also referred to as the rules of the game, coordinates the behaviour of the actors and facilitates interaction (Bruijn & Herder, 2009b). The process design describes how decisions are made, by whom and under what conditions (J. Koppenjan & Groenewegen, 2005). The process design shapes the design process and thereby also the technological and social design (see Figure 4). Thus, a design or improvement to a design starts with a process design.

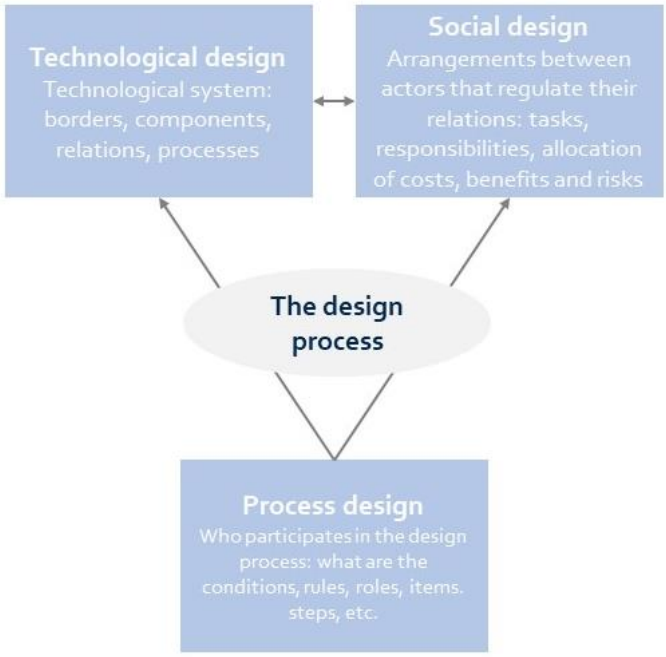


Figure 4. The relation between technological, social and process design. Adapted from (J. Koppenjan & Groenewegen, 2005).

In the case of the energy system, it is also important to balance the technological, systems perspective and the social, actor perspective and to facilitate the design process with a process design. There is

no perfect formula for designing socio-technical systems and proper methods are still lacking (Bauer & Herder, 2009). Thus when designing in a socio-technical system, multiple perspectives should be considered, leading to a range of design guidelines. However, which perspectives and methods to use is dependent on the situation and should be tailored to the researched system (Bauer & Herder, 2009).

1.3 Research questions

The goal of this thesis is to construct the contours of design guidelines which could serve as a basis for the long-term regional collaborative process for integraal programmeren to better suit uncertainties in the process. The corresponding research question is:

How can uncertainties that occur in the development of long-term collaboration for integraal programmeren be managed given the characteristics and context of these uncertainties?

1.4 Linkage to CoSEM program

In the energy system, many disciplines and actors come together in a socio-technical environment. The energy transition is a complex problem, and the capacity shortage makes it even more complex because it also involves a big social component. Designing a governance structure requires both social and technical knowledge of the energy system, which makes it a good fit for the CoSEM energy track. Current policies, technical limitations, and social components must be considered in the design. Grid scarcity is a very relevant challenge at the moment and both governmental organizations and transmission system operators are very active in this field. This research couples theory and practice and will therefore also contribute to both theory and practice.

1.5 Structure of the thesis

This thesis first presents the methodology (Chapter 2), in which the research approach and methods are explained and the sub-questions are formulated. Then the theoretical framework (Chapter 3) is constructed, providing the theoretical lens for the research. Followed by a conceptual analysis of integraal programmeren (Chapter 4). Then the results of the case study (Chapter 5) are discussed and analysed. And finally, the result and analysis of the focus group (Chapter 6) are reported. Which all results in an answer to the research question (Chapter 7).

2. Methodology

2.1 Research approach

Following the problem introduction and scientific literature research, a gap can be identified within the design process of collaborative processes in an uncertain, socio-technical environment, such as integraal programmeren. Consequently, the research question indicates the need for the development of design guidelines for a collaborative process to help manage uncertainties. However, since integraal programmeren is a new program that is still under development and that has not been researched before and socio-technical systems benefit from multiple perspective approaches, a preliminary analysis is carried out to better understand the problem. Therefore this research is of an exploratory nature. An explorative research approach is suited to gaining familiarity with a situation and developing new ideas and techniques (Elman et al., 2020). This research focuses on managing uncertainties through the collaboration process of integraal programmeren and will take the first steps to identify guidelines to improve the collaboration.

Exploratory research is messy and time-consuming, but it also allows flexibility (Stebbins, 2001). This approach allows the research to adapt to research findings of a live and ongoing process, as is the case with integraal programmeren, and filter out the most important aspects later on in the research (Casula et al., 2021). In order to structure the research, the scope of the research is adjusted along the way. The first part of the research focuses on exploring the current situation and identifying uncertainties the process of integraal programmeren currently encounters, this is a convergent step. At the beginning of the second part, a more delineated scope is chosen. Within this scope, experiences and ideas are collected and contrasted with scientific work. The last step is divergent in nature, which means that different mitigation measures are explored and substantiated. Exploratory research brings the risk of getting lost in the exploration phase, it can be difficult to determine when to stop considering new inputs in the research. To lessen the risk of delay in the research, scope decision moments are pre-determined, after which new inputs outside the scope are no longer taken into account.

2.2 Research design

The main research methods being used are scientific literature studies and case studies, to analyse both the theoretical and practical points of view of integraal programmeren. Because the research is exploratory in nature, the scope of the research is further specified along the way. The first scoping decision is about the main theme of the uncertainties in the research and the second decision is aimed at selecting a few uncertainties to further elaborate on. These scoping decisions are validated by interviewed actors in the process after each phase. The final phase of the research is divergent in nature and explores possible mitigation measures. The different phases of the research are visualised in Figure 5.

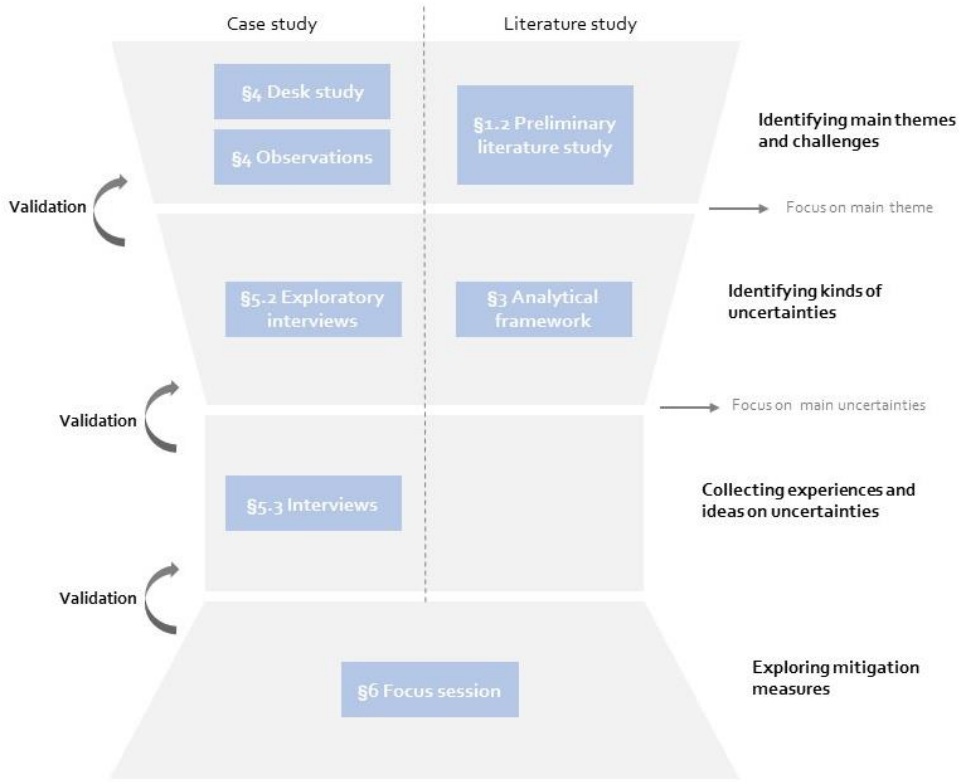


Figure 5. This research consists of four phases in which practice and theory are explored simultaneously. The first phases are convergent in nature and help further define the scope. The last phase is divergent and explores multiple mitigation measures for uncertainties in the process of integraal programmeren.

2.2.1 Preliminary research

The first phase of the research is aimed at exploring the field of integraal programmeren and starting points for the theoretical framework. As noted before, it can be difficult to decide when to stop exploring therefore the first scoping decision about the main theme is made at the kick-off meeting. For the practical exploration internal documents of different regional integraal programmeren processes are scanned and content-related sessions are attended. Based on this exploration, the main challenges in the process of integraal programmeren are identified. What stood out as a theme is that market parties are not yet involved in the process in most regions, while market parties in the roles of non-regulated system operators, energy providers, and energy users have a big influence on the energy system. In the short run-through of the 22/23 iteration, the involvement of market parties has not gotten much attention yet. Therefore this research will look further into what influence the (lack of) involvement of market parties has on the process of integraal programmeren and how uncertainties originating from this can be better managed in the collaboration process.

The preliminary scientific literature study explores different ways in which the integraal programmeren process can be approached from a theoretical perspective. Designing within socio-technical systems can be approached in many different ways, therefore multiple perspectives are researched. Starting with concepts such as 'process design', 'collaboration in socio-technical systems', 'collaboration in uncertain environments, 'system analysis' and 'process analysis' are used to examine possible approaches for the theoretical framework. Four angles are chosen to further explore in the theoretical framework.

- The collaborative process takes place in a socio-technical system.
- The collaborative process is shaped by (existing) institutions.
- The collaborative process takes place in a network of public and private parties.
- The actors in the collaborative process interact with each other.

2.2.2 Theoretical framework

The theoretical background and the preliminary scientific literature study showed that a framework to analyse a process such as integraal programmeren and address the core of the issues is still lacking. Therefore a theoretical framework is composed that combines insights from different scientific works to analyse the process. Ultimately, it could turn out that not every scientific work is as relevant in the framework. This possibility has been confined as much as possible by means of preliminary research.

A theoretical framework is composed to analyse the collaborative process of integraal programmeren and the uncertainties that affect this from a theoretical point of view. The framework consists of two parallel scientific literature searches. One aimed at generating design guidelines for collaborations in an uncertain environment and the other at defining different kinds of uncertainties.

Based on the angles that emerged from the preliminary study, various scientific works are explored. Following a short analysis looking at the mentioning of uncertainties and design principles or guidelines, four works are chosen to further elaborate on in the context of integraal programmeren. These different theoretical perspectives all say something about collaboration in an uncertain environment but look at it from a different scale. Furthermore, each work discusses design principles or key factors for a successful collaboration process, that are bundled in the theoretical framework to analyse and improve the process of integraal programmeren.

The following theoretical works are explored in the first pillar of the theoretical framework:

- *Anna Bergek's work on innovation systems*: provides a framework for analysing the functionality of a system based on a few key functions and how mechanisms, such as uncertainties, can block functions and cause the system to fail.
- *Elinor Ostrom's IAD framework*: analyses how institutions are shaped and influence interaction and decision-making moments between actors. And provides design guidelines to explain what conditions are necessary to reduce uncertainty in complex environments.
- *Ernst ten Heuvelhof and Hans de Bruijn's work on management in networks*: describes the principles on which a collaboration process design should be based.
- *Bart Nooteboom's work on trust*: explains the need for trust in relationships and its role in reducing uncertainties. And gives suggestions on how to build trust.

Parallel to the scientific literature on collaboration processes, theoretical work on uncertainties is further explored. The concept of uncertainties can be approached in various ways. Two often used approaches to distinguish different kinds of uncertainties are 1.) based on the severity of the uncertainty and; 2.) based on the location of the uncertainty relative to the process. These groupings are researched to define and understand the uncertainties in the process of integraal programmeren. Additionally, mitigation measures linked to different kinds of uncertainties are explored.

2.2.3 Case study

A case study is used to contrast experiences with the scientific literature study. The process of integraal programmeren is being developed while this research is carried out, therefore case studies are used to keep up with the live developments and gain insight into current problems of the collaboration process. In each province, a collaboration process is being set up, which can be used as a case. To give insight into the full range of situations diverse case selection is used (Gerring, 2007). This means, that given certain characteristics, like for example the complexity of the stakeholders, cases are selected that outline the most diverse situations. For each case, multiple interviews will be conducted with actors involved in the regional process of integraal programmeren.

Because of the focus on the involvement of market parties in the research, the case studies are chosen based on the accessibility of data, the complexity of the market parties with a significant influence on the energy system in the region and the progression in the process. Subsequent to a short analysis the following case regions have been chosen:

- *Noord-Holland Noord*: A pilot region that completed the first run-through of the process. Has greenhouses, transport companies and wind-at-sea.
- *Zuid-Holland*: A region with a big industrial port, many greenhouses, multiple big cities and great potential for heat.
- *Groningen*: A region with a big industrial area, wind at sea and great potential for hydrogen.

The goal of the case study is to gain a better understanding of uncertainties in the collaboration process in these different regions and the issues that underlie these uncertainties. The experiences and opinions of the actors in the process of integraal programmeren will be used in combination with the theoretical analysis to draft design principles for the collaboration process.

Because of the novelty of the process of integraal programmeren, there are only a handful of actors in each region with substantial knowledge and experience of the process. These are mostly people working at generally work at a regional level like the province or a system operator. This means that the collected input is often on a higher abstraction level and it can be difficult to consider local circumstances. However, this can be overlooked, since this research aims to construct only the contours of guidelines for the collaboration process, and thus not concerns a specific situation.

The research is carried out at Groen Licht, a consultancy firm focused on the energy transition. Through the company, data and contacts can be accessed, like governmental organizations and transmission and distribution system operators. Because of their wide range of contacts, no big problems in organizing interviews are expected. In addition, the employees at Groen Licht have experience with integraal programmeren in multiple regions and on a national level, wherefore they can validate and complement the results. The meetings, as part of observations, can also be accessed through the company. It is difficult to say how many meetings will be attended and how relevant they will be for the research, therefore it can be necessary to go into further detail in interviews if the observations do not provide enough information.

The interviews will all be semi-structured with open-ended questions because this grants the possibility to go further into a topic. Interviewing is often used in qualitative research because it allows participants to provide elaborate answers and descriptions (Byrne, 2001). While interviewing is a time-consuming method and it can be difficult to subtract the right information, it is useful in this

explorative research because there are many stakeholders involved with different opinions and interests, which can be easier identified and collected via in-depth interviews. In addition, the interviews provide an overview of the different requirements of different stakeholders, which can be linked to the theoretical requirements. The interviews will be manually analysed with axial coding, to easily identify similarities (Allen, 2017).

The first part of the case study is aimed at exploring the current situation and uncertainties actors in the process come across. Introductory interviews are held with experts on integraal programmeren of the provinces in the case regions. Because the provinces have the leading role in the process, they have a good overview of what is happening in the region. Therefore they can provide a broad image of the issues and uncertainties in the region. Based on these introductory interviews a number of uncertainties, that are mentioned in multiple regions, are chosen to focus on in the next phase of the research.

In the second part of the case study other actors with experience in the process of integraal programmeren, such as TSOs, DSOs and municipalities, will be interviewed. They will be asked to reflect on the selected uncertainties and share their ideas on how these uncertainties should be managed in the process of integraal programmeren.

2.2.4 Focus group

Out of the theoretical framework follow several categories of design guidelines that say something about a collaboration process in an uncertain, socio-technical environment. All guidelines could lead to better collaboration and redefine the involvement of market parties in the process. However, to fit in the scope of the research a few guidelines are selected to further explore in a focus group. These guidelines are chosen based on a discussion with practitioners in the energy transition of Groen Licht.

A focus group is useful to understand contradicting opinions of people (Mclafferty & Diped, 2004). The advantage of using a focus group is the interaction between the participants. This is helpful in this research since it mimics a real-life situation where the same stakeholders have to decide on process requirements. The focus group will be semi-structured, to keep the participants on the right subject and ensure progress, but to still provide the possibility to include new suggestions.

The goal of the focus group is to look at the effect of uncertainties resulting from little or no involvement of market parties in the integraal programmeren process and come up with suggestions for dealing better with these uncertainties. Previously interviewed provinces and system operators are asked to discuss the selected design guidelines together and share ideas on how these can help deal with uncertainties. Municipalities are left out of the session because of their capacity issues and relatively little experience with the process.

A risk of a focus group is that participants give socially acceptable answers and diminish their opinions. Additionally, the discussed topics are touching on future aspects of the process, so the participants are partly only speculating and can be unsure about their answers. Regarding these risks, it is important to guide the actors in the session and translate their ideas on a higher abstraction level.

2.3 Sub questions

Three sub-questions are formulated that together lead to an answer to the main research question. Figure 6 shows the research flow diagram which displays that each sub-question gives input for the

next sub-question and the main research question. The sub-questions correspond with the first three phases of the research.

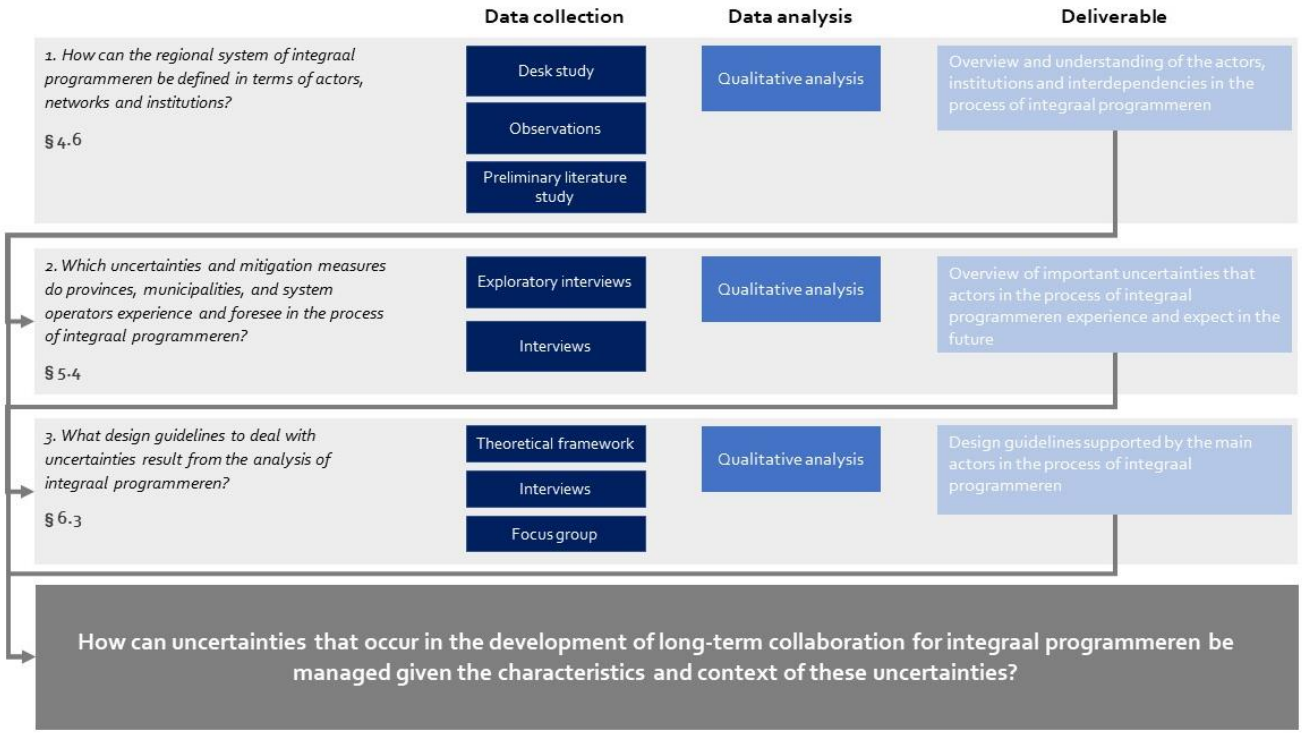


Figure 6. The research flow diagram shows the data collection and analysis method and the deliverable corresponding to each sub-question.

2.3.1 Analysing the current process

The first sub-question focus on defining the current situation and the origin of integraal programmeren to gain a better understanding of the context:

1. How can the regional system of integraal programmeren be defined in terms of actors, networks, and institutions?

This should result in an overview and understanding of which actors are involved in the process of integraal programmeren, what their responsibilities are and which interdependencies are at play. This requires data on which agreements have emerged out of the regional working group. In addition to this, information is needed to further define the current state of the process of integraal programmeren. This data will be collected through observation of the cases and a desk study of governmental documents.

2.3.2 Identifying uncertainties

Secondly, uncertainties in the process of integraal programmeren will be identified and defined:

2. Which uncertainties and mitigation measures do provinces, municipalities, and system operators experience and foresee in the process of integraal programmeren?

The case study first consists of a quick scan of uncertainties in the different regions. And then selects a few frequently mentioned uncertainties to further elaborate on. These uncertainties will be identified in the case study. In the interviews provinces, municipalities and DSOs will be asked about

the influences they see of uncertainties stemming from market parties on the formation of the collaboration. Using the theoretical framework these influences will be further defined and linked to mitigation measures.

2.3.3 Design guidelines

After understanding the context, the principles for the design of the collaborative process can be defined. These are addressed in the next sub-question:

3. What design guidelines to deal with uncertainties result from the analysis of integraal programmeren?

In this phase, suggestions for requirements and steps for designing the collaboration process will be formulated and substantiated. These will be based on the theoretical framework, interviews, and a focus group. First, the design guidelines stemming from the theoretical perspectives are analysed and grouped into categories. Of these design guidelines a few are chosen, in consultation with the experts at Groen Licht, to further explore in the focus group. These guidelines are selected based on their relevance to mitigating uncertainties stemming from market parties.

3. Analytical framework

The goal of this thesis is to analyse the process of integraal programmeren and assess how and to what extent uncertainties are taken into account, which feed the contours of a design strategy that would result in a new version of a long-term regional collaborative infrastructure planning process. A theoretical framework was constructed to analyse process requirements and uncertainties of integraal programmeren. The framework is used to identify theories that can be connected to the practice of integraal programmeren. The theoretical framework consists of two pillars: (1) collaboration process design and (2) uncertainties. Both pillars cover multiple theoretical perspectives.

To construct the first pillar, four theories have been chosen as a starting point, as elaborated on in the methodology:

- Anna Bergek's work on innovation systems
- Elinor Ostrom's IAD framework
- Ernst ten Heuvelhof and Hans de Bruijn's work on management in networks
- Bart Nooteboom's work on trust

For each theoretical perspective knowledge about how to design a long-term collaborative process is gathered, based on which the theoretical framework is developed, the theoretical lens with which to approach the topic of this research: the integraal programmeren collaborative process.

3.1 Systems

The energy system is a socio-technical system, it consists of connected elements, like actors, networks, institutions and artefacts that are necessary to fulfil a societal function, in this case, energy provision (Edmondson et al., 2019). A socio-technical system consists of technical structures that shape the physical processes as well as institutional structures that shape the decision-making processes (Bots et al., 2012). Socio-technical systems often face complex problems that call for policy interference (Bauer & Herder, 2009). To analyse or design a (part of a) system often optimisation or simulation models are used, however, in a socio-technical system there is not one correct answer (Bauer & Herder, 2009). Bergek et al. (2005) acknowledge three important aspects of systems to keep in mind when analysing a system. First, a system develops over a long period, which leads to considerable uncertainty. Second, because it does not concern an optimisation problem, goals are unclear. And third, in a multi-actor system, policymakers are not necessarily the ones making the decisions which makes policies not always the best solution (Bergek et al., 2005).

System design methods are often aimed at the design of technical systems, but they can also apply to socio-technical systems since both require a design that fits into an existing environment (Bots et al., 2012). Although Jacobsson and Bergek (2011) agree, they see this with a bit more nuance and say socio-technical systems are more complex because of their multi-actor and multi-dimensional character and therefore require more attention. This complexity calls for a better understanding of how a system functions before intervening in a system (Jacobsson & Bergek, 2011). Therefore Bergek et al. (2008, 2015) constructed a framework to analyse the functioning of a system to identify system weaknesses (figure 7). This framework was originally focused on identifying policy issues in

technological innovation systems and has since also been applied in socio-technical innovation systems, such as (parts of) the energy system[1].

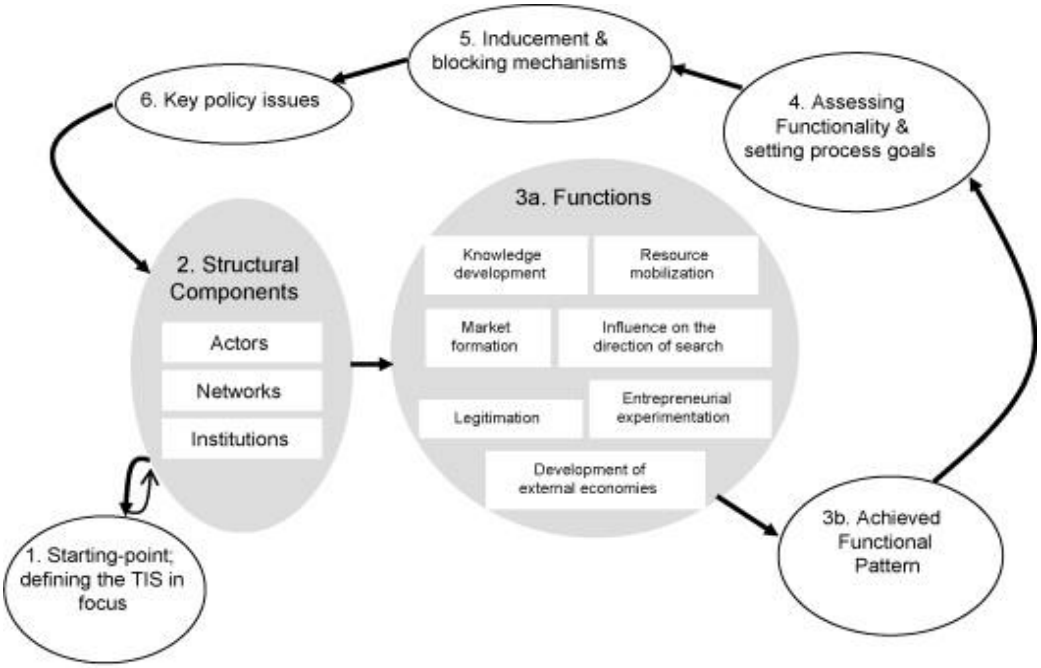


Figure 7. Scheme of analysis for systems (Bergek et al., 2008).

3.1.1 Analysis of systems

The framework follows six steps to identify key policy issues, that hinder the functioning of the system. A system consists of components working together to serve a common goal (Jacobsson & Bergek, 2011). The processes are influenced by the contextual structures of the system, therefore the scheme of analysis begins with defining the system and describing the main components of the system: actors, networks and institutions (Bergek et al., 2008, 2015). In practice, this step can be quite difficult since systems often overlap and the system borders can be blurry. In the next step, seven key structural processes are described which lead to an achieved functional pattern (Bergek et al., 2008). The steps after that describe possibilities of how to get from the achieved pattern towards a desirable functional pattern, through goal setting and identification of issues. However, in socio-technical systems there is often not only one right solution, therefore the analysis is a circular scheme so after implementing the policy instrument, the system also keeps being monitored and is open to minor improvements (Bergek et al., 2005).

Each of the seven key processes is shortly discussed (Jacobsson & Bergek, 2011):

- *Knowledge development*: generation, diffusion and combination of knowledge in the system.
- *Market formation*: the creation of new structures to exchange products and services.
- *Resource mobilization*: the extent to which (human, physical financial, etc.) resources can be activated or moved.
- *Influence on the direction of the search*: incentives and pressures for entering the system.

[1] Based on a scan of the documents that have cited Bergek et al. (2008)

- *Legitimization*: fitting in the social and institutional context.
- *Entrepreneurial experimentation*: learning process coming forth out of testing of new technologies, applications, processes etc.
- *Development of positive externalities*: the resulting positive side-effects of the system.

Furthermore, for new systems, additional key processes are defined (Jacobsson & Bergek, 2011):

- Entry of firms and other organizations along the supply chain.
- Formation of social, political, and learning networks.
- Alignment of institutions.
- Accumulation of knowledge.

Mechanisms, like for example uncertainties, that block a function can cause the system to fail (Jacobsson & Bergek, 2004). A problem in any of the processes can cause hindrance to the development of the whole system (Jacobsson & Bergek, 2011). So, the key processes are preconditions for a functioning system and in that sense can be translated to design principles for a system. However, it can be difficult to measure the functionality of the processes. Bergek discusses a range of indicators, but these are highly dependent on the nature of the system and the goal you are trying to achieve. Therefore no standard indicators have been defined (Bergek et al., 2005; Jacobsson & Bergek, 2011). Clear criteria to define weaknesses in the processes are often vague and therefore best defined in interviews with actors in the system (Bergek et al., 2008).

System weaknesses are not only found in the system itself but can also originate from the context of the system, on a sectoral, regional or national level (Jacobsson & Bergek, 2011). The interactions between the system and its environment are often neglected in the analysis of a system. Bergek et al. (2015) identify four different kinds of interactions: (1) with another system, (2) with the relevant sector, (3) in the geographical structure, and (4) in the political context. The coupling with other structures means that interdependent dynamics can arise, and changes in the system can change the context and vice versa (Bergek et al., 2015). Therefore it is very important to also observe the context when analysing a system.

3.2 Institutions

Processes of interactions, in which decisions are made, are shaped by institutions. Ostrom defines institutions as "the prescriptions that humans use to organize all forms of repetitive and structured interactions" (Mcginnis, 2020). To understand how interactions are shaped from an institutional perspective Ostrom designed the Institutional Analysis and Development (IAD) framework (Figure 8) (McGinnis, 2019). At the centre of the framework is the action situation, in which interaction and decision-making moments between actors can be identified (Mcginnis, 2020). The action situation is influenced by contextual variables: biophysical conditions, attributes of community and rules in use. Institutions cannot be seen separately from their environment, and the uncertainties stemming from the contextual variables. Therefore, Ostrom states that institutions change over time and should be thought of as an ongoing learning process in an uncertain environment (Ostrom, 1993). So the IAD framework analyses institutions based on the interactions between actors, rules, and resources and their role in shaping the behaviour and outcomes of collective action, which makes it suited for institutional analysis on a local scale (Ostrom, 1990). In comparison, the comparative institutional analysis of Aoki recognizes the importance of historical and cultural factors in shaping institutional

arrangements and distinguishes between different levels of analysis, such as individual, organizational, and societal, making it more suited for a global scope (Aoki, 2001).

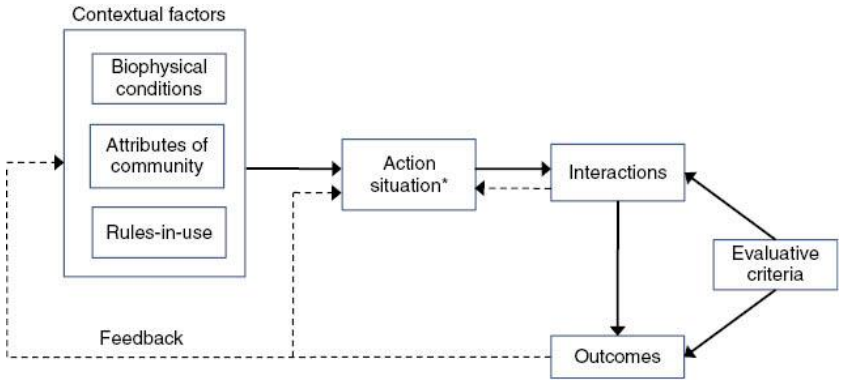


Figure 8. The Institutional Analysis and Development (IAD) framework (Ostrom, 2011).

Institutions can be seen as instruments to reduce uncertainty in complex, uncertain environments (Cox et al., 2010). Trust and norms of reciprocity can result from reducing uncertainties, which can help in building collaborations. Ostrom identified a set of eight design principles to explain what conditions are necessary to build and sustain trust and norms of reciprocity for groups managing common pool resources (Ostrom, 1990; 1993). Because in a group that adheres to these principles, group achievements are higher valued than individual success (Wilson et al., 2013). Common pool resources are goods and services that are difficult to exclude people from and are rivalrous. Because of these characteristics common pool resources are vulnerable to the tragedy of the commons, which entails that people overuse the resource leading to depletion over time (Ostrom, 1990). Energy can be considered a common pool resource because it is a shared and finite resource and its infrastructure makes it difficult to exclude people.

Ostrom's design principles were originally formulated for common pool resources in small communities (Ostrom, 1990). However, the principles have since then been applied in many different situations, which gives enough theoretical and empirical foundation to suggest that the design principles can be adjusted to be applied in a broader context (M. Mcginnis & Ostrom, 1992; Wilson et al., 2013).

Each design principle is shortly discussed (Ostrom, 1990):

1. *Boundaries (biophysical and social) are clearly defined.* Organizations and individuals who have rights to be involved in the system should be clearly defined, as must the boundaries of the system itself. This ensures that no outsiders can reap benefits that they have not helped create. And this can help create collective action.
2. *Congruence between appropriation and provision rules (for fairness considerations) and fitness to local conditions (for practicality)*. Appropriation rules concerning time, place, technology, and quantity of resource units and provision rules about labour, material, and money should be made. These rules have a strong relationship with the local conditions and should be fitted accordingly.
3. *Collective choice processes enable most affected individuals to participate in making rules.* Organizations and individuals affected by the rules should be able to participate in modifying the rules. This allows better customization of the rules for local circumstances since the

people making the rules are directly involved in the system. And in addition, it is suggested that having an influence on the rules results in more compliance with the rules (Ostrom, 1990).

4. *Monitors are accountable to appropriators (or are the appropriators themselves).* Monitors that oversee the system should feel responsible. Monitors may not perform satisfactorily if they do not directly benefit from the improved resource conditions (Cox et al., 2010)
5. *Graduated sanctions are applied to rule violators (in increasing levels of intensity).* Organizations and individuals who violate the rules should be punished in accordance with the seriousness and context of the offence. Sanctioning is undertaken by participants of the system themselves because they are motivated to monitor and sanction in order to assure themselves that others are following the rules.
6. *Participants have easy access to low-cost local arenas to resolve conflicts.* In a long-term process, the chances are high that over time mistakes are made or rules are differently interpreted. Therefore, it is important to have a structure in place to discuss and resolve conflicts. This mechanism can be quite informal.
7. *Minimal recognition by "higher" authorities that appropriators have rights to self-organize and devise their own institutions.* Rules can be adjusted over time without creating formal governmental jurisdictions. External governments should give the appropriators the freedom to set and enforce their own rules.
8. *Nested enterprises for appropriation, provision, monitoring, enforcement, conflict resolution, and governance.* Appropriation, provision, monitoring, enforcement, conflict resolution, and governance are organised in horizontal and vertical linkages and each has its own sub-organisation (Cox et al., 2010). This enables different sub-organisations to make rules fitting the problems they face without affecting the entire system. This is especially relevant for complex systems, as it allows for better organisation and coordination of different functions.

The design principles have been critiqued for being too broad (Cox et al., 2010; Wilson et al., 2013). For that reason, a distinction should be made between the principles and the implementation of the principles. There are many ways the design principles can be implemented. The implementation should be tailored to the local situation, but the principles can account for different situations. That is why the design principles can be defined in more general terms (Ostrom, 1993; Wilson et al., 2013). Furthermore, many scholars consider the design principles incomplete because social mechanisms like trust, legitimacy, and transparency have been proven to have a bigger impact on sustaining institutions (Cox et al., 2010). For instance, groups whose members have similar values have been shown to better collaborate without requiring rules on monitoring and punishment (Wilson et al., 2013). Therefore, Ostrom formulated four additional requirements (McGinnis, 2016):

9. *Effective leadership is demonstrated in all action situations*, individuals and groups managing a common pool resource require guiding and coordination. Therefore each suborganisation, responsible for their own function, should be held accountable to the larger system.
10. *Long-term concerns are incorporated in dispute resolution and other evaluative processes*, meaning that long-term consequences should be considered in the decision-making and learning process.
11. *Information is available in a timely fashion for all monitoring and evaluative processes*, decisions should be made with the best available information in order to effectively manage the resource.

12. *Trust and reciprocity norms are reinforced by participation in most or all of these processes*. Trust and reciprocity norms encourage cooperation and work towards a shared understanding.

With the addition of these requirements, the design principles can be very useful for groups that need to accomplish shared objectives (Wilson et al., 2013).

3.3 Networks

Changes in complex environments always occur in a network of actors (Bruijn et al., 1998). A network consists of multiple actors that have different goals and their own resources but that are dependent on each other to achieve their goals (Bruijn & Heuvelhof, 2007). Mutual dependency is a key characteristic of a network, and because of this interdependency actors need to cooperate (Bruijn & Herder, 2009). In a complex problem, uncertainties often arise because the knowledge required to solve the problem is invested with different actors. To access the information, these actors need to be involved in the problem-solving process (Bruijn et al., 1998). However, since actors have different and sometimes conflicting views, it can be difficult to reach collective decisions in a collaboration (de Bruijn & Heuvelhof, 2002). Therefore working in a network leads to a process of negotiation between the actors (Bruijn et al., 1998). In such a process, actors may make use of strategic behaviour to pursue their own interests (de Bruijn & Heuvelhof, 2002). These strategies have a positive impact on the effective functioning of networks but have a negative impact on trust, which is an important factor for the success of cooperation as well (Bruijn & Heuvelhof, 2007; Heuvelhof, 2016). Processes are part of a bigger context and therefore actors often also meet in different circumstances. This has consequences for their behaviour in the process: they can make use of their dominant position to get their way, bring up issues of different processes as leverage or they can play strategic games like waiting or having no interest in consensus (Bruijn et al., 1998).

A process design can help manage strategic behaviour but also should provide actors with the freedom to act in their self-interest (de Bruijn & Heuvelhof, 2002). Actors are not always eager to join the process on their own initiative and may think of it as a trap (de Bruijn & Heuvelhof, 2002). Designing the process in a way that offers actors opportunities to pursue their interests, motivates actors to be involved in the process since it gives them something to gain (Bruijn et al., 1998). In addition, actors need a sense of urgency to get involved in the process, they need to be aware of the issue and to be convinced they can only solve it through collaboration (Bruijn et al., 1998).

Once actors are aware of the need of collaborating, they can make process rules. The concept of process rules is often used interchangeably to describe different sets of rules (Bruijn & Herder, 2009b). Two kinds of process rules can be distinguished in the literature of Bruijn and Heuvelhof: rules on behaviour and rules to consider in the process design (Bruijn et al., 1998). Rules on behaviour also called the rules of the game, are negotiated by the actors at the start of the process (de Bruijn & Heuvelhof, 2002). There are four categories of rules of the game (Bruijn et al., 1998):

- *Entry and exit rules*: Describe who may participate under which conditions and how they can leave the process.
- *Decision-making rules*: Describe how and by whom decisions are made in the process. This often also includes agreements on conflict resolution.
- *Organic rules*: Describe the organisation of the process, and which structures and roles the process requires.

- *Rules about planning and budget*: Describe how resources are divided and used.

The rules of the game are directed at actors regarding their goals, perceptions and their strategies (J. F. M. Koppenjan et al., 1993). They can be explicitly established at the start of the process but also extend to implied standards of conduct. Following these rules in combination with regular interactions results in trust between actors, making most rules almost unnecessary in the long run (Bruijn & Heuvelhof, 2007).

In addition, a good process guiding the interactions is just as important to facilitate complex processes of change (J. F. M. Koppenjan et al., 1993). Therefore rules or guidelines are needed for designing the process. The actors in the network work towards a common goal, for which they need each other to succeed. However, in a complex uncertain environment goals can change over time. This calls for a dynamic process that is equipped to deal with these changes (Bruijn & Heuvelhof, 2007). So instead of the commonly used project approach, it has been suggested that in a network of dependencies, process management is used (Bruijn et al., 1998). This form of management intends to create a collaboration between actors to solve societal problems. Process management can be used to direct the interactions in a multi-actor process and to facilitate processes of change (J. F. M. Koppenjan et al., 1993). To advance the collaboration, the process design needs to balance four core design principles: openness, safety, progress and content (figure 9) (Bruijn et al., 1998).

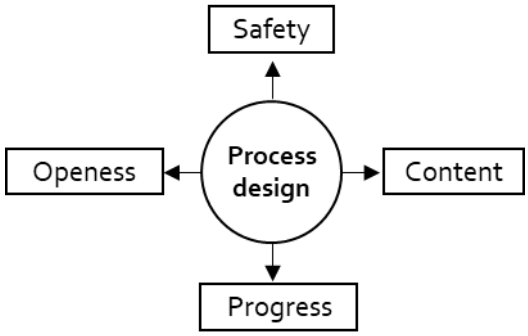


Figure 9. Key elements of process design, adapted from (Bruijn et al., 1998).

3.3.1 Openness

Both the process and process management should be open to negotiation. Actors should be offered the same chance to influence the process and the decision (Bruijn & Herder, 2009b). This allows them to pursue their own goals and interests. This requires the process to conform to three design principles. Firstly, all actors that are needed to achieve the overarching goal of the process should be involved in the decision-making process (Bruijn et al., 1998). Which actors should be involved in the process is not always clear, in this case, it can help to assign accounts to actors in which they represent a broader interest.

Secondly, it is important that substantive choices are made part of the process. At the start of the process, only choices about the process itself should be made like when and how decisions are made, therefore substantive decisions are made in light of the process agreements (Bruijn et al., 1998). And lastly, openness should go hand-in-hand with transparency. Transparency makes sure that actors can check if the process is fair and if they are offered the same opportunities as the other actors. These three design principles contribute to the commitment of the actors to the process (Bruijn et al., 1998).

3.3.2 Safety

Openness needs to be balanced out by creating a safe environment for the actors in which trust can be built. Committing to a process brings along a risk for the actors, it could be possible that in the end they disagree with the result and it is too late to back out. Therefore Bruijn et al. (1998) formulated four design principles to contribute to a safe process environment. First, the core values of the actors need to be protected in the process to give the actors an incentive to cooperate in the process. This also entails that the actors respect the core values of the other actors.

The next principle concerns the commitments made by the actors, these may be postponed in order to prevent a difficult decision-making process. In a complex, uncertain process it is difficult to predict what the outcome of the process will be, committing early in the process can lead to a perceived lock-in effect (Bruijn & Herder, 2009a). Putting off the decision will also result in space and time for learning experiences and trust-building during the process. Moreover, actors should be given the possibility to leave the process over time and this requires exit rules. This lowers the threshold to enter the process and when the process is ongoing, it will often no longer be appealing to leave. Finally, actors should commit to the process rather than to the result. This means that the execution of the result is not implied in the process. This is in line with setting exit rules, if an actor no longer feels safe or feels like his core values are disrespected he is free to leave the process.

While these design principles appear to be without prejudice, it leads to actors joining the process. While they are free to leave, in reality, they will not often do so, since trust in the process grows over time (Bruijn et al., 1998). However, this does require a balance with the other design elements.

3.3.3 Progress

The first two design elements ensure actors are involved in and committed to the process. However, this does not guarantee a good process. Therefore, it is also important that there is progress in the process (Bruijn & Herder, 2009a). Progress can be defined by the time it takes to make a decision in addition to the robustness of the decision. Progress requires the willingness to participate, conflict avoidance and also looking at the external environment. This is rendered in six design principles. First, in order to incentivise actors to collaborate and keep collaborating during the process there should be a prospect of gain to motivate them. Secondly, the process should be heavily staffed. Furthermore, it is important that the external context of the process is taken into account and when possible is used to create opportunities for wins or to stimulate collaboration. In return, the process needs to regularly provide the external environment with updates that increase trust from out the environment. Additionally, the context of the process includes a bigger timeline the process is part of. The finiteness of the process can also be used to create cooperative behaviour. And lastly, a process calls for conflict management, since conflicts close to the decision-making centre can delay the process.

3.3.4 Content

The last design element that needs to be balanced is the content of the process. The process should be of sufficient qualitative substance in order to be of use, otherwise, the process will lead nowhere (Bruijn et al., 1998). This is expressed in two design principles: 1.) substantive insights are used for facilitation and 2.) substantive variety and selection. To adhere to the first principle, experts can be activated. In this case, it is important that there is a clear coupling and uncoupling between the experts and the actors. They need to be coupled to improve the quality of the decision-making process but need to be uncoupled to generate objective information (Bruijn & Herder, 2009a). The second design

principle refers to a broad insight at the start of the process that is narrowed down through selection phases, this helps with reducing uncertainties over time (Bruijn et al., 1998).

These design principles are meant to keep the balance between a focus on the process and a focus on the content, resulting in a focus on a good methodology with content to achieve the goals of the process.

3.4 Collaboration

In a collaboration, actors interact with each other and share experiences. Collaborating comes with a risk since it can have both positive and negative effects (Nooteboom et al., 1997). In an increasingly complex world transactions between organisations have become more important, and therefore the processes behind them, like knowledge exchange, trust, and conflict resolution, have also gotten more scholarly attention (Nooteboom, 1995, 2000). Collaborations assist the process of knowledge and resource exchange and in that sense can play a crucial role in achieving shared goals (Nooteboom, 2000). In order to interact actors need to understand each other, which can be difficult. People perceive the world differently and think and act within their own physical, social and institutional context (Nooteboom, 2000, 2001). Different actors will therefore interpret problems differently. This means that in a collaboration, this cognitive distance needs to be reduced to be able to achieve shared goals (Nooteboom, 2000). Reducing cognitive distance goes further than understanding each other, it is also about making sense of and comprehending the explanation and thought process. As actors interact the cognitive distance between the actors reduces, which increases the functioning of the collaboration (Nooteboom, 2000).

In a collaboration, there are mutual dependencies and a need for coordination of knowledge as well as competencies. Because of this, collaborations are characterised by relational risks and governance problems (Nooteboom et al., 1997). Nooteboom (2000) discusses different governance solutions to reduce risks in collaborations, of which the most discussed is trust. There is a positive correlation between trust and information, if there is trust between actors they are more likely to exchange information (Nooteboom, 2001). Consequently, trust can reduce the risks actors experience and is suggested as a governance instrument (Nooteboom, 2000; Nooteboom et al., 1997). Nooteboom argues that even though trust grows over time and you cannot use it instantaneously, it can be seen as an instrument because it can influence your decision to select a partnering organization and it can be designed in a process to develop over time (Nooteboom, 2000).

To build trust, first, there should be made a distinction between trusting the partner has the right capabilities (competence trust) and if the partner has the right intentions (intentional trust) (Nooteboom, 2000). Nooteboom focuses on intentional trust since this is the most complex. In this context, he defines trust as "The expectation that things or people will not fail us, or the neglect or lack of awareness of the possibility of failure, even if there are perceived opportunities and incentives for such failure" (Nooteboom, 2001). This definition also includes trust in organisations.

3.4.1 Building trust

Trust can originate from different bases, as shown in Table 1. Trust builds over time, but this does not mean that it cannot be incentivised (Nooteboom, 1995). Institution-based trust can be included in a design as can process-based trust, however, this takes a while to develop. Characteristics-based trust

can be more difficult since the entry selection for a membership can be strict, but can be facilitated by creating favourable conditions (Nooteboom, 2001).

Building trust in a process can seem counterproductive since control and trust are sometimes seen as opposites because in highly controlled environments it can be difficult to build trust (Nooteboom, 1999; Nooteboom et al., 1997). Therefore trust most importantly needs to build on familiarity and mutual understanding and in a lesser sense on formal contracts and rules (Nooteboom, 1995; Nooteboom et al., 1997).

Table 1. Modes of trust production adapted from (Nooteboom, 2001).

Kind of trust	Basis	Examples
Intentional trust	Characteristics based trust	Membership of family, community, culture, religion
	Institutions based trust	Rules, ethics, professional standards
	Process-based trust	Loyalty, commitment
Competence trust	Characteristics based trust	Membership of professional associations, educational achievements
	Institutions based trust	Technical/professional standards, benchmarking
	Process-based trust	Mutual adaptation, learning by doing, routinisation

3.5 Uncertainties

All theoretical perspectives assume an uncertain, complex environment but interpret uncertainties in different ways. According to Jacobsson & Bergek (2004), uncertainties can stem from the long time horizon of a system and these uncertainties can cause the system to fail. Likewise, Bruijn & Heuvelrug (2007) recognize that goals can change over time, which can lead to uncertainties. To reduce uncertainties they suggest a collaboration process, with an underlying process design. Additionally, institutions can be seen as instruments to reduce uncertainty in complex, uncertain environments (Cox et al., 2010). Ostrom (1993) adds that reducing uncertainties can lead to trust and norms of reciprocity which can help in building collaborations. While Nooteboom et al. (1997) mention that collaboration can lead to relational risk from which uncertainties can arise and thinks of trust as a solution rather than a result. Evidently, uncertainties play an important part in the collaboration process but can be approached in various manners.

Uncertainties are shown to influence decision-making between actors and consequently influence the creation of a collaboration process (Erkoyuncu et al., 2013; Sniazhko, 2019). Sniazhko states uncertainty can originate from "a lack of knowledge about the probabilities of the future state of events". Koppenjan (2004) adds that uncertainties in a process can also stem from "strategic and

institutional features of the network setting in which these wicked problems are articulated and processed". The term uncertainty is often substituted by risk, ambiguity or ignorance. The distinction between these terms can be further defined by looking at two parameters that form four quadrants (figure 10): the knowledge about the likelihoods and the knowledge about outcomes (Stirling, 2017). These quadrants all call for different assessments and mitigation methods.

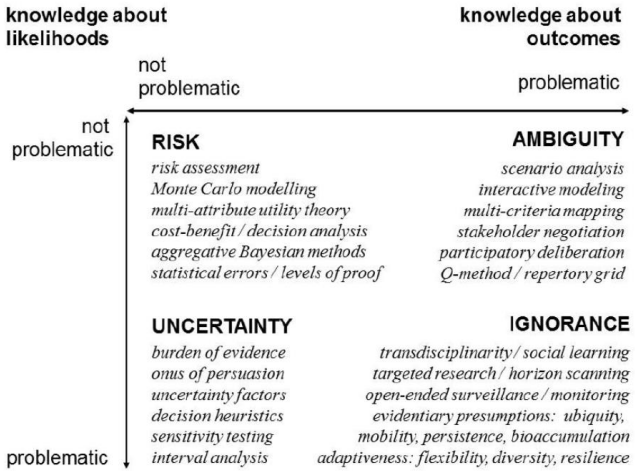


Figure 10. A matrix of different kinds of unknowns, depending on the nature of the unknown (Stirling, 2017).

Uncertainties can not simply be reduced by a risk approach, which has often been used as a control measure (Stirling, 2017). In today's complex and interconnected world uncertainties can lead to opportunities and hope (Scoones & Stirling, 2020). Stirling's distinction of unknowns is aimed at emphasizing the significance of the context of the unknown. Uncertainties cannot be reduced to the absence of knowledge, it is about how possible futures are understood and framed, and thus are subjective conditions. Different actors experience uncertainties in different ways based on their personal contexts (Scoones & Stirling, 2020). In practise the most dominant actor mostly influences the framing of an uncertainty, but Scoones & Stirling (2020) suggest that uncertainties should be kept open to debate. As a consequence, other forms of governance should be devised that facilitate negotiation and future-making between actors

In addition to different sources of uncertainties, a distinction can be made between different places of uncertainties. A process cannot be seen separately from its environment, as it constantly interacts with the environment (Abbott, 2005). The same is the case for the uncertainties within the process and uncertainties within its environment. Both types of uncertainties interact with each other but are still different in nature. The process uncertainties that occur within the process itself, are often loaded with value perceptions of the actors within the process (Abbott, 2005; Koh et al., 2002). Uncertainties in the environment come from economic, social, political, and environmental processes (Abbott, 2005). Miller (1992) has composed a similar framework for managing uncertainties in businesses. He identifies uncertainties in the general environment, industry, and within the firm (Miller, 1992; Sniazhko, 2019). For a process, these can be translated to process uncertainties, uncertainties in the process environment, and uncertainties in the external environment. The external environment includes uncertainties crossing over sectors and industries, while the process environment addresses uncertainties within the field of the process. To these categories, sub-categories can be assigned (figure 11).

Figure 11. Framework for categorizing uncertainties in a process based on the location relative to the process.

So, uncertainties can differ based on location and source of the uncertainty (Maxim & van der Sluijs, 2011). Different kinds of uncertainties require different kinds of assessment and mitigation. These frameworks help with understanding the different uncertainties in integraal programmeren and managing them.

3.6 Construction of the framework

This scientific literature study explored two theoretical domains in parallel to generate a theoretical framework (figure 12) with the aim to analyse collaboration process requirements and uncertainties of integraal programmeren. The theoretical framework consists of two pillars: (1) collaboration process design and (2) uncertainties. The framework aids in drafting design guidelines to improve the management of uncertainties in the process of integraal programmeren.

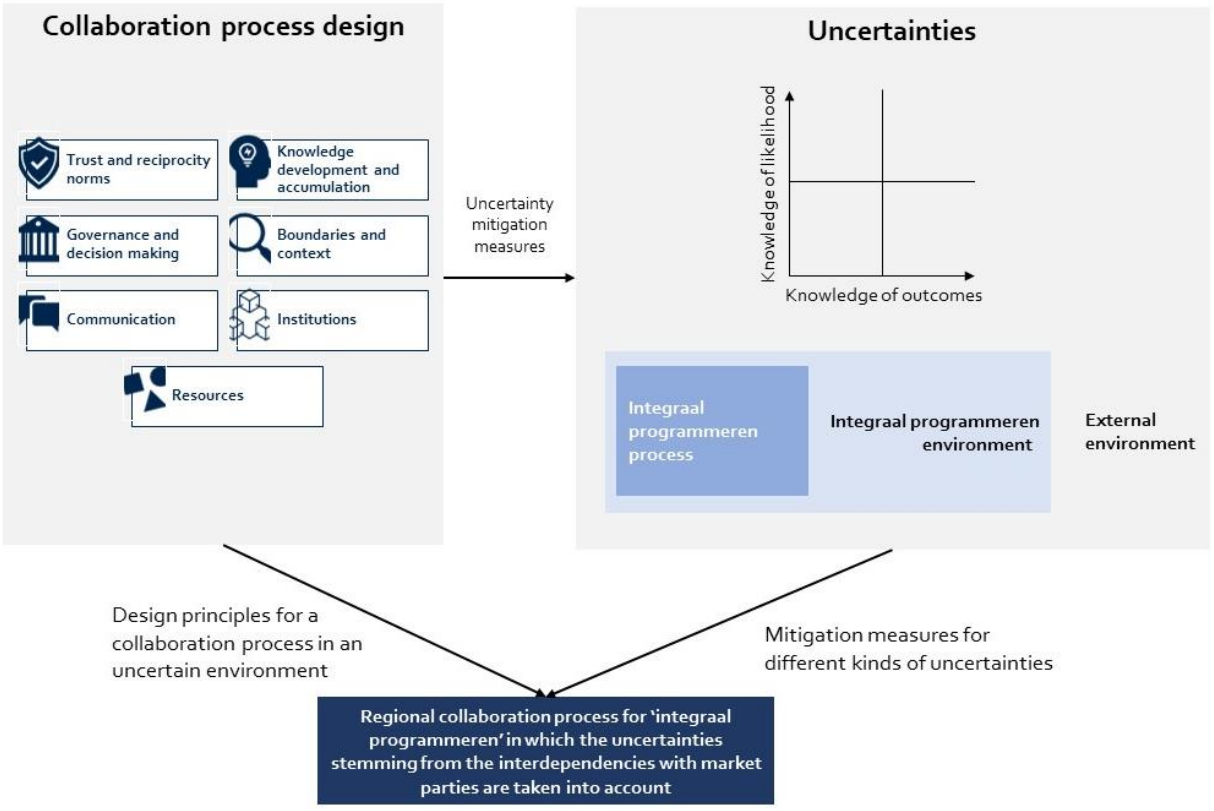


Figure 12. The theoretical framework consists of two pillars, used to research how a long-term collaboration process can be designed while taking into account process uncertainties.

3.6.1 Collaboration process design

The first pillar describes different perspectives on how to design an effective collaboration process in an uncertain environment. While the perspectives propose different design guidelines and focal points, certain similarities can be recognised. The guidelines can be divided into the following overarching categories:

- Trust and reciprocity norms
- Knowledge development and accumulation
- Governance and decision making
- Boundaries and context
- Communication
- Institutions
- Resources

The distinction in categories allows more versatility and usability since multiple perspectives are combined. Although this may lead to more generality, the underlying design guidelines can still provide more depth. The overview of design guidelines per category can be found in Appendix A.

3.6.2 Uncertainties

Uncertainties can differ based on the location and source of the uncertainty (Maxim & van der Sluijs, 2011). Different kinds of uncertainties require different kinds of assessment and mitigation. Two frameworks have been analysed, that can help with understanding the different uncertainties in integraal programmeren and managing them.

Stirling (2017) states that uncertainty originates from a lack of knowledge about the probabilities of the future state of events. For example, the uncertainty about the sustainability transition for a certain sector is an uncertainty where the likelihoods of something happening are mostly unknown, while the possible outcomes, transition to electrification, hydrogen or heat, are mostly known. To analyse this kind of uncertainty quantitative and qualitative methods are suggested like scenarios and decision heuristics. Stirling (2020) also adds the method of future-making between actors, in which uncertainties are mitigated by discussing them between the involved actors.

In addition to different sources of uncertainties, a distinction can be made between different places of uncertainties. A distinction is made between uncertainties in the process, uncertainties in the process environment and uncertainties in the external environment. However, the lines between these places are vague because there is a constant interplay between the uncertainties. For example, the uncertainty about the sustainability transition for a certain sector takes place in the process environment but can also cause uncertainties in the process about for instance which actors are involved.

Both these frameworks help to better understand the uncertainties. By defining the core of the uncertainties, it can be easier to work towards interventions to mitigate, solve or accept the uncertainties.

3.6.3 Use of the framework

The theoretical framework leads to the contours of design guidelines to improve the management of uncertainties in the process of integraal programmeren. The framework combines design guidelines

for a successful collaboration process in a socio-technical environment with methods for defining uncertainties. It can be used to interpret how design guidelines for a collaboration process can help with mitigating certain uncertainties. This builds on the idea that uncertainties should be kept open to debate and should be tackled by the actors together (Scoones & Stirling, 2020). In the case of integraal programmeren, the framework can provide a foundation for designing a collaboration process between the regional governments and system operators, and market parties in order to reduce the uncertainties stemming from market parties.

The framework explores the connection between process design and uncertainties, which is still a research gap in scientific literature. Combining these two notions and validating them with actors in the process can provide more clarity about the interaction between uncertainties and collaboration in the context of integraal programmeren. The use of the framework on integraal programmeren could also lead to more generally applicable insights about the interconnection between mitigating uncertainties and collaboration.

4. Conceptual analysis

In the method was stated that the collaborative process of integraal programmeren takes place in a socio-technical system, is shaped by institutions and is part of a network in which actors interact with each other. These characteristics made up the starting points of the theoretical framework. Socio-technical systems are often analysed in terms of their components, which in the case of a collaboration process are actors, networks and institutions (Edmondson et al., 2019). Therefore this conceptual analysis defines integraal programmeren along these concepts in addition to a description of the background and steps of integraal programmeren.

4.1 Background of integraal programmeren

The process of integraal programmeren was set up to better suit the changes the energy system is facing. The Netherlands is going through multiple transitions that have an impact on the energy system. A couple of developments that influence the energy system can be highlighted that played a part in the origin of integraal programmeren.

- *The energy transition*. In the transition to cleaner energy sources decentralization of energy and feeding into the net is increasing, also in rural areas, something the electricity infrastructure was not originally set out to do (Netbeheer Nederland, 2019). Renewable energy calls for different ways of transporting and distributing energy and more flexibility in the system (*MvT Energiewet*, 2021). The high ambitions and high energy prices because of the war in Ukraine accelerate the transition (Jetten, 2022a). Which calls for the expansion and reinforcement of the electricity network.
- *Sustainability plans of other sectors.* Not only the energy sector is becoming more sustainable, but also other sectors are transitioning to new ways and forms of using energy. The use of hydrogen or heat or electrification calls for new energy infrastructure (Yeşilgöz-Zegerius & Blok, 2021).
- *Scarcity of staff and materials.* While the pressure for new infrastructure, especially on the electricity network is rising, there is a shortage of technical staff to carry out expansion work (Jetten, 2022a). Normal expansion work is already a long process of 6-10 years, but the shortages delay this process even further (Netbeheer Nederland, 2019).

These developments show that the energy system is changing and becoming more complex and intertwined with other sectors (Yeşilgöz-Zegerius & Blok, 2021). Therefore energy infrastructure is not only conditional for achieving the energy transition but also for realizing other public goals (WRR Rapporten, 2008). Recent incidents of net congestion on the electricity network demonstrate this (Netbeheer Nederland, 2021). In many regions in the Netherlands, the development of energy networks cannot keep up with the supply and demand, which means, for example, new solar parks or industrial parks cannot be connected to the electricity network. These developments lead to new dynamics in the energy sector, instead of realising energy infrastructure whenever needed there is a division and planning issue, in which energy infrastructure must be approached in a social and spatial integrated manner (Jetten, 2022a).

Energy infrastructure planning is a complex problem in which many actors are involved. The investment process is not only about network planning, but in this process also environmental planning, spatial planning, financial decisions, regulation and government approval come together (WRR Rapporten, 2008). Because of the recent complications, distribution system operators have called multiple times for a directing role for provinces for energy infrastructure (IPO, 2021; Netbeheer

Nederland, 2021). A directing role of a local government provides the opportunity to look at investments beyond a technical and financial perspective and also take social values and spatial planning into account, as well as speed up permitting procedures (Jetten, 2022a). Consequently, a task force was formed by the provinces to research what such a role could entail (IPO, 2021). In April 2021 the task force concluded that a directing role for provinces on energy infrastructure would be beneficial. In light of this conclusion, the intergovernmental Workgroup Integraal Programmeren (WIP) was started to further develop the regional process of integraal programmeren (IPO, 2021). In this group representatives of the state, provinces, municipalities, regional water authorities and system operators work together (Werkgroep Integraal Programmeren, 2022).

4.2 Steps of integraal programmeren

Integraal programmeren is about designing, planning and making public decisions on future energy infrastructure in a way that is coherent with spatial developments and sectorial plans on energy demand and supply (Werkgroep Integraal Programmeren, 2022). Integraal programmeren takes place on multiple levels, like national and regional/provincial and can also be necessary locally (Rijksdienst voor Ondernemend Nederland, 2022). There is a strong coherence between these levels because energy infrastructure often goes across borders and is balanced on a bigger scale, therefore coherence between the different programs is important. This research focuses on the regional/provincial scale where integraal programmeren results in a 'Provinciaal Meerjarenprogramma Infrastructuur Energie en Klimaat' (PMIEK).

The regional process of integraal programmeren started its first iteration in 2022 with pilots in three regions to test the steps of the process (Werkgroep Integraal Programmeren, 2022). The process of integraal programmeren is a cycle consisting of five steps (figure 13).

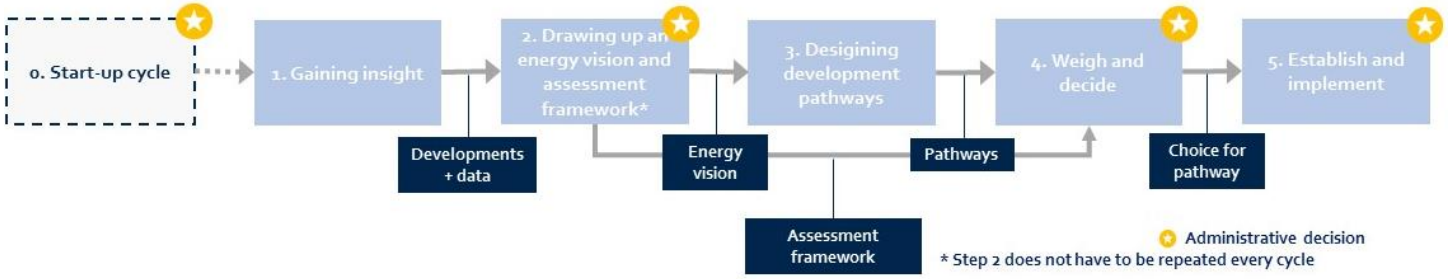


Figure 13. The steps of the integraal programmeren process and their outputs. The stars indicate an official decision that the actors anchor in their own organization. Not every step is repeated each cycle. Adapted from (Werkgroep Integraal Programmeren, 2022).

Integraal programmeren directs at the whole energy system and takes an integral look at different energy carriers (Werkgroep Integraal Programmeren, 2022). However, because of the urgency and congestion of the electricity network, this gets more attention right now (IPO, 2021). In the future hydrogen and heat will play a bigger part, especially since different energy carriers are becoming more intertwined and dependent on each other (IPO, 2021). These different energy carriers are organised differently, which is shortly explained below.

Electricity: The transport and distribution of electricity are regulated (Netbeheer Nederland, 2019). The transmission and distribution system operators are responsible for safety, security of supply and affordability, which is monitored by ACM (Autoriteit Consument & Markt) (*MvT Energiewet*, 2021).

Heat: The laws on the regulation of heat are changing. Heat is not yet regulated, but the new heat law, which will come into force in July 2024, poses that heating companies should be at least 51% owned by public parties (Jetten, 2022b). Which means heat will become regulated. As a consequence market parties are withdrawing from the sector (F. de Groot, personal communication, 10-11-22).

Hydrogen: Currently, hydrogen is not yet regulated. However, it is expected that it will be in a couple of years and Gasunie expects to play a role in this (G. Priester, personal communication, 14-11-22). This entails that DSOs are officially not allowed to invest in hydrogen but to accelerate the hydrogen transition the Ministry of Economic Affairs and Climate Policy has made an exception for pilot programs until rules on hydrogen are officially established in the new energy law (Netbeheer Nederland, 2022).

4.3 Actor analysis

The regional process of integraal programmeren is a collaboration between distribution system operators and provinces and municipalities. These actors bear joint responsibility for the process of integraal programmeren and make sure different values are protected in the process (Rijksdienst voor Ondernemend Nederland, 2022). In some regions, other actors are involved in the collaboration process as well, like water boards. The involved actors and their roles in the process are established in step 0, starting up the cycle, in a starting document. This starting document describes the approach in a region, agreed upon and committed upon by the actors in the process. Because integraal programmeren has no legal status yet, the actors are working from existing responsibilities and mandates (Werkgroep Integraal Programmeren, 2022).

The most important actors and their responsibilities in the process are shortly discussed:

Province: The provinces have a directing role in the regional process of integraal programmeren. This role entails they are responsible for organising the regional process, bringing the right actors together and drawing up a joint PMIEK (Werkgroep Integraal Programmeren, 2022). The legal duties the province has in the field of energy infrastructure are bounded to spatial planning, granting permits and supporting other actors in their tasks (IPO, 2021).

Municipalities: Municipalities contribute to the development of the PMIEK in the form of working on products, supplying information and establishing the outcomes of the process. The official tasks of municipalities include granting permits and designing spatial development plans. The role of the municipalities is still under construction and can have different interpretations in regions. In practice, this means municipalities are not yet involved in some regions or they are involved in the process by means of representatives.

Distribution System Operator: The DSO is in charge of constructing, managing and maintaining energy distribution networks. By law, they are responsible to keep the grid safe, reliable and affordable (Netbeheer Nederland, 2019). Their work is regulated by the ACM. In the process of integraal programmeren, they provide insight into possibilities in choices regarding investments and the technical, spatial and financial implications. They establish the outcomes of the PMIEK in their investment plans, which they are obliged to compose every two years.

Transmission System Operator: The TSO is responsible for the construction, management and maintenance of transmission energy infrastructure. While they mainly work on a national scale, they

are still involved in the regional process of integraal programmeren because of interdependencies with the networks of the DSOs.

State: The state is not directly involved in a regional working group for integraal programmeren, but does influence the process by setting national guidelines in the form of, for example, an assessment framework. The ministries of Economic Affairs and Climate Policy (EZK) and Interior and Kingdom Relations (BZK) are represented in the national working group for integraal programmeren.

Market parties: Market parties are relevant in the process of integraal programmeren in a few roles. The most apparent are those of energy users and suppliers. These market parties apply to the DSO for a connection to the grid or amplification of their existing connection. These market parties are now represented in the process through the sectorial plans from regional governments. Other kinds of market parties that might also be relevant for the process of integraal programmeren are non-regulated system operators and providers of flexibility measures (Netbeheer Nederland, 2019).

4.4 Network of dependencies

Integraal programmeren is a process in which actors with different values are dependent on each other to achieve their goals. These actors work together in a network of dependencies, which encourages them to work together. The most important dependencies in the scope of this research are visualised in Figure 14.

In the process of integraal programmeren, regional governments and network operators are dependent on market parties for, among other things, the provision of information about future developments, technical knowledge and investments. Market parties depend on regional governments and network operators for, connections to the grid, permits, co-investments, process knowledge, and legislation and regulations. Because of these dependencies, the process of integraal programmeren is sensitive to uncertainties among market parties, like uncertainties about their future development.

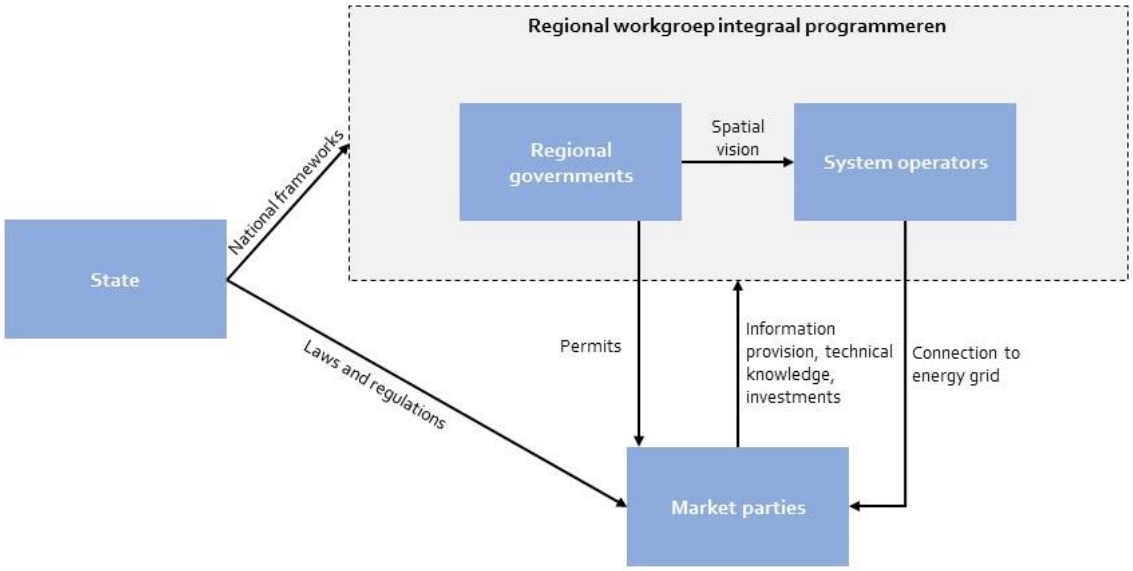


Figure 14. Interdependencies between the most important actors in the process of integraal programmeren.

4.5 Institutional context

Integraal programmeren is part of a bigger context of existing networks and structures. Since the process is still lacking legal status, everyone works from their existing mandates. As a result, there is some overlap with other programs, especially with the Regional Energie Strategie (RES). The RES regions are collaboration structures for drawing up a strategy for the generation and use of sustainable energy. This has a lot of common ground with energy infrastructure, which is why in many regions integraal programmeren is initially linked up to the RES collaboration structure. A disadvantage of this is that integraal programmeren exceeds the scope of the RES, which is aimed at the generation of sustainable energy, and therefore integraal programmeren eventually needs its own collaboration structure in which all sectors can be taken into account equally. How integraal programmeren relates to the RES and other government plans and structures is shown in Figure 15.

The figure shows that the process of integraal programmeren is in between spatial development and sectorial plans. At national, regional and municipal levels there are plans and programs that interact with each other. These plans provide input for integraal programmeren and the other way around. All these interactions make the process of integraal programmeren very complex. Therefore it can be difficult to scope the process and involve the right actors.

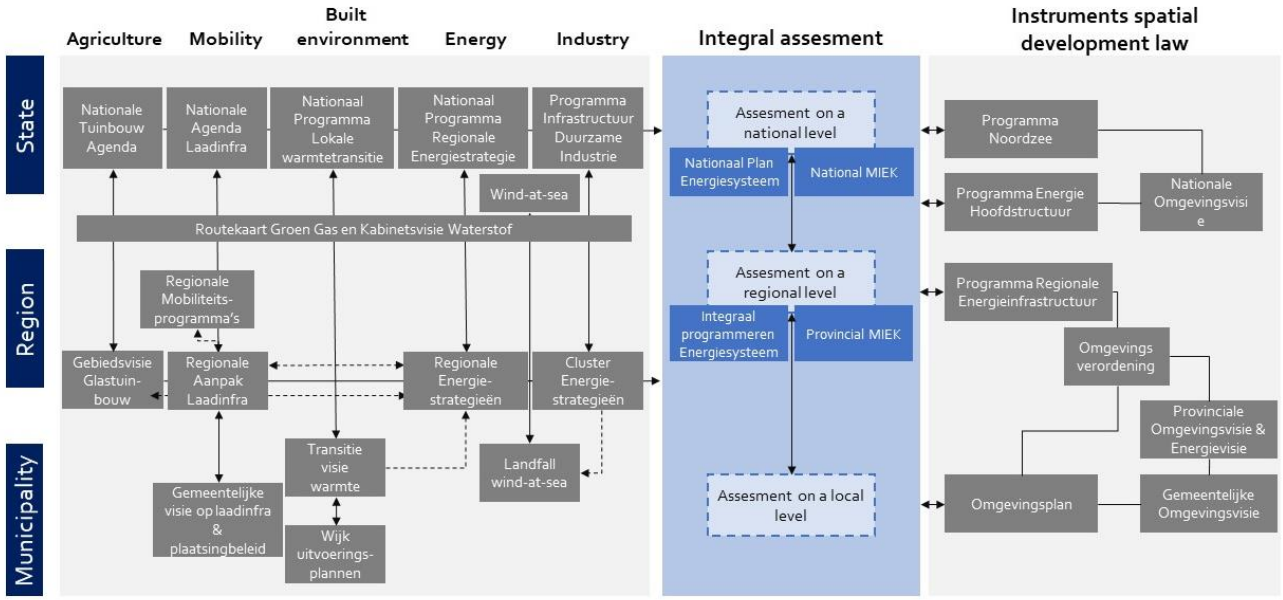


Figure 15. The institutional context of integraal programmeren. Adapted from (Provincie Noord-Holland, 2023)

4.6 Conclusions conceptual analysis

The conceptual analysis was aimed at defining the process of integraal programmeren in terms of actors, networks and institutions.

Integraal programmeren is about designing, planning and making public decisions on future energy infrastructure in a way that is coherent with spatial development and sectorial plans on energy demand and supply. It is a process mainly between provinces, municipalities and system operators of electricity, heat and hydrogen. The actors work together in a network of interdependencies and work together to achieve shared goals. In addition, there is a big interdependency between the actors in the process and market parties e.g. information provision and investments, which means the success

of the process of integraal programmeren is also dependent on market parties. Market parties can have the role of energy demanders, suppliers, non-regulated system operators and flex providers. Market parties have thus far not been actively involved in the process of integraal programmeren. This can be explained by the fact that the cycle of integraal programmeren has only just begun and the main focus is now on setting up a collaboration process between provinces, municipalities and system operators. Likewise, the process does not have a legal status yet and actors work from their existing mandates.

The design guidelines for a collaboration process from the theoretical framework are partly adhered to in the process, this is shortly discussed below:

- *Trust & reciprocity norms*: Governments and system operators have a need for insight into each other's processes, which can indicate a lack of trust between these parties in the process.
- *Knowledge development & accumulation*: The first step of the process of integraal programmeren is aimed at gathering input from the different sectors. However, clear subprocesses for combining and using this knowledge have not been defined.
- *Government & decision making*: Each actor establishes decisions in their own organisational structures.
- *Communication:* The process is still new, and communication with the outside world is no priority.
- *Boundaries & context*: The geographical boundaries of the process are set to the provinces. The 22/23 iteration of the process is mostly focused on electricity, but hydrogen and heat are also part of the scope.
- *Institutions*: The process does not have a legal status yet and actors work from their existing mandates.
- *Resources*: The process developed from a shortage of materials and people in the energy sector. This is also noticeable in the integraal programmeren process, where, especially municipalities, have limited working capacity available.

This shows the novelty in the process and the many uncertainties that are present in the process of integraal programmeren itself. These uncertainties can influence how the uncertainties in the process environment are perceived by the actors in the process.

5. Case study

In every province, a PMIEK is being composed, with an intended deadline of March 2023. This is the first run-through of the process, which is a sped-up version of the cycle. The focus of the 22/23 cycle is on testing the steps of the process and setting up a collaboration structure in each region but also has the aim to lead to substantive outcomes.

Three regions have been chosen as a case study to further examine the collaboration process and collect experiences and ideas on the uncertainties. In these regions, first exploratory introductory interviews are held with provinces and then more in-depth interviews are held with DSOs, TSOs, municipalities and experts on certain uncertainties.

5.1 Case context

For each region, the characteristics and made process rules are discussed below.

5.1.1 Noord-Holland Noord

Noord-Holland Noord is a RES region consisting of 18 municipalities. It is a region with a variety of different economic sectors and big ambitions for sustainable energy and housing, all of which affect the PMIEK. The most important developments in the region are the landfall of wind-at-sea, electrification of businesses, greenhouses and heavy mobility. In addition, data centres, electric vehicle charging stations, water purification and pumping stations and hydrogen have a big influence on the regional energy system.

Noord-Holland Noord was one of the pilot regions for integraal programmeren. From the beginning of 2022 till October 2022 the pilots tested the steps of integraal programmeren that were agreed on in the working group (Werkgroep Integraal Programmeren, 2022). Noord-Holland Noord has scarcity on the electricity network for both demand and supply, which has only gotten worse over the past year (M. Van de Ven, personal communication 15-11-2022). While a separate process has been set up to solve the acute net congestion, this still leads to more administrative pressure on the process of integraal programmeren.

The working group in the region consists of the province, Alliander, 3 municipalities, TenneT, Gasunie and the Ministry of Economic Affairs and Climate Policy. The working group is responsible for the progress of the process. In addition during the process, several sessions have been organised in which other stakeholders like all municipalities and market parties were invited. Eventually, the province of Noord-Holland will have to deliver one PMIEK but keeps the two RES regions separate administratively for now since Noord-Holland Noord already got a head start in the pilot and the spatial-economic differences between the regions.

5.1.2 Zuid-Holland

Zuid-Holland is a complex province with an international port and industrial area, big cities and lots of greenhouse horticulture. These segments all have a big energy demand, which will only keep on growing given sustainability plans. Furthermore, new energy carriers like heat and hydrogen are vastly coming into play in the region.

The process started in September 2022, with an expected delivery of the PMIEK in June 2023. The working group consists of the province, Stedin, Westland-infra, Alliander, TenneT, Gasunie, and a few representative municipalities. Market parties are expected to be involved in the form of in-depth

sessions to gather more information about certain sectors. However, the focus in the 22/23 iteration is deliberately not on the involvement of market parties but on the involvement of municipalities.

5.1.3 Groningen

Groningen is mostly known for its gas fields. Therefore, in the transition to sustainable energy, the generation and development of hydrogen is an important factor in this region. This also has a strong cohesion with the industrial cluster and wind-at-sea at the Eemshaven. In addition, electrification in housing, industry and mobility requires changes of the energy system and is therefore of importance to the process of integraal programmeren.

Groningen is not yet far along in the process of integraal programmeren. The working group consists of the province and system operators, so the municipalities are barely involved for now. Therefore the involvement of market parties has not been given much thought yet.

5.2 Introductory interviews

The introductory interviews with the provinces of the case regions are, as mentioned in the methodology, the first part of the case study and are aimed at exploring current issues and uncertainties in the process.

All interviewees recognise the need for integraal programmeren and changing the way distribution system operators and regional governments think and work, to better suit the current situation in the energy system. The provinces work now in a compartmentalised manner, but the developments in the energy system are becoming more integrated with developments in other sectors. In addition, the different energy carriers are becoming more intertwined, which adds to the challenge. Working together with system operators in the process of integraal programmeren allows them to look at the energy system as a whole and to make integrated decisions about energy infrastructure. A good consultation structure and more insight into each other's processes and methods are needed for this process to work. One province also emphasizes the involvement of market parties in the process and that this can lead to better coordination of developments.

5.2.1 Uncertainty sources

When asked about the developments between now and 2050 that they think will impact the energy system the most, all interviewees mention the sustainability plans of businesses and scattered industries. Big industrial areas in Zuid-Holland and Groningen are represented in a CES (Cluster Energie Strategie) which provides a platform for an information flow. However, the smaller businesses and industries together can also have a big influence, while data on their sustainability plans is not accessible. The program of Cluster 6 has been set up to gain insight into these smaller parties, but this appears to still be lacking in organisation and running into issues, having only interviewed 2 companies in Noord-Holland Noord for example.

Furthermore, the interviewees do not only specifically mention industry, but also mention areas with housing and mobility sustainability plans. While this information is often held by municipalities, it still involves sensitive matters and the planning can be difficult to predict because of delays in construction.

Another source of uncertainty mentioned by some interviewees are the regional consequences of national government decisions, especially for wind-at-sea. These decisions can have a big influence

on the region because they also influence the actions of market parties. For example, different landing sites of wind-at-sea can lead to different market developments, which call for different developments of the energy network.

Additionally, the development and use of hydrogen are mentioned as a big influencing factor. Hydrogen brings along two challenges. The process of electrolysing shifts the balance in the energy network between electricity and hydrogen, which means the dependency between the energy carriers in the network increases. And a hydrogen network brings a chicken-and-egg problem: whether hydrogen production or distribution should be developed first. The development of heat runs into similar issues, which is mostly recognised in Zuid-Holland.

5.2.2 Uncertainties

The expected developments in the regions with a significant impact on the energy system are sources of uncertainties. Overall, the range of possibilities of these developments is known, but the chances and planning are not. In light of Stirling's framework (figure 10), these uncertainties would land in the bottom left quadrant.

The following uncertainties in the direct environment of the process (figure 11) have been identified that influence the collaboration process of integraal programmeren:

- *Energy carriers of businesses and industries.* Market parties like to keep their options open for as long as possible and express strategic behaviour, which makes this uncertain. They will often choose the cheapest option or the easiest accessible one. This is especially the case for scattered industries.
- *Future energy demand of sectors* (industry, housing, mobility, etc.). Long-term information is essential for the success of integraal programmeren according to one interviewee. However, market parties are often uncertain about this information as well and do not think further than 2030 yet. This is especially the case for heavy mobility and industries.
- *National government decisions* can have different consequences in terms of market developments. So when a government decision is uncertain, there are more regional uncertainties attached to it.
- The use and development of *hydrogen* and *heat*.

5.2.3 Mitigating uncertainties

While the interviewees found it difficult to pinpoint how they think should be dealt with the uncertainties, one school of thought was mentioned. It could be possible that local governments take on a bigger part in energy planning. By making choices on energy infrastructure they can direct market developments.

The mentioned uncertainties and suggested mitigation measures were further discussed in detailed interviews with system operators, municipalities and other experts.

5.3 In depth-interviews

5.3.1 Perspectives on integraal programmeren

Every interviewee recognises the necessity of integraal programmeren but highlights various aspects of the process as most valuable. When asked about the biggest advantages of integraal

programmeren in contrast to the current process to determine investments in energy infrastructure, a few interviewees mention the awareness about the impact the energy system can have on other developments, both of other departments of decentral governments and market parties. Other interviewees emphasise the integral character of the process, which before has been hindered by the compartmentalisation of government organisations. The broader scope of integraal programmeren gives the possibility to take interdependencies into account and look at coupling opportunities, e.g. matching supply and demand, and coordination of activities.

Some interviewees think a big advantage lies in the coordination between system operators, the province, and municipalities. The collaboration can lead to a shared image of the developments in the region and agreement on the preconditions that are used to design the regional energy system. The cases show that right now there is still a big cognitive distance between the actors in the process. Another point made by multiple interviewees is that integraal programmeren leads to a more efficient way of working. Because integraal programmeren can be used to give direction and stop working reactively, which means you can prepare for the future. Additionally, it becomes more efficient because the coherence between developments is taken into account and developments can be optimised together.

According to almost all interviewees, the current developments in the energy system call for a new way of working both from system operators and governments, which entails making more choices. System operators need to look at what is needed for a robust energy system for the future by preparing for instead of following developments. This way of working is partly hindered by the ACM, which calls for purposeful investments, but the hinder also partly lies within the attitude of the DSO. Likewise, the energy departments of provinces and municipalities need to learn to work more integrally, instead of the compartmentalised organisation they are used to. The interdependence between the energy system and spatial-economical developments is becoming more apparent and therefore these components should not be looked at completely separately. This calls for better communication within provinces and municipalities with other departments.

5.3.2 Methods for dealing with uncertainty

The actors are not unfamiliar with uncertainties, by definition, they are working in an uncertain environment because they are always dependent on other actors and have to make decisions about the future. TSOs and DSOs, and government organisations have different procedures for dealing with these uncertainties.

Transmission and distribution system operators

System operators are obligated to publish an investment plan every two years in which their investments for the next 10 years are included. Further in the future are more uncertainties so when writing this investment plan the system operators have to deal with uncertainties. The investment processes of the different TSOs and DSOs are quite similar because the ACM regulates this. To compose a certain and purposeful investment plan TSOs and DSOs make use of different kinds of inputs, figure 16 gives a simplified representation of these inputs. Most investments in their investment plans are based on maintenance and repair work, existing client requests and plans. These are already very certain and short-term. To determine investments further in the future they make use of scenarios and assumptions based on government plans, forecasts, and a bit of logical thinking. The TSOs and DSOs make use of the nationally determined IP2022 and II3050 scenarios. Based on these scenarios they determine the regional developments and impact on the network by locating future bottlenecks. The interviewed TSO does critique their way of working in the sense that scenarios do not include all uncertainties. For example, social aspects, like the public acceptance of hydrogen, are not represented in the scenarios. The process of integraal programmeren, which is focussed on facilitating democratic, social decisions, could in that sense enrich the investment process.

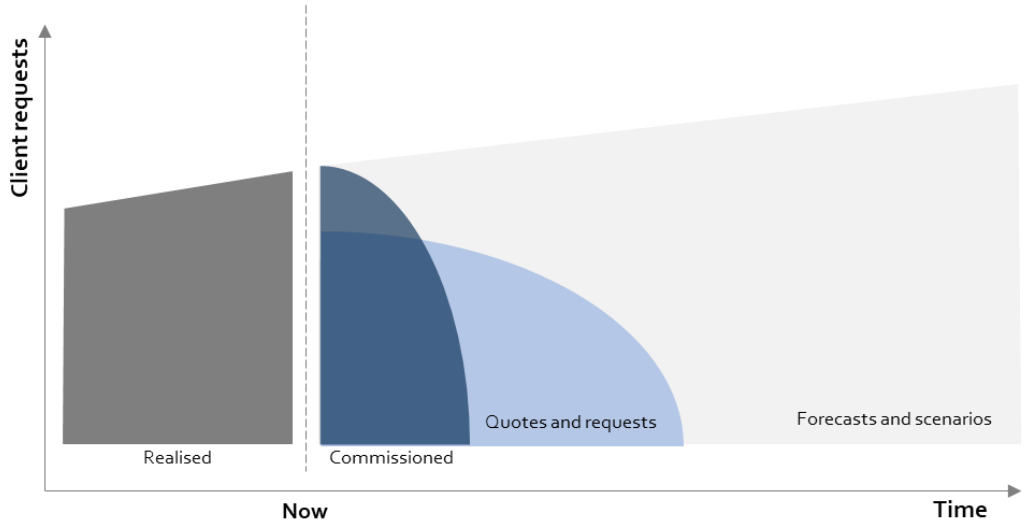


Figure 16. Simplified representations of inputs from the investment process as shown by an interviewed DSO

A DSO tells they make use of models and assumptions to determine growth rates and developments, which are not always on the same line as government plans. In these cases, they try to coordinate with the local governments as well as possible. In addition, system operators keep in contact with big energy users, local actors and citizens when necessary.

To make purposeful investments and reduce uncertainty, one of the DSOs has three decision gates in its investment process. Firstly including it in the investment plan, which means the investment has been planned and the budget is reserved. For the second gate, different alternatives are looked into and one is chosen. And the last gate is the final decision and then the investments are made. And before the last decision gate, there should be a bit more certainty about whether a bottleneck will actually occur. One of the interviewed DSOs complies with purposeful investing by only investing if there is certainty about a project and its location. However, this does not entail that they only look at certainties, they do think further ahead, but this does not yet land in their investment plan. The

system operator active in the field of hydrogen comes across even more uncertainties since the use and availability of hydrogen itself are still very uncertain. Therefore the government will financially mitigate certain risks associated with the start-up phase (e.g. timely development of supply and demand), so the system operator can continue with its pre-investment activities.

So overall, TSOs and DSOs deal with uncertainties by only including certain investments in their investment plan, which is encouraged by the rules regulated by the ACM since system operators are not allowed to pre-invest. However, as mentioned by one of the DSOs, this way of working does lead to lagging with investments, which has led to net scarcity and thus a break on sustainability transitions.

Governments

Governments have a different view on uncertainties because of their unique way of working, they give direction to uncertainties instead of working with them. The interviewed governments have different ways of dealing with uncertainties, municipalities bring up trial-and-error methods and learning processes. This way of working involves making small adjustments and trying to determine no-regret options. However, the interviewee of one municipality does acknowledge trial-and-error would not work with a big system like the energy system, since this requires big investments and decisions that cannot easily be made undone. Therefore, they suggest that bigger systems should work with a digital twin in which you can simulate and try out different options.

In the interview with a municipality, it is pointed out that to get an outlook on uncertainties it is important for governments to keep in contact with citizens and companies. Additionally, they mention governments always deal with uncertainties in the form of political uncertainties. In that case, they keep to a timeline and finish things up before the elections.

The interviewee of a province mentions another way of dealing with uncertainties. In one province, the large areas with high demand and supply are clustered and looked at as a whole, this way they become less dependent on individual market parties and the risks are lowered. So another way of dealing with uncertainties is spreading the risk.

5.3.3 Uncertainties in integraal programmeren

The interviewees were asked about how they experience uncertainties stemming from market parties in the process of integraal programmeren. The uncertainties from the introductory interviews were recognised by all interviewees. A DSO said about these uncertainties: "These are uncertainties everyone is still in the dark about as long as decisions are not made". A municipality adds: "There are many elements in a general sense in the energy system that are not yet sure, will they continue or not? Will they become economically viable or not? And that creates a complex whole, with a lot of uncertainties." Market parties play an important role in these uncertainties since you cannot directly influence their behaviour and choices.

It is always tentative to work with market parties because you will encounter strategic behaviour and privacy issues, so companies will generally keep their plans secret. On top of that, businesses often do not know yet how and when they are becoming sustainable, partly because they are not aware of their options, but also because they do not think that far ahead, they have a different time horizon than what is needed for the process of integraal programmeren. Because of this a DSO and a

municipality, both encountered problems with companies when collecting data for integraal programmeren.

Moreover, it appeared difficult to find the right person within organisations to talk about energy data. Big companies like for example Shell, also have a big internal, hierarchical structure that plans have to go through to be approved. Also, companies lack awareness about the impact of the energy system on their development. This makes it difficult to have the right conversations with market parties. Lastly, international developments can also play a part in the plans of big companies, while the process of integraal programmeren focuses on a regional scale.

So, it proved to be difficult to get a clear view of the developments where market parties play a key part. The uncertainties of these developments and their impact on the energy system affect the process of integraal programmeren. According to a DSO, the consequences of these uncertainties on the energy system are that you keep falling behind and the energy system will not be designed in a smart effective way.

Industry

Overall there is a lack of insight into the sustainability plans of industrial companies and business parks. One interviewee disclosed that in their municipality there is a big data gap in data on scattered industries. Also for DSOs, it is difficult to gain insight into the sustainability plans of smaller industries and business parks, since they do not have personal contact with these companies yet. Right now the DSO estimates the future energy demand of the industries by looking at historical data and adding a growing percentage. However, this is no longer accurate in 2030 if industries are switching to electrification. One of the interviewed DSOs thinks this could lead to big problems and calls it a blind spot. While the blind spot is slowly becoming clearer, many companies still have no idea how they are going to become more sustainable because they do not think that far ahead.

On the other hand, companies that do share their sustainability plans often exaggerate their future energy demand or keep their options open by exploring both electrification and hydrogen. Net scarcity in a way also simulates this kind of strategic behaviour, a DSO refers to it as 'laying a towel', when companies claim net capacity they do not necessarily need yet to be secure of the progress of their future developments. Another consequence of net scarcity is that industrial companies follow the availability of electricity, this means they settle on places you do not always expect or want.

In the Netherlands, there are six industrial clusters, 5 fixed locations and one called cluster 6 which includes all scattered industries. All industrial companies must supply their sustainability plans via the Cluster Energy Strategy (CES). Each cluster delivered a CES 1.0 which reports how the cluster is becoming sustainable, what the impact of this is on the energy infrastructure, and if this leads to bottlenecks. This is a difficult process in itself and for cluster 6 even more so, because cluster 6 includes about 400/500 industries all over the Netherlands which are completely different in terms of activities. In all provinces of the case regions, there is a Cluster energy strategy industrial area, which includes big companies like the port of Rotterdam and Tata Steel. The other industrial companies in the case regions are either (going to be) presented in Cluster 6 or are not represented at all.

The Cluster 6 organisation does not have an actual organisational structure yet and because of this, there has been little to no data collected so far. A consultancy was hired to go to the companies with a data format to collect sustainability plans for 2030 and look ahead to 2050. In the first iteration, 100

companies participated. And while some companies were already doing very well and had clear plans, the overall picture is that companies are not ready to formulate concrete sustainability plans yet. The interviewed TSO emphasizes the need for more decisiveness from Cluster 6 companies, right now they do not look at all possibilities and only look at certainties, while this may not lead to an optimal choice. So, in the future, the Cluster 6 outcomes can hopefully be used as input for integraal programmeren.

However, Cluster 6 will not entirely take away the uncertainties about industries. The chicken-and-egg problem of infrastructure is a big challenge, someone has to take a big risk by investing first. In the interview with the Cluster 6 expert, he mentioned that an area-oriented approach that is more directive could help with this, but how this would work and where this would fit he is unsure. In addition, municipalities also look at other solutions for industries and business parks, which often leads to local optimization. In the interview with one municipality the ratio centralised versus decentralised is therefore also mentioned as an uncertainty. He believes smaller industries and business parks would benefit from smart solutions and thinks governments should aid them by providing information to these companies. Similarly, in another municipality, they have set up a business counter to help business parks to become gas-free.

So, there is a data gap on small industrial companies and business parks, which could be problematic in the future. Even though more information does not necessarily lead to more decisions, information is crucial in making sound decisions. Different structures to aid companies with their sustainable plans and collect information are being set up. However, this proves to be difficult because of the different natures of the companies and the strategic behaviour they display.

Mobility

The uncertainty about mobility is mainly recognised by the interviewees for heavy goods traffic and maritime transport. The transition to sustainable heavy mobility is still in its infancy, which means a lot of questions are still unanswered, like how fast this will go and how big the impact will be. According to one of the DSOs, this uncertainty calls for a lot of time, communication and coordination. Another DSO adds that what makes this uncertainty even more complex is that this is influenced by international developments since trucks and cargo ships often follow international routes.

In one of the municipalities, they are researching the use of hydrogen for heavy mobility. To reduce uncertainties and lower barriers the region gives out subsidies and brings the right actors together. The interviewee comments that by creating small ecosystems, it is easier to coordinate supply and demand in the hydrogen network which lowers the risk of a chicken-and-egg problem.

Hydrogen

The uncertainties about hydrogen are strongly intertwined with those in industry and mobility and were often reviewed in conjunction by the interviewees. For example, industrial parties do express interest in hydrogen according to a system operator. But uncertainties about the availability of hydrogen causes restraint from the companies. The same thing an interviewee recognises in other cases, municipalities disregard hydrogen because it is still too uncertain or far away. Because of the uncertainties, people fall back on certainties like electrification, which only further promotes net congestion. He, therefore, calls for them to take a good look at all the options and not only look at the easy, certain things.

Heat

Uncertainties about heat, like the availability of geothermal energy, are mostly acknowledged by actors in Zuid-Holland. According to the interviewee in one municipality, heat is often pushed aside because it is not as pressing as electricity. But in the future heat will play a bigger role and can also help with easing the pressure on the electricity network. The municipality recognises uncertainties from market parties from their recent participation in the feasibility study of the Warmtelinq project. In this project, they also come across a lot of uncertainties with private actors expressing strategic behaviour and building business cases.

State decisions

Noord-Holland and Groningen are both dealing with uncertainties around wind-at-sea. While these projects themselves are part of the national program of integraal programmeren, they do have a big effect on the regional economy and spatial development. Market parties like companies behind electrolysers and parties with a high energy demand like datacentres wait with their investment decisions because these are dependent on these state decisions. Therefore, these projects can also have consequences for the regional process of integraal programmeren. One of the sources of uncertainties is locally matching the supply and demand. The DSO said it is already known that not all electricity can be fed into the national electricity network, but no decisions have been made yet on who is going to use the electricity locally.

The province of Noord-Holland is only involved in the development of wind-at-sea in an advising role. Therefore they try to map the local consequences by discussing different scenarios, but in the end, they have little influence on it and it still leads to uncertainties. The TSO is also involved in the development of wind-at-sea and also understands the uncertainty. However, he also sees that this uncertainty is vastly reducing since decisions are made. What he still sees as a big uncertainty is the role of hydrogen in wind-at-sea projects, especially if hydrogen will be produced at sea at some point, how long this development will take and how this will be coordinated with other developments.

Wind-at-sea is not the only state decision that has local consequences and leads to uncertainties in the local energy system, a municipality mentioned the nitrogen policy, which can have big consequences on local companies and the progress of their developments.

Other uncertainties and constraints

During the interviews, a few other uncertainties and constraints were brought up, that are not directly about market parties, but do play an important role in the development of integraal programmeren and thus should be mentioned. One interviewee declared that while the discussed uncertainties are important, she did not notice a lot of effect of the uncertainties in the 22/23 iteration. Most uncertainties they came across in the process are uncertainties about the process itself, which overshadowed the other uncertainties. A few mentioned examples were the legal status of the PMIEK, the relationship between the PMIEK and the investment plan of the system operators and consequently the commitment of system operators to the PMIEK.

What was also mentioned by multiple interviewees is the shortage of people and time in the process. Especially municipalities have a hard time finding capacity in order to, for example, collect data as input for the process. Because of this shortage, the process does not function optimally and other uncertainties may not get the attention they need. Other mentioned constraints are the difference in

knowledge level between actors in the process and the lack of a communication platform to share updates on the process with the outside world.

These uncertainties and constraints within the process can also influence the uncertainties in the direct environment of the process. For example, the lack of legal status could cause hesitation from market parties to provide input or join the process.

5.3.4 Mitigating uncertainties in integraal programmeren

The aforementioned uncertainties have consequences for the development of the future energy system. According to one DSO, if these uncertainties are ignored, this could lead to more net congestion in the future and desirable developments that come to a standstill. Another DSO states that integraal programmeren will not solve the uncertainties, but thinks that the process of integraal programmeren can help address these uncertainties by creating clarity on the future of the energy system and the choices that have to be made. In addition, integraal programmeren can help by prioritising certain projects, the TSO, therefore, thinks it can also accelerate developments, like the use of hydrogen in industrial clusters and therefore take away some uncertainty. However, the process of integraal programmeren will always still take place in an uncertain environment and thus requires ways of dealing with uncertainties in the process.

Net congestion calls for a different way of working and a new dynamic between governments and system operators, which takes some time to get used to. According to an interviewed municipality, the contact between the municipality and the DSO was very minimal before integraal programmeren. Likewise, net congestion is leading to a new dynamic in which the further development of the energy system is conditional on other developments. So, according to both the DSOs, companies will be forced to share their sustainability plans if they want to be able to proceed with their developments on time. The success of integraal programmeren is, as said by the interviewee of a province, highly dependent on the input, which in the 22/23 iteration was not much new data. Partly this data needs to come from market parties, but most interviewees agree that this also requires a more decisive and directive approach from governments.

Integraal programmeren gives the opportunity to influence decisions about the future of the energy system. One DSO example suggests that governments and system operators should focus on things they can control like energy visions and spatial development plans. In some cases, it can be more efficient to focus more on government planning, than to wait on actions from market parties. Hence, many interviewees stress the second step in the process of integraal programmeren, drawing up an energy vision and assessment framework. One interviewee said: "In the PMIEK all actors have different visions while there are a lot of interdependencies. Therefore, it is important to create a shared vision about what steps to take." Creating a shared image of the future energy system helps with setting a direction and making preparatory choices and in that sense can lead to acceleration.

One of the DSOs has been working for a while on creating a shared image of the region with municipalities. They have created an online platform on which data from different sectors in the region can be seen by the municipality. This helps with checking plans, creating awareness, and making it easier to talk with municipalities about their plans and how smart solutions can be implemented. They plan on continuing to develop this platform in the coming years and also involving the province, to create a shared vision.

5.4 Conclusions case study

From the interviews can be concluded that integraal programmeren enables coordination between regional governments and system operators and can lead to a more efficient way of designing the future energy system. The current changes in the energy system call for a different way of working regarding making choices leading to the prioritising of developments. The interviewees are well aware of the fact that this also requires internal changes in their organisations. Integraal programmeren looks further ahead than the current investment process of the TSOs and DSOs, which means the actors in the process of integraal programmeren come across more uncertainties. The energy system is becoming more conditional for other developments, which means that if the uncertainties are ignored, this could lead to desired developments coming to hold or even unwanted developments.

The case study was aimed at identifying uncertainties and mitigation measures that actors experience and foresee in the process of integraal programmeren, to answer the second sub-question.

The focus of the actors has mostly been on the uncertainties in the process itself since it is all very new. However, it is recognised that uncertainties stemming from the uncertainties with market parties can eventually have a big, unforeseen influence on the regional energy system. Therefore it is important to take them into account. The following uncertainties which highly depend on market parties are deemed as the most ambiguous:

- Sustainability plans of (scattered) industries and business parks
- Sustainability plans for heavy transport
- Use and development of hydrogen
- Reactions of market parties on state decisions (e.g. wind-at-sea, nitrogen policy), leading to consequences for the regional energy infrastructure
- Development of heat networks

Given the theoretical framework, these uncertainties can all be defined as uncertainties in the direct environment of the process. The source of these uncertainties lay outside the process, but the process can influence them as well as the other way around. The knowledge of the outcomes of these uncertainties is not problematic but the likelihoods are, meaning e.g. the sustainable development options for a small industrial company are known, but the chance of each option is not.

The uncertainties stemming from the interdependence with market parties can be dealt with in the process in different ways. Firstly, information is essential for the success of integraal programmeren. A substantive knowledge base is needed about the expected developments in the region, which, as it turned out in the 22/23 iteration, is not always easy when market parties are involved. Part of this responsibility, according to the interviewees, also lies with the market parties themselves by providing their sustainability plans as input for the process of integraal programmeren. Otherwise, their plans cannot be taken into account. However, two important notes on this are that market parties are mostly in the unknown of the process of integraal programmeren and the impact of the energy system on their sustainability plans, and market parties will also behave strategically, which will not always lead to wanted situations.

A second important aspect of the process of integraal programmeren is arriving at shared insight. When it is not possible to collect more information on the uncertainties, drawing up a joint vision

about the future of the regional energy system can partly reduce the uncertainties, because the vision provides direction so the actors work towards the same things. This is similar to the method of future-making between actors suggested by Stirling (2020). Multiple interviewees also underlined the importance of continuing to talk to each other to create a shared view. The vision also provides an opportunity for governments and system operators to direct the developments in the energy vision. What became clear from the interviews was that the uncertainties often emerge out of pushed-forward decisions, market parties are waiting to make decisions to keep their options open. Giving directions through integraal programmeren could speed up these decisions by limiting options.

So, uncertainties among market parties can be dealt with in the PMIEK process in two ways. Firstly, by obtaining more information about it or in the case when this information does not exist or is unavailable by formulating a shared vision. Involving market parties, in a different way than they are involved now, can help with these mechanisms. This relation is visually represented in Figure 17. Currently, communication with market parties is still lacking in the process. Since they can play an important role in providing more information and are needed to realise some developments, the process of integraal programmeren could benefit from the more active involvement of market parties.

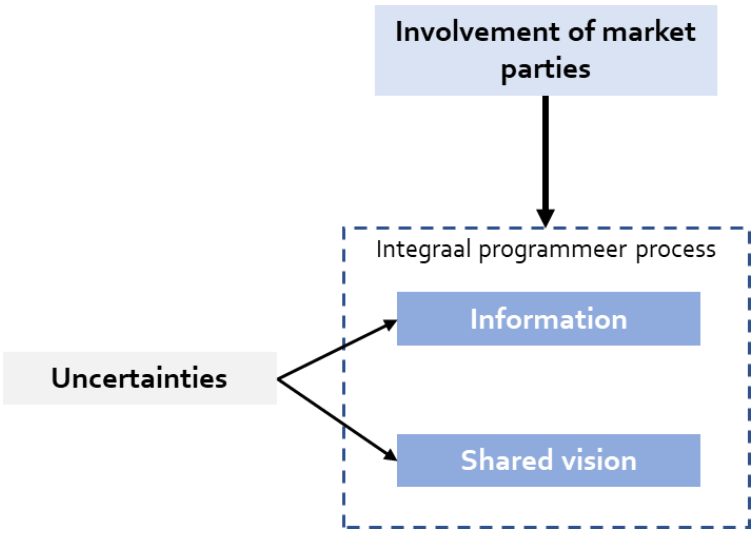


Figure 17. Visual representation of the mitigation of uncertainties from market parties in the process of integraal programmeren

Both gathering information and composing an energy vision are steps of the current process of integraal programmeren. In the 22/23 iteration, these steps have been partially executed in the case regions. By involving market parties more intensively in these steps in the next iteration, you can create a feeling of ownership and responsibility among market parties. This could lead to more input in the information-gathering phase and more support for the energy vision. On the other hand, this could require more adaptations of the process like new process rules and new organisational structures, like entry- and exit rules and decision rules. What the involvement of market parties would entail could differ per region and situation and can be designed in different ways. The next chapter explores how design guidelines for collaboration with market parties can be interpreted to suit uncertainties in the case regions.

6. Design guidelines

As concluded from the previous chapter the process of integraal programmeren is still very new and so far the collaboration process has mostly run in practical issues like shortage of staff capacity. However, all interviewees did recognize the complications that the dependencies on market parties bring along. And ignoring the uncertainties emerging out of this could lead to unwanted situations in the future. The process of integraal programmeren is crucial in preventing this by either gathering more information about the uncertainty or by creating a vision about the uncertainty in which different options are explored. The involvement of market parties in the process has thus far been minimal and could be improved in different ways.

In the focus group previously interviewed provinces and system operators are asked to discuss design guidelines and share ideas on how these could help deal with uncertainties in the process of integraal programmeren.

6.1 Focus group results

6.1.1 Governance

When asked about the form of involvement suited for market parties to get a better outlook on uncertainties, the first reaction is a warning, involvement of market parties can lead to lobbies. What was experienced in the deep dive session in Noord-Holland Noord, was that when market parties were asked about their future energy usage, they often responded with a wish list. This was also recognised in Groningen. DSOs have given, thus far, little thought to the energy profiles of small companies while these can have a big impact on the energy system in the future. Therefore, it is important for TSOs, DSOs and governments to give more attention to these menacing problems. But it is important to ask the right questions to the market parties, that are specific enough to get the information you want. For example, asking market parties for their future energy profile will not lead to a clear answer, but asking if they are going to electrify or use hydrogen and the expected growth of the company can provide more insight.

Different ways of involving market parties were discussed, ranging from co-creation to a more informative approach. Firstly, a consulting role was discussed, in which a few companies from each sector are asked to sketch the outlines of the expected development over time of each sector. Another suggestion, especially to counter lobbies, was to ask companies to reflect on the energy vision composed by the regional governments and system operators. A vision offers the opportunity to ask specific questions. This way of asking closed questions is almost leaning towards an informing role rather than consulting since the space for input from market parties is limited. And lastly, a form of co-creation was discussed, which was used in Noord-Holland on a small scale. In this form of involvement, market parties are asked in a session to envision their future based on a sketch of the future energy system, which in return leads to adjustments of the sketch. This process is quite similar to the method of future-making between actors described by Stirling (2020).

Originally planned in the process, market parties were mainly asked for input at the front of the process in step 1, in the form of their energy profiles and development plans. In contrast, the discussion during the focus group leaned more towards directive and designing approaches from governments and system operators where market parties are involved later on in the process. This was favoured because providing suggestions prior to market party involvement counters wish lists. Although it was argued that the manner of involving market parties is strongly dependent on the local

situation. For example, a region with net congestion on the electricity network could favour a more directive approach because options for development are limited and market parties will mainly look at their own benefit and not the whole region. During the focus group, an example was mentioned of a region with brick factories, where the system operators have, taken more control and declared the factories cannot electrify. Other than that, it is still unclear in which situation which form of involvement is most beneficial and this goes beyond the scope of this research.

However, in reality, market parties are barely involved in the process of integraal programmeren yet, and even getting input from them at step 1 of the process proved to be difficult. Overall, everyone agreed that the current way market parties are involved can be improved. As was experienced in the RES process, market parties are interested in being involved in such a process. But this does require awareness amongst market parties about the goal and working of the process, which is further elaborated on in 6.1.2.

A final note to take into account when involving market parties is that because they are not familiar with the process yet, it will take some time to create awareness amongst them about the impact of the energy system on other developments, like the sustainability plans of businesses. This knowledge gap can hinder collaboration if it is ignored.

6.1.2 Communication

The discussion about communication consisted of two parts. Firstly, communication was understood by the attendees as exchanging data on for example energy usage with market parties. In this case, transparency and openness were found to be very contradicting, since this is information you have to be careful about. However, there should be transparency about the rules you make about sharing data. Tools that can enable more transparency about data between the involved actors are NDAs, data safehouses or keeping to a higher aggregation level when making data public.

Secondly, transparent communication from the process to the outside world is missing, which is recognised by all attendees. Both how the process works, who makes which decision when, and the deliberation and substantiation of decisions are unclear for someone who is not taking part in the process. This could be done through an official website or platform, which one of the provinces is already working on, or a more active communication method. Municipalities were in a similar situation at the start of the process; they were unfamiliar with the process and suddenly became involved in the fast-moving process of integraal programmeren. Therefore the provinces and DSOs had to take some time to explain the background of the process and how the process works. A comparable course can be undergone for market parties, meanwhile, communication should be adapted to this.

Some attendees found it difficult to decide which information the actors in the process should share with the outside world and what should be kept private and think that clear agreements should be made about that. An attendee reacted to this by asking if a completely open and transparent process would even be possible. By laying all the cards on the table there is limited space to make decisions and market parties may think that by being in the known they also influence the outcome of the process. Therefore it is important to also be transparent about the part market parties play in the process and how much influence they have.

Additionally, it was mentioned that the technical substantiation could include sensitive information. The justification of the choices made in the process of integraal programmeren should therefore be similar to the justification of policy choices and not be too specific. An important condition of communication to the outside world is that the connection between integraal programmeren and the investment plan of the TSOs and DSO should be clear. The investment process is, even for governments, not transparent nor understandable. The system operators are obligated to publish an investment plan every two years, but the substantiation of the decisions is perceived as vague and not every step is well explained. Therefore, system operators should also work on the transparency of the process behind the investment plan and its relationship with the PMIEK.

6.1.3 Trust

Trust has a strong correlation with transparency and therefore the discussion was kept short. First pointed out during the discussion, was that trust is not only about market parties versus governments and system operators but the relations between these actors should be seen as a triangle, of which each side requires its own type of trust. This is endorsed by Nooteboom (2006), who distinguishes different types of trust and different ways to develop trust. The relationship system operators have with market parties is different in nature than the ones governments have with market parties. Governments can easily switch political courses after elections, which makes it difficult for other actors to count on them. To boost trust governments should provide more course stability. In addition, transparency can help build trust. The choices promoted by integraal programmeren will always also have a negative side for some actors, since there still is scarcity and not all developments can be accommodated at the same time. Transparency about the substantiation behind these choices can help with some acceptance from market parties because it provides more insight into the situation. This transparency does have a flip side, it is possible that transparency leads to trust and cooperation if actors agree with the decisions, however, they still have the chance to act opportunistically. And especially when they are discontent with the results they can still decide to no longer cooperate. Therefore the process of integraal programmeren needs rules that can counter this strategic behaviour. There is an important relationship between trust and control (Nooteboom, 2006). Subsequently, trust and control can replace or complement each other to some extent in the process of integraal programmeren.

6.1.4 Knowledge

In the process of integraal programmeren, a basic knowledge level of electricity, heat and hydrogen should be present according to the attendees. These energy carriers all have a different domain and playing field, which means different actors are involved. Additionally, among the involved actors in the process, there should be knowledge about different disciplines; technical, economical, spatial, legal and stakeholder knowledge is needed to create a good and complete vision. Thus far in the process, not all these kinds of knowledge have been enough represented. One attendee emphasizes the lack of knowledge of spatial planning and thinks the so-called "spatial puzzle" should be solved first in order to use it in integraal programmeren. Other attendees think there is an important interaction between the two and the input goes both ways. While many domains affect the energy system and are therefore important for the process of integraal programmeren, the scope of the process should not become too broad. There is a balance between being able to represent each kind of knowledge in order to successfully carry out the process of integraal programmeren and tacking too much on your plate.

What complicates things in the process of integraal programmeren are the knowledge gaps between actors. To have a better conversation, it is essential to first close this gap and create a shared knowledge base, which will take some time and constant repeating. Especially when market parties are becoming involved, it will take some time to work on awareness and understanding of the problem. For example in a hydrogen pilot, one of the attendees experienced a similar situation in which the knowledge level of everyone involved was lower than expected. This required constantly repeating the concepts and taking away some uncertainties the actors had. Eventually, this led to more trust between the actors.

Lastly, during the session, it was mentioned that it is crucial to combine the knowledge that different actors have by having conversations together and not only with separate actors. In Noord-Holland, they experienced that seating different actors together physically at a table and looking at the region with an area-oriented approach helped with making choices.

6.2 Analysis focus group

The focus group first validated the conclusions of the case study. The attendees recognised the function of information and vision in reducing uncertainties and the role market parties can play in this. In addition, during the session, it was further established that the attendees have a fairly positive attitude towards a more directive approach to energy infrastructure since it was often mentioned and endorsed by the other attendees. Especially in areas with limited net capacity more direction from regional governments and system operators was promoted by the attendees. Provinces and system operators are becoming more aware of how conditional the energy system is for other developments and the opportunity integraal programmeren offers to take more control over the energy system. This has consequences for the design of the collaboration process and the role of market parties in the process. Subsequently, while the involvement of market parties was supported, their role can take different forms fitting to the process conditions.

Different ways of involving market parties were discussed during the session, which could be used next to or instead of each other. An important notion was that the involvement of market parties can easily lead to a lobby for their goals, while integraal programmeren is aimed at democratic legitimate decisions that are more extensive than individual goals. Therefore the attendees do not foresee a dominant role for market parties in the decision-making process in order to counter strategic behaviour. This is in contrast with the theoretical framework since one of Ostrom's (1990) design principles state that involving all actors that are needed to achieve the goal in the decision-making process leads to more compliance with the process. Therefore it is important in the case of integraal programmeren to find a balance between involving market parties in the process and countering their strategic behaviour.

An important concept in the theoretical framework is that of the role of trust in collaborations, trust reduces the risks actors experience. Nooteboom (1995) distinguishes different types of trust and declares that you can have trust in both individuals and organisations. These types require different actions to increase the level of trust. In the focus group, it was endorsed that transparency as well as course stability can lead to trust and better collaboration. There is a positive correlation between trust and information (Nooteboom, 1995). Trust builds on mutual understanding, which in the case of market parties in integraal programmeren is lacking. Transparency and clear communication about the way the process works and substantiation of choices are therefore crucial. In return, trust and

transparency can lead to acceptance of the outcomes of the process because the market parties can see if the process was fair and it creates expectations.

Mutual understanding is also important in knowledge development and accumulation. The attendees highlighted the knowledge gap between the actors in the process and actors outside the process, such as market parties. Nooteboom (2001) mentions this kind of cognitive distance as a barrier to a collaboration process. The actors in the process need to be able to understand each other in order to combine their knowledge. And substantive knowledge is needed to ensure the quality of the process and reduce uncertainties. Thus working on the knowledge gaps between the actors in the process of integraal programmeren is an important prerequisite when involving new actors like market parties.

6.3 Conclusions focus group

The goal of the focus group was to validate the design guidelines and to collect ideas on how these can be implemented in the process of integraal programmeren to reduce uncertainties.

Involving market parties in the process of integraal programmeren can reduce uncertainties because their compliance leads to 1.) more information about subjects that are now still uncertain in the process and; 2.) a wider endorsed energy vision. Four categories of design guidelines were discussed in the focus group that can shape the involvement of market parties in the process of integraal programmeren: governance and decision-making, communication, trust and reciprocity norms, and knowledge development and accumulation.

The discussion on governance and decision-making was focussed on the role of market parties in the process of integraal programmeren. The attendees agreed that a more active role for market parties in the process can help mitigate uncertainties. However, it is important to note that involving market parties in the process of integraal programmeren complicates the process. New actors bring along new values and goals, consequently, involving market parties in the process can lead to strategic behaviour. Therefore the role of market parties should be well defined, so it is clear what impact they have. This role can change depending on local circumstances. As the example of the brick factory showed, in an area with net congestion more control from regional governments and system operators and less input from market parties may be favoured.

As was already mentioned during the in-depth interviews, the process of integraal programmeren lacks transparency. Both about the outcomes and the substantiation of the outcomes to the stakeholders outside of the process, which currently includes market parties. It is of the essence to work on this knowledge gap to increase acceptance of the outcomes of the process by market parties. Additionally, working on transparency should go hand in hand with decreasing the knowledge gap with market parties. Market parties are not only in the dark about the process of integraal programmeren but also about the impact their developments have on the energy system and the other way around. This knowledge gap can hinder collaboration.

Transparency is also important for establishing trust between market parties and the actors in the process of integraal programmeren. Trust is different between market parties and regional governments versus market parties and system operators, and is consequently, established in different ways. In addition to transparency, course stability is an important factor to establish trust with governments. The election cycle of governments leads to the association of fluctuations of plans. Consequently, the involvement of regional governments in the process of integraal programmeren

can lead to wariness of market parties. Therefore, plausible course stability from regional governments is needed to establish trust.

Lastly, the category knowledge development and accumulation were discussed in the focus group. In the process of integraal programmeren, many domains come together, therefore the process requires many different kinds of knowledge. This knowledge is often invested with different actors and needs to be combined to understand the whole picture and make sound decisions. Therefore, structures need to be created in the process of integraal programmeren to facilitate combining knowledge of different actors. Additionally, knowledge gaps play a role here as well and the cognitive distance between the actors in the process of integraal programmeren needs to be reduced to facilitate collaboration.

The implications on the process of integraal programmeren and recommendations for practitioners based on these conclusions are further discussed in 7.3.

7. Conclusions and discussion

7.1 Answering the research question

This thesis aimed to construct the contours of design guidelines that could improve the long-term regional collaborative process for integraal programmeren to better suit uncertainties stemming from the interdependencies with market parties. A theoretical framework has been constructed as a theoretical lens to analyse three cases to research both the theoretical and the practical side of the integraal programmeren. This has led to an answer to the following research question:

How can uncertainties that occur in the development of long-term collaboration for integraal programmeren be managed given the characteristics and context of these uncertainties?

Integraal programmeren is still under development and is a learning process. Because of the fast pace and the underlying pressure of net congestion, the first iteration of the process of integraal programmeren started while the process was not completely thought out. As a result, when practitioners are asked about uncertainties the focus is mostly on developing a good working method and process-related uncertainties like the legal status of the process and uncertainties that influence the process from the outside are neglected. However, in the interest of the next iterations the problems uncertainties involving dependencies on market parties can bring along, are also acknowledged. The actors in the process state that these uncertainties can lead to undesirable situations or dissatisfaction of actors in the future.

The uncertainties stemming from market parties can be characterised, using the theoretical framework, as uncertainties that are problematic in terms of knowledge of the probabilities, but not in terms of knowledge of the outcomes. These kinds of uncertainties are often associated with methods like scenarios and probability calculations. However, Stirling (2020) states that instead, uncertainties should be tackled by actors together in the form of future-making, as explained in the theoretical framework. As became clear from the case study, interviewed regional governments and system operators, gravitated in this stage of the process towards reducing uncertainties by either accumulating more information about the uncertainty or by crafting a vision about it, similar to the future-making process suggested by Stirling (2020). This can be explained by the fact that the uncertainties lie in the immediate environment of the process of integraal programmeren. Therefore regional governments and system operators can use integraal programmeren to direct developments and reduce uncertainties, in order to design an energy system coordinated with the developments in all sectors with a claim on the energy network. This research enhances Stirling's (2020) suggestion of future-making by acknowledging the sequence with information gathering and how these both forms of dealing with uncertainties can be organised through the design of a collaboration process.

Although regional governments and system operators can accelerate certain developments through integraal programmeren, in the end, they are still dependent on market parties for the realisation of for example energy supply and demand. By involving market parties more intensively in the process a feeling of ownership and responsibility among market parties can be created. This could speed up the process of integraal programmeren and lead to more input in the information-gathering phase and more support for and adherence to the energy vision. However, this involvement can also bring along risks since market parties will almost always act strategically, according to the actors in the process of integraal programmeren. The involvement of new actors increases the complexity of the process of integraal programmeren. This requires adaptations to the process like new process rules

and organisational structures to counter strategic behaviour and to deal with the increased complexity. Contours of design guidelines to shape the involvement of market parties in the process emerge out of the theoretical framework and were validated in the focus group, these are further elaborated on in the section on practical implications.

So, the uncertainties that emerge out of the interdependencies with market parties in the process of integraal programmeren can be managed by giving more direction to developments, which is partly enabled by the conditional nature of the energy system. Giving direction to developments mitigates the uncertainty since the parties in the process are more likely to adhere to these directions. However, market parties are still not forced to make a choice based on these directions. Therefore, further acceptance and endorsement can be achieved by giving market parties a role in the process of integraal programmeren. The appropriate extent and form in which market parties to involve depend on local circumstances. This can also differ between different areas in a province. A area with limited capacity on the electricity network, like the earlier mentioned example of the brick factory, could for example tend to take a more directive approach and merely inform market parties of their options instead of actively involving them. This suggests that one of the aspects that influence the further design of the collaborative process of integraal programmeren is the availability of net capacity. And this influences the way uncertainties are perceived.

7.2 Scientific implications

The theoretical framework aimed to interpret how design guidelines for a collaboration process design can help mitigate uncertainties. The theoretical framework consisted of two components, design guidelines for collaboration in an uncertain socio-technical system and characterization of uncertainties, of which the combination was not well represented in scientific literature. There is a range of scientific literature available on design guidelines which often note that when designing in a socio-technical system the use of methods and perspectives depends on the situation. No framework exists that specifically zooms in on aspects of a process that influence uncertainties. Therefore, in this research, four scientific works were combined to analyse the process of integraal programmeren from different perspectives. While all perspectives assume an uncertain environment, the coupling between the design guidelines and managing uncertainties was not explicitly made. This research explored the link between the design of a collaboration process and the management of uncertainties. It showed that collaboration is expected to positively impact uncertainties in the process of integraal programmeren. As a result, a broader set of stakeholders becomes engaged in the process of integraal programmeren. However, this does require good process rules and governance structures to guide the increased complexity of the collaboration process.

The characterisation of uncertainties was approached with two theories, one based on the place of the uncertainty (Miller, 1992) and the other on the nature of the uncertainty (Stirling, 2017). In this research, the place of uncertainty appeared to be more relevant for the proposed mitigating measures. This shows that uncertainties do not only influence the process and the choices that are made but also the other way around. This mutual interdependency has thus far been unexplored in scientific literature. Therefore, this research explores a new way of managing uncertainties.

Two ways of dealing with uncertainties were discussed in the research. Firstly, by obtaining more information about the uncertainty. Uncertainty is often explained as a lack of knowledge about the probabilities of the future state of events (Erkoyuncu et al., 2013; Sniazhko, 2019; Stirling, 2017).

However, Scoones & Stirling (2020) argue that uncertainties are context-dependent and understood differently by different actors. Therefore it is important to leave them up for debate, which is where the second way of dealing with uncertainty comes into play: creating a shared vision. Scoones & Stirling (2020) discuss the concept of future-making between actors but do not explore what this means for the collaboration process design. Regional circumstances, for example, net scarcity, can influence the way uncertainties are perceived by actors in the collaboration process. The combination of scientific literature on uncertainties and collaboration process design in the scientific framework brings new perspectives on this relationship. While the focus of most scientific literature on uncertainties has focussed on knowledge as an enabling factor, this research shows the importance of the design of a collaboration process in mitigating uncertainties.

The concepts from the theoretical framework were understandable and recognisable by actors in the process of integraal programmeren, which facilitated the discussions during the focus group. The framework proved to be useful in bridging the two research areas by identifying similar concepts and notions. For example, closing the cognitive distance between actors and establishing trust are important factors in both collaboration and reducing uncertainties. Nooteboom (2006) discusses both these concepts in the context of collaboration. He notes that various types of trust exist which are established differently. This is supported by the actors in the process of integraal programmeren, who recognise that trust between governments and market parties versus system operators and market parties are different and require other actions. Trust has a relationship with control, they can replace or support each other (Nooteboom, 2006). This balance is also at play in the collaboration process of integraal programmeren; the collaboration with market parties requires trust, but to counter strategic behaviour a degree of control is also advocated. Because the process of integraal programmeren is constantly learning and adapting to new situations and ideas, there is not one balance point for the entire process, this is something that can change during the process. For example at the start of the process of integraal programmeren, more control may be required to establish the credibility of the process. As the actors noted in the focus group, the balance between trust and control can be difficult to find and can differ between situations. Nooteboom (2006) appoints a balance of mutual dependence between the actors as an instrument for control, which could apply to the case of integraal programmeren. However, as thus far experienced in the process of integraal programmeren, the presence of mutual dependency on its own is not enough for a successful collaboration since market parties will still act strategically when given the chance. Therefore a more elaborate collaboration process design is required, such as process rules on entry and exit of the process and decision-making rules. This demonstrates that the discussed scientific works can complement each other and shows, in that sense, the strength of the theoretical framework.

The theoretical framework provides design guidelines both on individual relationships as well as the context of the collaboration process. The work of Ernst ten Heuvelhof and Hans de Bruijn and that of Bart Nooteboom focus more on the actors in the process and their relationships. While Elinor Ostrom and Anna Bergek take on a broader perspective which looks more into the context of the collaboration process. Both kinds of perspectives are of relevance for the collaboration with market parties, especially since market parties are not (yet) actively involved in the process and thus are also part of the context. The different perspectives of the theoretical framework enabled analysis of market parties both as an actor in the process as well as part of the broader context of integraal programmeren. However, since the research focused on more involvement of market parties, the design guidelines on the relationships between the actors got more attention. When the process of

integraal programmeren is more established the focus can shift towards the context of integraal programmeren. Because of the combination of perspectives, the theoretical framework is well suited for processes that can change based on new insights and ideas, such as integraal programmeren.

In the section on the construction of the framework, it was mentioned that the use of the framework on integraal programmeren may lead to more generally applicable insights about the interconnection between mitigating uncertainties and collaboration. The scientific literature states that there is a positive relationship between collaboration and information and uncertainties largely emerge out of a lack of information. The premise of a positive relationship between collaboration and uncertainties was seconded by the actors in the process of integraal programmeren. Along the same argumentation, this premise could be applicable in other situations where uncertainties are at play. Most obvious by obtaining more shared information about the uncertainty, in the case of uncertainties stemming from knowledge invested with different actors. But also through future-making between actors. This could be used as an alternative to the often-used scenario- and probability studies in situations where uncertainties can be influenced by the choices of actors. The design guidelines discussed in this research can help shape the collaboration process to enable information gathering and future-making. While only four categories of design guidelines were further elaborated on in this research, the other categories may be relevant as well. Boundaries and context, institutions and resources were not covered in the cases, since these concepts were less applicable to uncertainties originating from market parties. However, especially boundaries and context could provide interesting opportunities for further research, since scoping rules have a relationship with knowledge. The discussion in the focus group showed there is a balance between having enough knowledge present in the collaboration process and keeping the scope manageable.

In conclusion, the theoretical framework holds in the case of the collaboration process of integraal programmeren. The framework provided new insights into the relationship between uncertainty management and collaboration. In addition, the framework resulted in the contours of design guidelines to manage uncertainties stemming from market parties through the collaboration process, supported by the actors in the process. The use of different perspectives that complement each other proved valuable to analyse the collaboration with market parties both from within the process as well as its context. This was appropriate in this research since market parties are currently still outside of the process and thus part of its context, but with the next iterations in mind are taking on a more active role in the process of integraal programmeren and are thus also becoming part of the process itself.

7.3 Societal implications and recommendations

Integraal programmeren is set up as a learning process, so the process can keep adapting based on new ideas and situations. The focus in the 22/23 iteration was mostly on setting up a good base for a collaboration process between regional governments and system operators. However, the interviewed actors did recognise the interdependencies with market parties and the need to involve them more intensively in the process. While the pressure of net congestion will still be there in the next iteration, there is more time set out for the process. This could allow more focus on the long-term aspects of the process, like the uncertainties stemming from the interdependencies with market parties. The process of integraal programmeren can play a role in mitigating uncertainties in the energy system by accumulating knowledge on developments, drawing up an energy vision and assisting in making decisions. To improve the management of uncertainties in the process, this research proposes to further develop the collaboration process with market parties. Collaborating

with market parties can decrease uncertainties because this can either lead to more information since in a collaboration actors are more inclined to share information, or it can facilitate processes of future-making between the actors to create a shared vision.

Four elements that can shape this collaboration process and their influence on uncertainties were discussed in the focus group: type of involvement, transparency, trust and knowledge. How these elements impact the process of integraal programmeren is discussed below. The elements were discussed separately in the focus group, in the order they are mentioned. Sometimes the attendees of the focus session referred back to earlier comments on other elements. However, the relationships between the elements have not been analysed in detail, so no clear conclusions can be made about this.

7.3.1 Type of involvement

Bruijn et al. (1998) state that all actors that are needed to achieve the overarching goal of the process should be involved in the decision-making process. Since market parties play an essential part in the realisation of the energy system, for instance, demand and supply, according to this theory they should be involved in the process of integraal programmeren. The involvement of market parties in the process of integraal programmeren can be designed in different ways, as elaborated on in 6.1.1. Some discussed methods include representatives, region sessions and consultation forms. When to use which form can depend on the local circumstances. For example, in an area with limited options for the energy system, it may be favourable for regional governments and system operators to take more control and merely inform market parties of their options. Thus, it is important, when market parties are taking on a more active role in the process, to ask the right questions about which information you want from them. Additionally, it is important to manage their expectations and make sure they understand their role in the process of integraal programmeren.

Net scarcity has already led to strategic behaviour of market parties, in the form of claiming net capacity or keeping their options open, which worsens net scarcity. Collaboration is associated with sharing information and thus involving market parties in the process could lead to more insight into their development plans. If market parties are involved in the process and get more certainty about other developments, they are more likely to make decisions about their development plans. However, there is a tension at play here between involvement and lobbies. Involving market parties in the process and giving them influence, can lead to lobbies for their own goals and wishes. Market parties will act strategically to steer the process towards their desired outcomes. Therefore precise questions need to be asked and process rules are needed to direct the interactions with market parties.

7.3.2 Transparency

The process of integraal programmeren is lacking transparency and clarity towards stakeholders outside the process, including market parties. Both the outcomes and the substantiation of them should be transparent to advance the acceptance. This requires rules on what information to share and how since this could include sensitive data. This becomes even more important when more actors are becoming involved in the process.

In addition, it is important to become aware of the knowledge gap between parties in the process and those outside the process. Transparency is useless if the actors cannot understand the shared information or are even unaware of the process's existence. Knowledge gaps can hinder collaboration because actors are less able to relate to each other (Nooteboom, 2012). Additionally, the knowledge

gap can make it difficult for actors to understand their role in the process of integraal programmeren. Therefore it is important to work on creating a basic knowledge level amongst market parties before involving them in the process, for example by setting up a website on integraal programmeren. Setting up a secondary process next to the regional process of integraal programmeren would allow the actors to actively work on transparency and the knowledge gap.

7.3.3 Trust

Trust has a positive relation with sharing knowledge and information within a collaboration. How trust is built differs between market parties and governments versus market parties and system operators. In the case of trust with system operators transparency is important, not only about the process of integraal programmeren, but also about their investment process. This can be classified as competence trust; trust in the ability to act according to expectations (Nooteboom, 2006).

In addition to transparency, trust between regional governments and market parties requires course stability of government plans as a base for intentional trust. The involvement of regional governments in energy infrastructure can cause tension. Government plans are often perceived as not very stable, because of the election cycle. This also played a part in energy becoming part of the private domain. Decisions on energy infrastructure are often irreversible and must therefore be robust. The involvement of governments and trust in them as actors in the process is therefore largely based on the stability they must maintain in the process. Agreements must therefore be made about course stability from the regional governments. And more importantly, the course stability must be made plausible to other actors. These agreements are also part of scoping decisions since they indicate what is discussed in the process of integraal programmeren and to what extent regional governments can influence the outcomes of the process of integraal programmeren and consequently the energy system.

7.3.4 Knowledge

In the energy system, many domains come together. Therefore the process of integraal programmeren requires diverse kinds of knowledge. When composing a shared vision it is therefore important to have a basic knowledge of all energy carriers and different disciplines present. Because of this broad scope, the process of integraal programmeren is often associated with the 'spatial puzzle', however, it is important to keep to scoping decisions and not make the process a planned economy. So there needs to be a balance between having basic knowledge about all important disciplines available in the process and staying away from solving the 'spatial puzzle'. What can help with finding this balance is making an inventory of which knowledge must be covered per area and involving actors in the process with this knowledge. Linking the role of the expert to these actors can make sure that facts and personal interests do not get mixed up.

Knowledge gaps could pose a problem when different kinds of knowledge are invested with different actors, as mentioned before. However, knowledge gaps can also bring opportunities for innovation and learning. Therefore Nooteboom (2012) introduced an optimum knowledge gap: when actors can understand each other but can still provide new insights. This optimum knowledge gap is achieved by trial and error. For integraal programmeren, this could, for example, mean a basic technical knowledge of the energy system is required for all actors, so they understand the implications of other developments on the energy system.

7.4 Limitations and future research

This thesis resulted in design guidelines for the collaboration with market parties in the process of integraal programmeren with the aim to reduce uncertainties. A case study and a theoretical framework were used to combine concepts from scientific literature with ideas and experiences from the real world. The design guidelines that resulted from the theoretical framework were validated by actors from different regional processes of integraal programmeren. However, it can be argued that given certain choices made in the design and execution of the research, the research question could have led to other results.

7.4.1 Research method

The thesis followed an exploratory approach, which entailed the research being further scoped down along the way. Important scoping decisions were made in the first two phases of the research about the theme and kind of uncertainties. The course behind these scoping decisions resulted in a longer orientation phase than originally planned and consequently a longer research duration. Because of the longer orientation phase, the original aim of the research of delivering an improved design of the collaboration process had to be downplayed to the creation of design guidelines. Hence, the outcomes of the research provide suggestions to improve the collaboration with market parties, but more information is needed for actual implementation and this requires further research.

The exploratory approach was chosen because the process of integraal programmeren is still under development. The risk of researching a process that is carried out at the same time as the research is that it is a moving target. The actors' views highly depend on the current situation and can change over the course of a couple of weeks if new issues or ideas are brought to light. In practice, due to the process's haste and urgency, the actors found it difficult to think ahead about uncertainties stemming from the interdependencies with market parties. The attention of the interviewed actors in the process of integraal programmeren was in the first instance on current issues and process uncertainties they were facing, which made it difficult to pinpoint important uncertainties further in the future. The questioning in the interviews led to the actors think about the future, however, some interviewees were reserved in their answers and underlined they were merely speculating. This has as a consequence, that actors could easily renounce their statements. However, the validation of these statements by other actors in both interviews and the focus group provides substantiation.

7.4.2 Theoretical framework

As discussed in the scientific implications, the theoretical framework proved to be useful in the case of integraal programmeren. However, the framework could be critiqued for being too general. The framework consists of overarching categories and rough frameworks to define uncertainties and determine design guidelines. In light of the novelty and haste of the process, a fast overarching approach was deemed more suitable, but as a consequence, this has led to more general results. There has not been made a distinction between the design guidelines on which is more important or which part of the uncertainty they take on. Scientific knowledge is lacking to zoom in on certain aspects of a process and determine the core of a problem. This could have been useful for the process of integraal programmeren to determine which process components have the most influence on uncertainties stemming from market parties. Further research on a smaller scale could provide more insight into how specific aspects of a process influence a problem. This does require a way of analysing process aspects separately.

7.4.3 Data collection

The choice of interviewees and attendees of the focus session can be argued to have significantly affected the outcomes of the research. Because of the novelty of the process of integraal programmeren, not many people have substantial knowledge of and experience with the process. As a consequence, market parties have not been interviewed as part of the research, even though they are significant actors in the research. It was overall acknowledged by the actors that market parties are not sufficiently involved in the process to understand the process and to give input about uncertainties. Also, representatives for market parties were difficult to find. As a replacement experts that are closer involved with market parties like the expert on Cluster 6 and the expert on wind-at-sea. However, in the next iteration, there may be more capacity available to work on the involvement of market parties in the process. This presents opportunities for further research. The design guidelines resulting from this research provide some starting points for designing this collaboration. Nevertheless, the involvement of market parties will lead to more (contrasting) interests in the process, which will make the process even more complicated. In reality, collaboration with market parties calls for more changes in the process design than open and transparent communication, building trust, closing the cognitive distance and creating structures for combining knowledge. Further research on the design and implementation of the collaboration with market parties, in which the opinions and experiences of market parties themselves are taken into account could therefore lead to interesting new insights.

7.4.4 Scope

In the conceptual analysis, four roles of market parties were stated: energy users, suppliers, non-regulated system operators and providers of flexibility measures. Nevertheless, in the interviews market parties were mainly discussed in the roles of energy users and suppliers. This can be explained by the focus on the electricity network in the process of integraal programmeren. Non-regulated system operators and providers of flexibility measures are currently less relevant in the process and thus less mentioned. However, in the future, these actors will play a bigger part in the energy system and consequently become more important for the process of integraal programmeren. These could require a different dynamic than energy users and suppliers. Designing a process such as integraal programmeren is not a linear process, during the process, the design requirements can change based on new situations and ideas and thus it calls for flexibility, while still keeping its credibility. Therefore, further research could show what the influencing factors are that call for a change in the collaboration process design.

Another recommendation for future research is to look at the process with a different scope. This research has looked at three case regions on a provincial or RES-region scale. However, as mentioned during the focus session, the process can require different types of involvement of market parties depending on the local circumstances. Further research on a more local scale could provide insight into which factors determine the choice for a certain form of involvement and what this entails for the design guidelines and the way uncertainties are perceived.

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Appendix A: Overview of design guidelines

The analysis of different theoretical perspectives on collaboration in an uncertain environment resulted in a number of design guidelines. To make the guidelines easier manageable and suited to use in the process of integraal programmeren, they have been divided into seven categories.

Trust and reciprocity norms	Trust and reciprocity norms are reinforced by participation in most or all subprocesses.
	There is intentional trust between participants
	There is competence trust between participants
	Monitors are accountable to appropriators (or are the appropriators themselves)
	There are methods of conflict management available
	There are exit rules for participants to leave the process over time
	The core values of participants are protected in the process
	There are incentives and pressures for entering the system
	Participants commit to the process rather than to the result.
Knowledge development and accumulation	There are processes for knowledge development: generation, diffusion and combination of knowledge in the system
	There are processes for the accumulation of knowledge
	Information is available in a timely fashion for all monitoring and evaluative processes.
	Substantive insights are used for facilitation in the process
	Substantive variety and selection in the process
	There are processes of entrepreneurial experimentation: learning process coming forth out of testing of new technologies, applications, processes etc.
Governance and decision-making	Collective choice processes enable most affected individuals to participate in making rules.
	The commitment of participants may be postponed to prevent a difficult decision-making process.
	All participants needed to achieve the overarching goal of the process are involved in the decision-making process.

	Substantive choices are made part of the process.
Boundaries and context	Boundaries (biophysical and social) are clearly defined.
	The context of the process includes a bigger timeline the process is part of
	The external context of the process is taken into account and used to create opportunities for wins or to stimulate collaboration.
Communication	Process regularly provides the external environment with updates that increase trust from outside the environment.
	Social, political, and learning networks are formed
	The process is open and transparent
Institutions	The institutions of the participants are aligned
	New structures are created to exchange products and services
	There is minimal recognition by "higher" authorities that appropriators have rights to self-organize and devise their own institutions
	There are nested enterprises for appropriation, provision, monitoring, enforcement, conflict resolution, and governance.
	The process is fitted in the social and institutional context
Resources	Effective leadership is demonstrated in all action situations
	There are rules on resource mobilization
	Entry of firms and other organizations along the supply chain
	The process is heavily staffed
	There is congruence between appropriation and provision rules and fitness to local conditions

Appendix B: Interview protocol – Introductory interviews

Algemene vragen

Doel: informatie verzamelen over de context van de case en het beeld van de geïnterviewde

- Vanuit welke rol en organisatie ben je betrokken in het programmeerproces?
- Wat zie je als de toegevoegde waarde van integraal programmeren ten opzichte van de gebruikelijke werkwijze om tot investeringen te komen?

Betrokkenheid van marktpartijen

Doel: overzicht van welke marktpartijen de grootste invloed hebben op het energiesysteem en hoe ze wel of niet betrokken zijn in het proces

- Introductie marktpartijen: 4 rollen
- Welke grote ontwikkelingen zie je in de regio die grote impact hebben op het energiesysteem tot 2050? (3 belangrijkste)
- Hoe hebben jullie de informatie-uitwisseling met de marktpartijen die bij deze ontwikkelingen betrokken zijn tot nu toe aangepakt?
- Welke afspraken en verwachtingen hebben jullie hierover gemaakt voor latere stappen?

Invloed van onzekerheden op integraal programmeren

Doel: de gevolgen van de onzekerheden vanuit marktpartijen op het proces van integraal programmeren in kaart brengen

- Korte introductie van onzekerheden vanuit marktpartijen (vb: energievraag van industrie, ontwikkeling van warmteaanbod, waterstof)
- Wat doet eventueel beperkte data met de mogelijkheid om keuzes te maken?
- Wat zijn de gevolgen van de onzekerheden vanuit marktpartijen op het proces?
  - Op welke manier beïnvloedt dat de opstelling en houding van actoren in het proces?
  - Verandert het iets aan de doelstellingen of focus van integraal programmeren?
  - Verandert het iets aan de status van het MIEK?
  - Vraagt het om andere instituties of regels in het proces?
- Hoe gaan jullie hiermee om?
- Wat zou kunnen helpen om meer zekerheid te krijgen over investeringen vanuit marktpartijen?

Appendix C: Interview protocol – In-depth interviews

Gespreksleidraad afstudeeronderzoek Onzekerheden in integraal programmeren

Dit interview is onderdeel van een onderzoek genaamd Onzekerheden vanuit marktpartijen in het samenwerkingsproces van integraal programmeren. Dit onderzoek wordt uitgevoerd door Tisja Kuiper van de TU Delft en Groen Licht.

Het doel van dit onderzoek is om te komen tot ontwerpprincipes voor een langdurige samenwerking in het kader van het regionale proces van integraal programmeren. Hierbij wordt er specifiek gekeken naar welke invloed onzekerheden die voortkomen uit de wel of niet betrokkenheid van marktpartijen hebben op de totstandkoming van de samenwerking. Om hierover data te verzamelen wil ik interviews houden in de drie regio's met de verschillende partijen betrokken in het regionale proces van integraal programmeren. Dit interview zal ongeveer 30-45 minuten in beslag nemen en hiervan zal een audio opname worden gemaakt. De data zal gebruikt worden voor een Master Thesis, die openbaar gedeeld zal worden via de TU Delft repository. U wordt gevraagd om een aantal vragen te beantwoorden over hoe de totstandkoming van de samenwerking tot dusver is gelopen en hoe u de doorontwikkeling van het proces voor u ziet.

Zoals bij elke online activiteit is het risico van een databreuk aanwezig. Wij doen ons best om uw antwoorden vertrouwelijk te houden. We minimaliseren de risico's door alleen een samenvatting van de interviews bij te voegen bij de thesis en deze voor gebruik te laten goedkeuren door de geïnterviewden. De opname van het interview wordt na afronding van het onderzoek (maart 2023) vernietigd.

Introductie

- Voorstellen
- Uitleg afstudeeronderzoek
- Uitleg opbouw interview
- Uitleg datagebruik → toestemming om op te nemen?
- Heb je vooraf nog vragen of opmerkingen?

I. Achtergrond

In hoeverre is de respondent bekend met en betrokken bij het proces van integraal programmeren? Hoe is het huidige proces ingericht en wat voor voordelen biedt integraal programmeren hierbij?

- Ben je bekend met het proces van integraal programmeren/PMIEK?
- Ben je betrokken in de PMIEK en op wat voor manier?
- Kan je kort iets vertellen over het huidige proces om tot keuzes voor investeringen te komen?
- Wat zie je als voordeel van integraal programmeren ten opzichte van de huidige processen?

II. Methoden om om te gaan met onzekerheden

Welke scenario's en methoden worden gebruikt om met onzekerheden om te gaan?

- In hoeverre komen jullie onzekerheden tegen in jullie normale processen van planvorming?
- Wat voor invloed hebben deze onzekerheden op de planvorming?
- Welke methoden en aannames gebruiken jullie om deze onzekerheden mee te nemen?

III. Onzekerheden met invloed op integraal programmeren

Worden de onzekerheden (waterstof, verspreide industrie, rijksbeslissingen, hoge concentratie verduurzamingsplannen) herkend door de respondent, waar komen ze vandaan, hoe problematisch zijn de kansen en de uitkomsten en hoe kan je hiermee omgaan?

- Uitleg onzekerheden vanuit marktpartijen in 4 rollen
- Onzekerheden die uit andere interviews naar voren kwamen zijn de integratie met waterstof, verspreide industrie, regionale gevolgen van rijksbeslissingen, hoge concentratie verduurzamingsplannen. Herken je deze en mist hier volgens jou nog een belangrijke onzekerheid?
- Waar denk je dat deze onzekerheden vandaan komen?/Waar worden ze door veroorzaakt?
- Wat is de invloed van deze onzekerheden op het energiesysteem?

IV. Effect onzekerheden op integraal programmeren

Hoe beïnvloeden de onzekerheden het succes van het proces en wat voor onzekerheden veroorzaken ze binnen het proces?

- Wat doet eventueel beperkte data met de mogelijkheid om keuzes te maken?
- Wat zijn de gevolgen van deze onzekerheden op het proces? (bvb verwachtingen, doelstellingen, status) evt analogie RES
- In hoeverre denk je dat deze onzekerheden opgelost moeten worden voor het succes van het proces?

Afsluiten en bedanken