# Master thesis

## Capturing solar energy in non-highway road infrastructure projects
## Stimulating market involvement in the planning phase of integrated projects

University of Groningen
Witteveen+Bos Consulting engineers

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## PREFACE

The submission of this thesis marks an important point in my educational career. Even though I still have to complete three courses, the completion of this thesis makes me feel like a burden fell of my shoulders. The hardest part is behind me and it will be a short journey along the homestretch before I will officially be able to call myself Master of Science.

The reason why I chose to start the bachelor Human Geography & Urban and Regional Planning in Groningen in 2011 was because the subject of Geography always had my attention in middle school. When I enrolled, I could never have predicted the ways in which my views towards our surrounding environment changed, and how many things that shape our society are connected to the field of planning. It was because of this I chose to start a master degree programme Environmental and Infrastructure Planning in 2017. Early into the programme it felt like I hit bull's-eye. The programme was everything I hoped for and expected and further increased my interest in infrastructure projects. The many projects I have seen and talked about in lectures and excursions, and dilemmas that can be encountered in planning practise confirmed I had made the right choice. It was with great anticipation I wanted to get into the field, the real world of planning and projects, as quickly as possible.

Therefore I contacted Witteveen+Bos after a presentation on possible internships at the Thesis Market. I already had positive experiences with Witteveen+Bos following my participation in A day in planning practise. After starting over with a completely new subject following an early reality check by Erik and Ben and some difficulties when it came to finding a thesis supervisor at the University of Groningen, my internship could finally start in the final week of May. From the first day, I felt very welcome at the office in Heerenveen and I realised early on the internship would greatly benefit my levels of knowledge in ways that would have not been attained when I would have chosen to write my thesis in the University Library.

I have to note that the completion of this thesis, and thus ultimately my master degree, would have been unattainable if it was not for the support and contributions of others. In the first place I would like to thank my interviewees. Without the contributions of Richtsje van Berkum, Hilde Kloosterziel, Marco Westhuis, Willem de Boer, Sander Lenferink, Richard Pool, Paulien Hoogvorst, Floris Oosterhof, Sip Sixma, Wim Elzing, Marcel Doyer and Ronalt Folbert it would have been impossible to finish my thesis. Their willingness to take time out of their busy schedules to engage in interesting conversations is greatly appreciated.

A thank you is also in its place for all the Witteveen+Bos employees at the office with at Heerenveen. Your sincere interest in me and my research greatly helped me to stay motivated. You showed me there is always time for a little bit of justified distraction and the importance of humour in the workplace. *Grimmige vrijdag* was always something to look forward to.

Next, I want to thank Erik and Maaike for their supervision during my time at Witteveen+Bos. Your constructive feedback and suggestions were very helpful, and your networks helped me to get in contact with some interviewees. It helped me to realize the differences between studying at the University of Groningen and what is expected of consultants in practice, which is a very valuable lesson.

Ferry, I would like to thank you for guiding me in the process of writing this thesis. Your critical but supportive feedback helped me to aim high and greatly influenced the quality of my thesis in a positive way. Your knowledge on my thesis subject and your knowledge of research processes were the common threads that run through this thesis. Because of your enthusiasm and humour it was always a pleasure to engage in a sparring session with you.

Finally, I am grateful for everyone that supported me during the full duration of my study. Special thanks goes out to my parents, my brother, all the friends I got to know during my time in Groningen and of course to Barbera. Without the help of these people I would not be where I am today, on the brink of starting my professional career. I am looking forward to whatever the future has in store for me.

Arjen Harm Bouma

Groningen, 3 January 2019

## ABSTRACT

The Dutch national government is facing multiple challenges in the near future. Two of these challenges are the renewable energy transition and the need for reconstructions in non-highway road infrastructure. In order to efficiently make use of the contested space in the Netherlands, it is wise to combine said functions. Despite best efforts, levels of innovation seem to be lacking in the road infrastructure sector. The main research question of this thesis is: "which factors can help to successfully stimulate market involvement in the planning phase of photovoltaic installations in non-highway road infrastructure projects?" The factors that were discovered in interviews have been categorized in Political, Economic, Social, Technological, Environmental or Legal (PESTEL) opportunities and barriers.

When looking for synergies in the field of photovoltaics and road infrastructure, it is clear that early market involvement is key to project success. The market is able to insert creative ideas into a project and can be engaged by constructing a dialogue which is scoped towards innovation It is important to do this in the earliest phase of a project so additional matching opportunities can possibly be discovered. To further stimulate innovation, it is important to reward sustainability in project bids. For the exploitation of photovoltaic installations it is important to bring in an energy cooperation. Thorough knowledge of local networks and key stakeholders is therefore crucial for the success of an integrated project.

Keywords: Photovoltaics, area-oriented approach, tendering, contracts, infrastructure reconstruction, early market involvement

## SAMENVATTING

De Nederlandse overheid staat voor verschillende uitdagingen in de nabije toekomst. Twee van deze uitdagingen zijn de transitie naar duurzame energiebronnen en de noodzaak voor reconstructies van provinciale weginfrastructuur. Om efficiënt gebruik te kunnen maken van de ruimte in het toch al volgebouwde Nederland kunnen deze functies gecombineerd worden. Ondanks verwoede pogingen innovatie te stimuleren is de wegenbouwsector echter nog altijd conservatief. De hoofdvraag in deze thesis is "Welke factoren kunnen bijdragen aan het succesvol stimuleren van marktbetrokkenheid in de planvormingsfase van zonnepanelen in provinciale weginfrastructuur-projecten?" De factoren die in interviews zijn ontdekt zijn gecategoriseerd in Politieke, Economische, Sociale, Technologische, Omgeving of Juridische (PESTEL in het Engels) kansen en barrières.

Wanneer synergieën gezocht moeten worden in de wereld van zonnepanelen en weginfrastructuur, wordt het duidelijk dat vroege marktbetrokkenheid de sleutel is tot het succes van een project. Marktpartijen hebben de capaciteit om creatieve ideeën toe te voegen aan een project en kunnen betrokken worden door een op innovatie gerichte dialoog aan te gaan. Het is belangrijk dit zo vroeg mogelijk in een project te doen zodat eventueel andere koppelkansen ontdekt en benut kunnen worden. Om innovatie verder te stimuleren is het belangrijk om duurzaamheid te belonen bij inschrijvingen. Voor de exploitatie van de zonnepanelen is het belangrijk een energiecooperatie te betrekken. Kennis van lokale netwerken en de belangrijkste stakeholders is cruciaal voor het succes van geïntegreerde projecten.



Sleutelwoorden: Zonnepanelen, gebiedsgerichte benadering, aanbestedingen, contractvormen, reconstructie van weginfrastructuur, vroege marktbetrokkenheid.

## LIST OF ABBREVIATIONS

| Abbreviation | Full |
|---|---|
| CO2 | Carbon dioxide |
| EIA | Energy Investment Allowance |
| GDP | Gross Domestic Product |
| MEAT | Most Economically Advantageous Tender |
| PESTEL | Political, Economic, Social, Technological, Environmental, Legal |
| PPP | Public-Private Partnership |
| PV | Photovoltaic |
| RWS | Rijkswaterstaat: the executive organisation of the Dutch Ministry of Transport, Public Works and Water Management |
| SME | Small and Medium Enterprise |

## LIST OF TRANSLATIONS

| English | Dutch |
|---|---|
| Area-oriented approach | Gebiedsgerichte benadering |
| Competitive dialogue | Concurrentiegerichte dialoog |
| Leasehold estate | Recht van opstal |
| MEAT | EMVI/Economisch Meest Voordelige Inschrijving |
| Netherlands Enterprise Agency | Rijksdienst voor ondernemend Nederland |
| Notion of State aid | Staatssteunrecht |
| Private actors | Marktpartijen |
| Procurement | Inkoop |
| Public actors | Overheidsinstanties |
| Royal Dutch Touring Club | Koninklijke Nederlandse Toeristenbond (ANWB) |
| Tender law | Aanbestedingswet |
| Tendering procedure | Aanbestedingsproces |

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# 1

## CHAPTER ONE: INTRODUCTION

### 1.1 Scientific relevance

Following the Paris climate agreement in 2015, many countries have agreed to recognize the urgent threat that climate change forms for the planet and agreed to fight global warming by reducing greenhouse gas emissions (United Nations, 2015). This can be achieved through a transition from traditional sources of energy, which are largely based on fossil fuels, towards sustainable forms of energy (International Energy Agency, 2014). On top of that, different scenarios show that global energy demand will rise in the next decades while fossil fuels are depleting. If the current transition to and implementation of renewable energy is not accelerated, the energy supply will not be able to meet global energy demands, putting pressure on the system (Capellán-Pérez, 2014).

The Dutch government also signed the Paris climate agreement, and goals have been set to aim for a 14% national renewable energy production by 2020. By 2023, that percentage should rise to 16% (Ministry of Economic Affairs, 2016). Following these national goals, many provinces established their own regional goals in terms of the generation of renewable energy.

Currently, the most common forms of renewable energy in the Netherlands, photovoltaic systems and wind turbines, deliver some negative externalities. Given the densely populated nature of the country, further development of sources of renewable energy to meet regional or national energy goals will generate resistance because of conflicting land use (Cruz, 2016). The key to overcome these problems is an integrative approach to incorporate these renewable energy networks into the environment (Ministry of Economic Affairs, 2016). The Dutch government decided to delegate the task of spatially designing these combined networks to local and regional governments.

To further decrease the environmental footprint of infrastructure projects, policies that deliver stimuli for innovative solutions need to be adopted (Dong et al., 2018). In order to achieve this, energy and infrastructure networks can be integrated in order to efficiently make use of contested space. However, policy and practice do not necessarily connect in the contemporary planning arena, and it is an issue that should be tackled in order to successfully manage the energy transition. Open and clear interactions between client and contractors, including the sharing of project risks, are becoming more important as well as the maintenance of infrastructure projects to be integrated into a project contract (Kennis In Het Groot, 2009).

A knowledge gap exists because every location has a different context consisting of stakeholders, nature- and landscape qualities, local communities and SME's, and local governments and their policies. Therefore it is difficult to come up with a standardized approach that guarantees the successful integration of different functions in infrastructure projects. Despite the amount of academic literature available on energy policy and energy transitions, little is known about the effects those have on each other on a regional scale.

### 1.2 Societal relevance

The transition towards forms of sustainable energy concerns everyone on the planet. This is not only because of climate change on a global scale caused by increased levels of carbon dioxide in the atmosphere, but also because humanity will run out of fossil fuels sooner or later. Different scenarios can be established for when

this will eventually occur, but at that point communities have to be able to switch to an energy supply that is 100% sustainably generated.

With the current development rates in the Dutch sustainable energy sector it is unlikely the Netherlands will be ready for this inevitable transition within the next few decades. Local resistance puts the brake on large-scale development, so it is essential to let energy and road infrastructure networks overlap in order to make use of the contested spaces in densely populated areas. Since infrastructure developments often take place in urban areas, it is especially important to integrate energy neutrality into the design of infrastructure projects (Ministry of Economic Affairs, 2016).

## 1.3 Corporate relevance

The concept of the market is an important theme in this research. The market is defined as the optimal institution for the production and exchange of private goods (Ostrom, 2010, p. 642). An important thing to note is that infrastructure is a non-private or public good. This means a government needs to impose taxes to gather necessary resources in order to generate efficient levels of public goods since individuals will refrain from doing so. Assuming the market is capable of delivering quality (Leendertse, 2015), governments will search for a partnership in order to efficiently and innovatively procure public goods like road infrastructure.

Singels et al. (2003) describe different market parties that can be incorporated into the process when combining infrastructure with renewable energy: contractors, grid providers and consultancy firms. Especially consultancy firms can play an important role, since they possess specific knowledge on sustainability and infrastructure planning that can be utilized in the project and are often approached by local governments to share that knowledge. They furthermore are important when an open procedure is chosen since local or regional governments are not always familiar with that particular tendering instrument. Third, they can also execute a market consultation or monitor the project. The wide variety of roles a consultancy firm can play in the planning process therefore makes an important contribution to the scope of this research. In the conclusion, the findings will be translated into an assessment model which can be used by consultancy firms to determine which strategy to use when aiming to utilize an integrative approach to a project.

## 1.4 Aim of this research and research questions

The aim of this study is to analyze the ways in which market involvement can be stimulated to add photovoltaic installations to the planning phase of non-highway road infrastructure in the Netherlands. The goal of the thesis is to build a road map to successfully incorporate sustainable energy in infrastructure planning and realisation. Market parties and governments can profit because the research results can contribute to better reciprocity. Governmental organizations know how they can successfully involve the knowledge and creativity of market parties to realise innovative solutions that contribute to a society that is more sustainable, and market parties will be better able to cope with the complexities and uncertainties that occur in the planning domain of combining the functions of road infrastructure and photovoltaics.

### Main research question

Which factors can help to successfully stimulate market involvement in the planning phase of photovoltaic installations in non-highway road infrastructure projects?

### Secondary research questions

1. What is the influence of procurement and tendering policy and energy policy on the realisation of renewable energy generating road infrastructure projects in the Netherlands?
2. Which steps are needed to include an area-oriented approach in non-highway road infrastructure projects?
3. Which possible synergies between different actors in the planning phase of non-highway road infrastructure can be created and which steps are necessary to reach the full potential of these synergies?
4. Which incentives can be implemented to stimulate the innovative power of market parties in the planning phase of energy generating non-highway road infrastructure projects ?

5. Which obstructions that limit the innovative power of market parties in the planning phase of energy generating non-highway road infrastructure can be observed?

## 1.5 Research design

In this first chapter, the scientific and societal relevance of this thesis have been addressed along with the aim of this research. In order to fulfil this aim and truly close the scientific knowledge gap and the results to be of value to society, the main research question and the sub-questions that help answer the research question have been proposed.

The second chapter brings a bit more context on climate change, the energy transition in a Dutch context and the decentralized generation of renewable energy.

In chapter three the theoretical foundation for this research is laid out. Topics on infrastructure planning are further elaborated upon through a Dutch planning lens. Thereafter, the theoretical concepts on adding value through utilizing an area-oriented approach are brought to the surface, after which a discussion takes place on the role of market parties in the Dutch planning arena through procurement, tenders, contracts and early market involvement.

Chapter four describes the motivation for the research method that is chosen, explains how data will be collected, categorized through a PESTEL-analysis and how that analysis takes place, and how the author treats his data and approaches and interacts with participants. Analyses of policy documents and interviews with experts and stakeholders will determine which key actors and factors (in different levels of government, as well as market parties and stakeholders) can contribute to answering the research questions.

In chapter five the data from interviews is translated into results and barriers and opportunities per PESTEL-category. Data from different interviews are compared to each other to see where opinions and experiences overlap, which key opportunities can help conquer great barriers, and the other way around, which barriers should be avoided when trying to pursue a promising opportunity.

In chapter six, the conclusions of the research are presented and the author answers the research questions. The author also designs and offers recommendations for numerous ways to fight institutional barriers which can benefit actors in the private that are involved in the domain of energy neutral road infrastructure.

Chapter seven offers a critical reflection over the research and the gathered data. The chapter points out where the research could have been improved in terms of planning, data collection or missed elements in the theoretical framework. A discussion on the quality of the collected data is also included.

Chapter eight consists of a list of references that have been used to write this thesis. Appendices are included after the reference list.

# 2

# CHAPTER TWO: CONTEXT

## 2.1 Climate Change

Combined with contemporary trends in deforestation, increasing levels of greenhouse gases are emitted into in the atmosphere, leading to a rise in global temperatures causing sea levels to rise (Cazenave & Le Cozannet, 2014). According to the Intergovernmental Panel on Climate Change (2015), this is mainly due to thermal expansion of ocean water, as well as the transfer of molten land ice to the ocean. Different models can be established to predict future rises in sea level in the period until 2081-2100, with a rise of 26 to 55 centimetres for the lowest scenario to a rise of 52 to 98 centimetres for the highest scenario. Scholars agree that in the twentieth century the rise in global mean sea level has accelerated and probably will continue to do so, which makes it difficult to accurately predict long-term effects. Future models will have to be developed to mace a more accurate assessment of the risk of a rising sea level (Katsman et al., 2011, Cazenave & Le Cozannet, 2013).

With 60% of the population living in polders below sea-level, and 70% of the GDP being earned in that area (Ministries of Infrastructure and the Environment and Ministry of Economic Affairs, 2014), the Dutch have a rich history when it comes to water management and coastal zone protection (Kosterf & Hillen, 1996). It is vital to the welfare of the nation. Being situated in a densely populated delta region, the Netherlands have to cope with both storm surges and peak discharges of the Rhine and Mose rivers (Katsman et al., 2011). Global warming increases a complex flood risk, and to reduce that risk as much as possible, the Dutch Government wants to reduce national emissions of greenhouse gases to tackle climate change (Ministries of Infrastructure and the Environment and Ministry of Economic Affairs, 2014).

## 2.2 Energy Transition

### 2.2.1 Global Energy Transition

The physical limitations and future inevitable depletion of global fossil fuel reserves is something that has received a lot of attention in the scientific debate over the past couple of decades (Capellán-Pérez et al., 2014). The declining amount of available resources means that conventional sources of energy, on which mankind currently depends will become increasingly pressurized and the global community will need to turn to alternative, sustainable sources of energy in order to meet increasing global energy demands (Coyle et al., 2014).

### 2.2.2 The Dutch Energy Transition

In the late 50s and early 60s, another energy transition was made in the Netherlands, namely the transition from a coal-dependent energy system to a natural gas-powered energy system (Kemp, 2010). Factors that helped to boost this transition were the discovery of natural gas near Slochteren and declining imports of coal, leading to a less profitable Dutch coal industry (ibid.). Exploiting the gas field became a priority for the national government, and through campaigning public support for the use of natural gas was stimulated.

After a couple of years the transition was complete, and almost all Dutch households could enjoy central heating and a reliable supply of warm water. The main driver behind this transition was the Dutch government, whom stated a clear central objective, allowing a smooth transition (ibid.). In the case of a transition to renewables, this objective is less clear since there are different ways in which a goal can be

achieved, and the generation of the energy itself happens on a decentralized scale. It therefore calls for a transition management approach, as will be explained in the following sections.

Ambitions in sustainability do not match up with how those ambitions are translated into planning practise. Policy is written at a strategic level, while the implementation takes place on an operational level. The political regime, which could be supported by the traditional energy sector, has enough power to maintain its position and thus limit the growth in the energy transition. An external shock or increased societal pressure is required to act as a catalyst. A quick transition can lead to the downfall of the current regime, so a long-term transition is the only viable and durable option (Zuidema, 2016).

## 2.3 Decentralized renewable energy generation

This transition management approach has strong links with systems- and complexity theory (Kemp, 2010). Here, transition is focused on a continuous societal transformation. This means that there is no clear end to a transformation, as society is continuously developing. When one transformation is completed, another one is (or has already) started. On top of that transformations can only take place by alterations in connected subsystems. Therefore, transition management needs to be both adaptive enough to cope with dynamics in the playing field for stakeholders and institutional arrangements, yet still have a single fixed objective so a course to meet long-term policy goals can be lined out (Loorbach, 2007 in Kemp, 2010).

The Dutch provinces of Noord-Holland, Groningen, Drenthe and Friesland, also known as Energy Valley, jointly expressed an ambition to have a leading role in the production of renewable energy with smart grids and an international SuperGrid. In this region the presence of energy port Eemshaven, different knowledge institutes and the Energy Academy Europe could play a role when trying to achieve this ambition by sharing their expertise on projects that contribute to sustainability goals. The provinces together aim towards an increase in locally generated renewable energy (Van Oost et al, 2013). We can therefore assume the ambitious provinces aim to incorporate sustainability goals in every project.

According to the proposed Dutch Climate accord, society expects clear goals and orders from (local) governments, so that the boundaries of the transition playing field are clear, but there is still room for own input and initiatives. Local energy initiatives, for instance, can play a role in the exploitation and therefore the business case of an PV installation. Local governments are key in the planning process, since they need to implement the national ambitions into local context (Ministry of Economic Affairs and Climate, 2018a).

It is likely that the Dutch climate accord will form one of the biggest challenges in spatial planning for the coming decades. Landscapes will change severely and the proposed elements of sustainability will have a big impact on the physical environment. It proves a challenge to maintain spatial quality or add environmental value whilst carefully managing public support in an already heavily contested space (ibid.).

# 3

## CHAPTER THREE: THEORETICAL FRAMEWORK

In this chapter, we will establish a theoretical framework to help us thoroughly grasp the issues at hand, and in a later stage, helps us build an interview guide to retrieve as much relevant data as possible. In the first section of the chapter (3.1), we will examine characteristics of the Dutch infrastructure planning domain, how private actors are involved in infrastructure planning and how formal and informal institutions influence the planning process. Next (3.2), we will widen our perspective to an area-oriented approach and learn that in order to develop road infrastructure in such a way that it adds maximum value to its surroundings and is fully integrated into the environment instead of taking a traditional sectoral approach. In the following section (3.3), light is shed on the effect of formal and informal institutions on innovation. After that (3.4) we will explore how market potential can be reached through different tendering procedures, what the influence of different types of contracts are on the planning process and what role early market involvement plays. After taking a look at some projects in the Netherlands that can be examined as best practice (3.5) and gain some lessons from the approaches that were taken in these projects. In the final part of the chapter (3.6), we will present the conceptual model.

## 3.1 Characteristics of infrastructure planning

### 3.1.1 Dutch infrastructure context

The total amount of travelled kilometres in the Netherland nearly doubled in the last three decades of the previous century through a variety of socioeconomic factors (Arts, 2007). Trips by car made up the majority of this increase in mobility and accounted for 70% of all traffic moments by 2000. Predictions are mobility will rise even further in the coming years (ibid.) and is expected to do so until 2050 (Netherlands Bureau for Economic Policy Analysis & Netherlands Environmental Assessment Agency, 2015). The biggest rise could be observed in highway transport: mobility doubled between 1986 and 2000 whilst there was only a 12% increase in the amount of lane kilometres. To solve congestion issues, different levels of government focus on increasing efficiency of existing road capacity through expansions and reconstructions (ibid.).

Another argument that adds to the need for reconstruction is road safety. The Royal Dutch Touring Club and EuroRAP conducted studies on non-highway road infrastructure on all Dutch provinces in 2014 and concluded that on the 6% of the road infrastructure network (non-highway), 25% of all fatal accidents happen. According to Arts (2007) those numbers will only become worse if no significant action is taken. Safety is logically prioritized in infrastructure planning, and with the fact that obstacle free buffer zones are installed near built environment and infrastructure to guarantee safety, it might be a barrier to create space for PV later on (Ministries of Economic Affairs, Infrastructure and Environment, Home Affairs, 2018).

Next to these reasons, the vast majority of Dutch regional road infrastructure dates back from the 1960-1970 era and needs to be reconstructed in the coming decades (Economic Institute for Construction, 2017). This provides chances to add value to existing infrastructure by taking care of a better fit in the landscape, but also offers possibilities for increasing sustainability in the infrastructure network. This can be done through the addition of photovoltaic elements. Therefore it is important to reconsider the Dutch non-highway road infrastructure network and carefully study where it is possible to reconstruct a route.

Various scholars state that the complexity in Dutch infrastructure planning has severely increased, following the introduction of more actors with different values and opinions and ownership and financing structures. An integrative approach to combine issues in the infrastructure sector with issues from different sector in order to combine functions is necessary (Arts, 2007, Hijdra et al. 2015). Heeres et al. (2012) acknowledge a

growing role for private actors and society in policy development as well as changing dynamics between different layers of government, leading to a redistribution of responsibilities and tasks. Salet and Woltjer (2009, in Heeres et al., 2012) also observe a switch to a more proactive form of planning that involves shared initiatives from public and private actors, causing dynamics in the procurement, tendering and contract domain to change, as will be elaborated on later in this chapter. Despite the fact that different actors have different responsibilities, values and power in the domain of infrastructure planning, it seems clear that all described actors have a role to play when it comes to sustainable development of infrastructure.

### 3.1.2 Market involvement in road infrastructure planning

Over the past years, RWS increasingly allowed private involvement in projects (RWS, 2016). Since 2004, their motto could be described as 'the market, unless…' The idea behind this motto is to make use of knowledge and creativity of market parties in infrastructure projects to increase value and provide a higher level of quality. The innovative power of market parties allows for the creation of sustainable projects and solutions and the possibility to be more cost-effective when delivering products or services compared to the private sector (Spackman, 2002 in Rangel & Galende, 2010). Since tendering procedures where multiple private actors bid to get a project awarded to them drives competition, innovative designs that help the private firm gain an advantage flow from such a cooperation (Rangel & Galende, 2010).

With the goal to add more value to future projects the trend in Dutch tendering procedures changed in two ways (ibid.). Firstly, focus was shifted from technical specifications towards functional specifications. This means that clients name their issue, to which private actors can respond by providing solutions. There are no prescriptions when it comes to materials or methods, but just the function (for example the number of cars/trains that can pass the object on an hourly basis). This provides the market with enough freedom to provide solutions and try to outdo their competitors (CROW, 2011). Second, a shift in awarding criteria was observable. Where at first there was a strong focus on lowest price and the contractor that could realise the project at low cost was awarded the project, nowadays quality is also taken into consideration and carefully weighed when awarding a project. This is called the *Most Economically Advantageous Tender,* or MEAT (RWS, 2016). The Dutch tender law makes it an obligation to incorporate MEAT into every tendering procedure, however regional and local governments can decide for themselves how they value factors like price, quality, innovation or social gain for each individual project themselves, provided that a certain choice rests on argumentation and is made transparent to all bidders (Dutch Tender Law 2012). We can conclude that in the domain of Dutch infrastructure planning there is a great variety of actors, whom all have the potential to influence outcomes of planning processes. To add value for all involved actors it therefore is important to search for synergies in the surrounding area of the road infrastructure.

## 3.2 Area-oriented approach

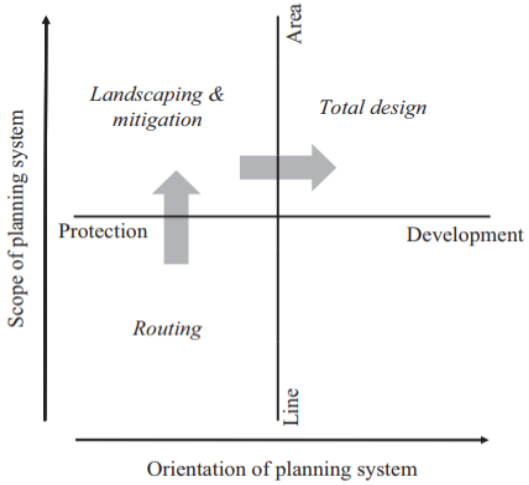
In order to be able to answer the research questions and help build a model which can be utilized to engage market involvement in the realisation of photovoltaic elements in non-highway road infrastructure, it is important to keep in mind an area-oriented approach in order to identify and utilize synergies. It is therefore essential to define the concept before the theoretical framework can be continued. Priemus (2007, in Heeres et al., 2012), describes an area-oriented approach as integrated solutions that combine the functions of road infrastructure and developments from other spatial sectors such as recreation, nature, water, energy or business in an innovative manner.

### 3.2.1 Maintain or improve environmental quality

As De Roo (2007) describes, planners and decision makers try to manage the physical environment in line with societal needs. For decades, planners thought that planning was solely focused on the physical environment and therefore were using a technical-rationale approach with a lot of top-down decision making involved. This dates back all the way to post-war functionalism. According to De Roo (2007), this traditional way of thinking in planning has been debunked and modern planning includes a lot more motivations and perceptions of stakeholders. In other words: interventions in the physical space can be seen as a result of human behaviour and therefore be steered by values, beliefs and interpretations of individuals and groups. Therefore no universal truths in the planning domain exist because everything is subject to interpretation. Context plays a big role, and knowledge can be gained when taking context (including involved actors) into account. This philosophy can be seen as constructivism. Constructivists think that reality is socially constructed through social interactions and continual processes (Salkind, 2010).

Over the past decades, the perception of the relation between infrastructure and the environment changed. Where infrastructure and the environment were seen as two separate subjects, a more integrated approach is provided by contemporary views (Leendertse et al., 2016). Investments in and development of one of both can very well bolster the quality of the other. An improvement in infrastructure can connect two or more areas on different scale levels and thus have a positive effect. Therefore, planning officials should be tempted to look for scenarios where (re) development of a road adds value to the surrounding area, but in Dutch planning practice infrastructure projects often are still approached in a line-oriented way (Leendertse et al., 2016), separated from other policies. According to Arts (2007), sustainable infrastructure planning can be seen as the search for balance in the dilemma between protection and development, between the environment and socio-economic values, between controlling risks and taking chances – from the standpoint of us, here, and now but also from the viewpoint of others, elsewhere and later.

Figure 1: From line-oriented to area-oriented development (source: Heeres et al. 2012)

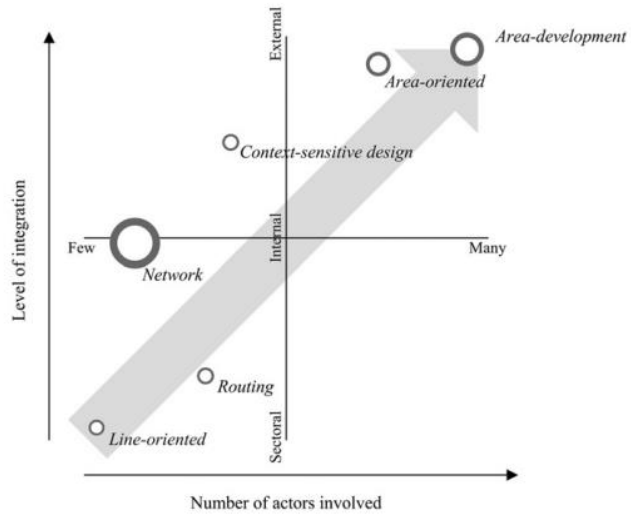



One step further than this line-oriented approach is landscaping and mitigation according to Heeres et al. (2012, figure 1). By orienting the process in such a way and developing a road, vulnerable environments are protected. We can only speak of a fully integrated design when one of two possible scenarios arises. Firstly, when the infrastructure is designed in such a way that it contributes to the area. Secondly, that developments in the surrounding area are taking place based on the qualities of the infrastructure network (Arts, 2007).

The fact that the entire infrastructure network can be seen as an interconnected sum of parts causes the need for a system-wide policy on decreasing the environmental footprint of infrastructure. It proves a challenge when taking into consideration that policy and time- and budget management needs to be consistent in order to function properly across different scale levels (Arts et al., 2016). In order to establish this, the dynamics of the infrastructure system have to be analysed on such a scale as well (Dong et al., 2017).

In a country like the Netherlands, where space is contested, it is preferable to combine functions to decrease pressure on the landscape wherever possible (Ministries of Economic Affairs, Infrastructure and Environment, Home Affairs, 2018). To be able to handle an area oriented approach, a 'softer' planning approach is needed according to Heeres et al. (2012), so local demands and characteristics can be taken into account to integrate multiple spatial sectors into one project. The desired level of integration and number of local actors thus together steer the planning approach, as can be observed in figure 2.

Figure 2: Effect of number of actors and level of integration on planning approaches. (source: Heeres et al., 2012).




Possible synergies also can have a positive effect on the business case of infrastructure projects, since societal benefits tend to increase when functions are combined. Still, this may not be self-evident for road owners, as Lijesen et al. (2006, in Lijesen & Shestalova, 2007) state. They say that environmental norms or other characteristics that result from handling an integrative approach affect the design and could lower efficiency for the road owner: their personal optimum is not achieved while societal benefits may still be bigger.

### 3.2.2 Combining functions: infrastructure and PV systems

Combining renewable energy with infrastructure projects is one of the examples where added value can be reached through the combination of functions. Renewable energy generating installations are usually quite space-consuming and often generates resistance from local communities (Cruz, 2016). One of the problems when it comes to integrating a renewable energy component into a project is that in the Dutch political system, infrastructure and (renewable) energy have different offices and therefore different priorities and budgets (Spijkerboer et al., 2017). Because of this pillarization, neither of both parties is willing to reserve a bigger cut of their own budget to increase functionality for another sector. The necessity for the implementation of photovoltaics is present, as well as (in some cases) the reconstruction of regional non-highway road infrastructure, but combining these functions has proven a challenge.

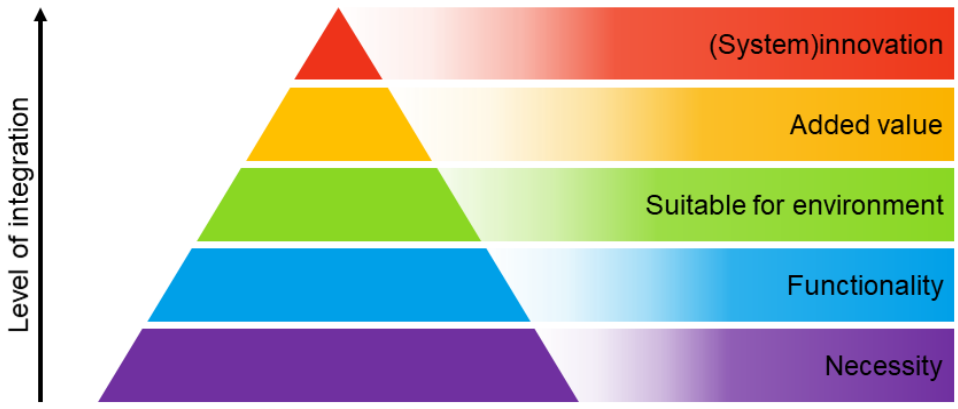
According to De Roo et al. (2001, in: Heeres et al., 2012), a national planning framework can be deconstructed to a combination of scale levels, with each their own characteristics. The first level, the micro level, aims mostly at aesthetic value for individuals in urban settings. At the second (neighbourhood) level, value is added through the utilisation of contextual circumstances. At a macro level, the goals become more abstract and an overview of a region is provided, including strategic (planning) policies. Developments in a specific area then should be combined with the transport goals of the infrastructure itself in order to realise both goals and create synergies.

To prove the effect that innovations can be integrated in a project in a safe manner, costly full-scale tests will have to be conducted. Pilot-projects can be useful because of this (Faems & Heijink, 2012). On top of that, road user safety is always prioritized (Spijkerboer et al., 2017), thus innovations that can increase safety risks have a long shot of actually being implemented. On top of that, an increased distance to connect the photovoltaic installation to the grid increases installation costs and thus requires a bigger project budget, increasing financial risk.

A problem that occurs is that the road that is to be developed is the main object of the procurement procedure. When designing a sustainable road, the object cannot be separated from its environment since they interconnect with each other. The sole implementation of photovoltaic elements does not contribute to the sustainability of the road itself, but the added photovoltaic elements compensate the road by contributing to the sustainability of the surrounding area (Ministry of Economic Affairs and Climate, 2018). Maintaining an area-oriented approach, with attention for relevant interconnected factors and elements in a project design, is therefore crucial in a sustainable design.

Spatial policy and legislation on a regional level provide us with an important framework for the chances of implementation of different types of renewable energy. Solar energy has the biggest chances to successfully be combined with road infrastructure according to the three Northern Provinces (Province of Groningen, 2016, Province of Friesland, 2018, Province of Drenthe, 2016), and the Province of Overijssel have also expressed desire to scout for potential locations for renewable energy generation along road infrastructure (Province of Overijssel, 2016). The provinces set policy, but nevertheless municipalities decide and approve of plans and can possibly zone photovoltaic installations without intervention of higher-level governments (Spijkerboer et al., 2017).

Figure 3: The ambition pyramid. (Source: Van Assen, 2015).



As shown in figure 3, a model towards an area-oriented approach is constructed. The model is based on an adaptation of Maslow's famous pyramid (Maslow, 1943) by Sandra van Assen (2015). In Maslow's pyramid, the base of the pyramid is built on physiological needs (the bare survival level), going up to safety, love, esteem and finally self-actualization at the very top. This basic concept can be translated to the domain of planning as well. The necessity for development, or in this case, the use of photovoltaics is at the bottom of the pyramid, where it provides foundation. The low level of integration means relatively few actors are involved, decreasing complexity. As we climb up the pyramid, complexity increases as integration increases as well. In order to add more value and be more innovative, the process gets complexer because of the increased level of integration. At the top of the pyramid the project goes a step beyond added value: it becomes an example of how future projects can be realised and thus has the potential for system innovation.

## 3.3 Effect of formal and informal institutions on innovation

Underlining the statements in the section above, decision making processes in infrastructure planning are steered by several different actors and institutions on different scale levels (Hijdra, 2015). This institutional context can heavily influence the planning process. To determine the effect that institutions can have on the planning process, it is necessary to construct a comprehensive perspective. Olsen (2009) sees institutions from an integrated perspective and describes them as a collection of rules and practices. Alexander (2005) states that institutions are traditionally divided in formal and informal institutions. Formal institutions are for example laws, formal rules and contracts. Informal institutions are values, traditions and codes of conduct. The concept of institutions can thus be seen as a collective term that includes a wide range of institutional elements, but they are important nevertheless since they can steer the behaviour of actors and together form the context of the planning- and decision making arena (Koppenjan & Groenewegen, 2005). Helmke and Levitsky (2004) state that informal structures shape the performance of formal institutions in important and often unexpected ways (p. 726), meaning that they cannot be separated so the dynamics of both types of institutions have to be included in the research.

In order to cope with the complexity that different actors and institutions add to the planning process, some kind of institutional transformation is required (Heeres et al., 2012). Complexity can cause barriers to the implementation of different forms of renewable energy into infrastructure projects since they are available on the market, but innovations seldom fulfil their potential. Advances in sustainability thus should not solely depend on technological progress, but try to realise an institutional framework where involved actors can provide stimuli for the combination of functions. Crabbé & Leroy (2008, p. 20) say about this: "*The essence of an institutional evaluation is to know whether that institutional context is suitable and adequately equipped for the type of policy one intends to pursue. And the ensuing recommendations will relate to the type of institutional context that is best or better suited for that type of policy.*" In order to create a context that is able to stimulate innovation, a recommendation for institutional design thus is necessary.

According to Loosemoore & Richard (2014) the building sector (with the infrastructure sector being a part of the building sector) has become complacent, a high-cost low-productivity sector. Faems & Heijink (2012) found out that innovations usually are implemented at a slower rate in the infrastructure sector compared to other technical sectors. There is little incentive for the market to come up with innovations that no-one asked for since (road) infrastructure only is built when demanded (by the government). Therefore, the client has power over the construction sector and often demands the lowest price, leading to less innovative designs except for when the price is fixed and quality is the main criterium (Loosemore & Richard, 2014).

## 3.4 Reaching market potential

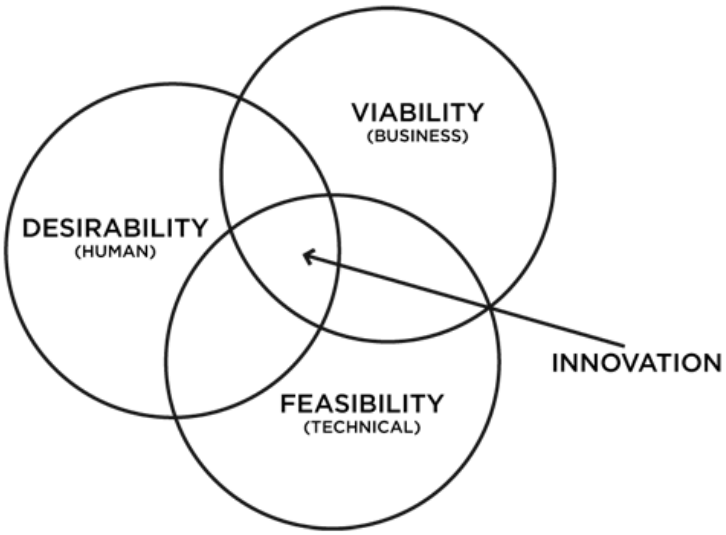
Rijkswaterstaat and a number of private actors came up with a shared market vision in 2016 and expressed the following ambition for the year 2020: "*We, as builders of the Netherlands, will excel by means of being reliable, approachable and inspiring, and will work together to create a safe and liveable Netherlands for its civilians and companies.*"

There is a list of points included in the market vision, but the ones that are most interesting for the development of photovoltaic installations along road infrastructure are

1. Sustainability: we take responsibility for the liveability and limited capacity of our planet.
2. Future-proof: A payback model, based on added value.
3. Learning: From (inter)national best practices, anticipating on technological developments (Marktvisie, 2016).

This can be seen as a balance between a human component (1), a financial component (2) and a technological component (3), which lets us use the following model (figure 4).

Figure 4: The innovation sweet spot. (source: IDEO, 2018)




In order for a project to be truly innovative, we can conclude the design needs to be feasible, desirable and viable. Links between two of the three components can be made as well, all altering the potential business case. Linking it to the subject of this research, an example could be that a solar project is viable and feasible, but generates public resistance because of degenerating landscape values. On the other hand, a project dan be feasible and desirable, but it is too expensive to realise. The goal is to align the three components to achieve the optimal project outcome. In the light of this research, a project should contribute to both sustainability and mobility goals in such a way that environmental values are protected and a healthy business case can be realized.

### 3.4.1 Public-private partnerships in the Dutch infrastructure sector

Public construction projects have frequently encountered problems such as low efficiency, unanticipated costs and late deliveries (Weisheng et al., 2013). Approaches that are taken to counter these cons are PPP (Public-Private Partnership) or PFI (Private Finance Initiative) and variations on those two. The traditional approaches to project contracts are declining in popularity and getting replaced with integrated approaches, as will be shown later on in this research. But: one size does not fit all, and projects are influenced by political, economic, social, technological, environmental and legal (PESTEL) circumstances and the dynamic relationships between these factors.

According to Weisheng et al. (2013) there is no one-size-fits-all-solution for procurement strategies because of the PESTEL-characteristics. This provides an opportunity to design an assessment model where relevant factors can be weighed against each other to determine the best approach in each context. The PESTEL-theory will be used in the data analysis, and will be further elaborated upon in chapter four.

Eversdijk and Korsten (2015, p. 9) describe PPP as a multi-motive-policy. Next to financial motives, different types of PPP can have a positive effect on project management and add value to a project. The expectations often are high, but nonetheless projects rarely reach full potential and live up to those expectations. Leendertse (2015) states as one of the most important reasons that public parties often still, despite the introduction of MEAT, base their choice of contractor on the price, leading to a lack of creativity and innovation, since those are likely to increase the risk in a project.

According to both public and private actors, there is a lot of room for improvement on both the private and public side in the Dutch infrastructure tendering domain (Ministry of Economic Affairs and Climate, 2018b). The Dutch ministry of Economic Affairs and Climate came up with the agenda for better tendering procedures. The agenda of 23 action points that has been presented to minister Wiebes of Economic Affairs needs to lead to better tendering processes. The dossier concludes there is a lack of knowledge of the market by public actors and how to properly utilize market creativity, the application of MEAT, one-way contract conditions, tendering costs and the clustering of projects so smaller businesses have negative

asymmetric chances. Inexperience in the tendering domain furthermore strengthens the inability of public actors to define desired specifications and then accurately formulate them in order to reach market potential (ibid.). A problem that occurs in procurement is related to the nature of the term sustainability. The fact that sustainability is a catch-all term and can be interpreted and defined in a number of ways (Lenferink et al., 2013b) makes it easy for a procurer to grant priority to factors like cost and time efficiency when awarding a project.

Governments can guarantee a higher level of quality in the tendering procedure by reducing errors whilst firms can improve by improving the quality of their specifications in the procedure and make those known as early as possible (Flemish Knowledge Institute for PPP, 2016). The 23 action points all have been assigned to a local/regional government, and they have been given a deadline to improve their tendering behaviour (Ministry of Economic Affairs and Climate, 2018b). Next to that, evaluating proposals and bids that lost is important, everyone is keen on learning to be able to perform better the next time. On a municipal level, government officials usually have the least knowledge and experience, so big gains can be made there. In 2016, 90% of Dutch building tenders missed basic data, 27% was clustered in an unnecessary way and 35% did not meet objective criteria standards. In 2012, this percentage was a staggering 70% so it is safe to say significant improvements have been made since then (Ministry of Economic Affairs and Climate, 2018b).

In the tendering phase, a government is in charge of an infrastructure project, but when the project gets underway, a market party usually is in charge. Political pressures also play a dominant role in tendering procedures with local governments, who do not always precisely know how to fulfil the role of tenderer (Flemish Knowledge Institute for PPP, 2016). Behaviour, values and experiences of individual actors play an important role, and it is difficult to break through that. According to Lenferink et al. (2013a), even when efforts are made to share information in an efficient manner, risk still exists that the information is outdated. Another risk can be traced back to changes in personnel which disrupts relationships.

For both public and private actors lies a challenge to develop a relationship to complete public infrastructure projects. This informal relationship is key because it is the fundament of the later formal relationship (the contract). The contract, in turn, potentially leads to a form of mistrust. In a cooperation where the contract, the project goal and relationships between different actors are well balanced an integral commitment to the project goal is the result (Flemish Knowledge Institute for PPP, 2016).

Valuable knowledge and trust can be lost when relationships are damaged, having a negative impact on the project. You need growing awareness of possible consequences of different types of behaviour in the tendering process to manage said risks (Ministry of Economic Affairs and Climate, 2018).

The Dutch tendering law made it obligatory to go for MEAT when conducting a tendering process back in 2012 (RWS, 2016), but it remained difficult to successfully tender projects despite a structured (legislative) approach to tendering. One of the reasons that the inclusion of quality increases the efforts firms have to make to be able to construct a serious bid. When mistakes are made, tendering parties are not always keen to admit their mistakes, increasing the chance they may reoccur in another tendering process, or mistakes are not mentioned at all because one does not want to potentially damage a healthy relationship (Flemish Knowledge Institute for PPP, 2016). This lack of transparency contributes to a difficult dilemma with which a parallel can be drawn towards Benner and Tushman's research (2003), who stated that successful firms are able to keep a balance between efficiency and innovation, or exploitation and exploration. When handling a wider scope, this dilemma is also apparent in the infrastructure sector.

Like described earlier, another shift can be described as the shift from technical specifications to functional specifications. Quite often a public party makes a project available for a tender with the technical solutions almost already finalized. Though this provides (financial) stability within a project, it also causes a lack of room for innovation. Another option would be to start with the desired functions and concretize the project design on the go. Together, the winner and the tenderer will work out the project characteristics and the contract. Private actors can provide bids that include flexible designs and innovation as would be the case in a traditional tendering procedure. After the initial bids, the tenderer picks the winner and concretizes the project. The private actor makes a price offer to complete the project. (Ministry of Economic Affairs and Climate, 2018). The question becomes then: which role should the tendering party play, and how will that behaviour steer innovative potential? Bresnen (2008, in Loosemore & Richard, 2014) argued that tendering parties do not always focus on innovation and usually go for the lowest price. This is creating a barrier for a

sector that is able and willing to innovate but have little (financial) incentive to do so. Decarolis (2018) argues that in every project there are uncertain, hidden costs and a low price could mean poor performance in the ex post contract stage. Tenderers therefore often award an auction not to the lowest bidder, but to the lowest reasonable bidder. When a contract is auctioned off to the lowest bidder, it is not guaranteed that the procurement costs are actually the lowest.

This observation is agreed upon by other scholars. Value in projects currently is mostly perceived as achieving a desired object at minimum costs, according to Loosemore & Richard (2014). They argue that the opposite should be the case; the process should be used to enhance the objectives of the client in order to create more value in infrastructure projects. Therefore governments at different scale levels often miss opportunities to act as a launching customer. Van Marrewijk et al. (2014, in Loosemore & Richard, 2014) also concluded that market behaviour is affected and this cycle keeps the sector conservative. Firms that do prioritize innovation get less projects awarded to them in the highly competitive market, meaning they risk financial losses.

Private actors currently are at risk when a project is not awarded to them after making a bid due to a lack of expertise with the public party. The smaller a governmental organization becomes, the less expertise generally is available. It therefore is important to include actors with knowledge on procurement and tendering so municipalities can ask for guidance when going into the tendering process. This will reduce the risk for companies, leading to a bigger number of private actors interested, and hopefully, more qualitative designs with more added value (Ministry of Economic Affairs and Climate, 2018).

In order to cope with complexity in the Dutch road infrastructure planning sector, public-private partnerships are commonly used. This way public parties receive bids that are potentially more innovative and creative, whilst understanding of public needs from private parties is increased (Lenferink et al., 2013a). In 2004, the European Commission introduced the competitive dialogue as an alternative to classic public-private partnerships, where authorities and private parties enter a dialogue prior to the bidding stage. Public-private partnerships will be addressed in another section, we will now shortly address competitive dialogues. According to the Dutch tendering law, a competitive dialogue can be used if there are no easy solutions available to meet a tendering party's needs, solutions that consist of innovative designs need to be implemented, complexity cannot be reduced without negotiations in the pre-contractual phase, and technical specifications are not formulated precise enough based on (European) norms (Dutch Tender Law, 2012). A problem is encountered when taking into account the first criterion, because apart from the fact it is difficult to specify what the needs of a tendering party are, it is also important to determine who's needs are represented. The tendering party is most often a public actor, trying to represent the public and cater to their needs. The problem is that this automatically involves a wide variety of values and opinions that may contradict each other.

The Flemish Knowledge Institute for PPP organised a dialogue between Dutch and Flemish PPP-experts from the field and some internationally acclaimed scientists in 2016. In order to build a proper business case, you need to introduce a realistic budget. To do so, one could take a fixed price and let quality be the deciding factor. A problem that occurs is the lack of expertise at governmental organizations to value quality in bids properly. It is wiser to construct a competitive dialogue, according to the Flemish Knowledge Institute for PPP (2016), since the competence of the market is a big bonus for public actors in carefully constructing their tenders. This needs to occur in a pre-competitive phase. A framework can then be constructed so future bidders can adjust their designs accordingly to the desired functions, but still leaving enough space for flexibility and innovations. The awarding of the project can then take place on qualitative grounds.

The tendering party is in charge of shaping the procedure of the competitive dialogue (Dutch Tender Law, 2012). Looking back at figure 4, it is important to determine the feasibility, viability and desirability of a project. This can be done by engaging in a market consultation and involving an energy cooperation to determine if the generated electricity can be sold to a nearby market (desirability), and the energy cooperation can possibly be included in the business case (viability). To complete that business case, the network manager (Tennet/Liander/Enexis) needs to be involved in an early stage to determine what investments have to be made to connect a project to the power grid (feasibility affecting viability). If predicted costs are acceptable according to those three parties, market parties can be involved again for further rounds of dialogue before the definitive specifications are made known and the bidding process can take place.

Firms that helped construct the framework in early dialogue phases do not necessarily get awarded the project, increasing risk. To guarantee more firms are able and willing to enter the dialogue (and more value is hopefully added), they should be offered a compensation and their intellectual property should be protected (Lenferink et al., 2014). This compensation can take different forms, firms can get compensated for the costs they have made to compose a bid, but they can also be offered a fictional discount on future bids so chances of winning a tender increase.

Based on the reviewed literature we can conclude two things. Firstly: competition is healthy and necessary to come up with the best possible design. Second: A dialogue is needed to maximize efficiency and quality of the tendering procedure. The question becomes then at what point in the planning process to enter the dialogue.

Another problem, according to the Flemish Knowledge Institute for PPP (2016), is that there are no incentives for exceptional performance. This creates a lack of ambition and innovation. When fines are implemented at the other hand, to ensure private actors perform well, another barrier for innovation is thrown up because firms will want to control the damage. Therefore, the best way to include a bonus is to be decided when the project is already awarded. Another problem in the Dutch tendering system is that a contractor has to build what he proposed and stick to the details in the contract, despite having innovative and creative ideas on how to add value to the project.

The European Commission (2017) tried to develop a framework for innovation related public procurement. Functional specification leads to functional procurement: "The procurement of products by an authority nor unit that describes a function to be performed or a problem to be solved instead of describing the product that is to perform the function". In other words: it is not a matter of how something should be achieved, but what should be achieved. This is a matter for individual (public) actors that choose the way in which a tender is set up. The needs (described as functions) are presented as requirements so potential bidders can incorporate innovative solutions into their initial designs. Innovation is very much possible in a situation like this, but not required, decreasing the risk of failure in comparison to direct innovation procurement.

### 3.4.2 Traditional and integrated contracts

#### Traditional contracts

A traditional contract can be characterized through its non-dynamic character. The client has already finalized the design for a big part so the main award criteria is the lowest price the contractor can offer. In the Dutch context, RAW (Rationalisatie en Automatisering Grond-, Water- en Wegenbouw) is the dominant contract form that is used in a fairly large amount of projects (CROW, 2018a & CROW, 2018b). It is highly standardized, decreasing risk and assuring quality standards are met when the project is delivered.
A special variation of a RAW contract is a RAW Framework contract, which is characterized when there happens to be a high degree of uncertainty on the project in terms of planning, budget and size. The contractor can, on call, engage in subprojects of which the price is fixed beforehand (CROW, 2018a).
Van Garsse et al. (2017) state that traditional public procurements often lead to contracts where infrastructure projects are financed by the government. The government takes those investments into account in the same year as the object is being built because of European laws. This means that when a surplus of contracts is signed, a government deficit is created on a relatively short scale, since large infrastructure projects usually span several years. If the funding is being provided via a loan, a longer impact of the government debt will be observed. A PPP offers the possibility to deal with these budgetary issues for governments. The costs can be divided over the length of the contract so the balance will become more stable.

#### Integrated contracts

Other scholars like Scharpff (2013) and Volker et al. (2012) have investigated the possibilities and applicability of so called integrated contracting in Dutch procurement. Although this is a relatively new approach in Dutch infrastructure planning by and large, it potentially is a very promising one. They are characterized by a higher degree of flexibility than traditional contracts, and are more comprehensive since they cover two or more parts of the lifespan of a project (Verhees et al., 2015, PIANOo, 2018). Examples of traditional contracts are Design and Construct (D&C); Design, Build, Maintain (DBM) or Design, Finance, Build, Maintain (DBFM) (ibid.). For an overview of integrated contracts and how they evolved through time in context of the Dutch infrastructure sector, see figure 6.

The increasing sympathy for these dynamic contracts can be regarded as a logical sequence on the trend from well-known regulatory contracts towards more innovative and flexible agreements (Scharpff, 2013), but some public actors nevertheless rather depend on traditional contracts because they are more experienced in that domain (Flemish Knowledge Institute for PPP, 2016). Integrated contracting is known for its relative high degree of innovation and flexibility, due to periodical revision and improvement of the contract. An approach that is not new to the Dutch infrastructure planning landscape is the construction team approach. In a construction team the both client and contractors are collaborating in an integrated formation and upon mutual agreement a design is being developed. It is different from parallelization or interweaving in this sense that a contractor is involved after a route determination or energy investment allowance (EIA) track has been run trough. Herewith there is no influence of the contractor to adjust the router determination or EIA, but is asked to optimize a design within the boundaries of these route determinations and EIA (Chao-Duivis, 2012).

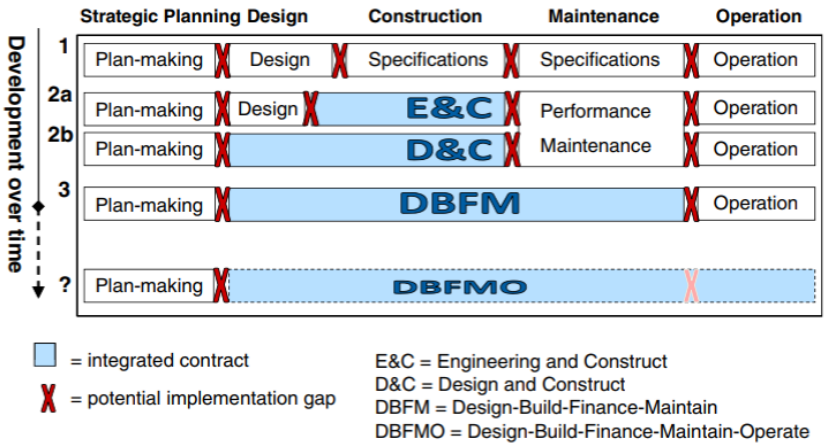
A contract type that became more present in Dutch infrastructure planning over the past few years is the DBFM(O) contract, which stands for Design, Build, Finance, Maintain and possibly Operate (Verhees, 2015, Verhees et al., 2015). The separate parts of this type of integrated contract can be outsourced to a market party contractor, to allow for a streamlined public-private partnership since a contractor can use their expertise to possibly integrate innovative solutions. Both Verhees et al. (2015) and Leendertse (2015) call for a soft and cooperative approach in PPP-projects. These approaches are scarce however in the Netherlands, one of the reasons is that DBFM(O) is better at managing risks. It thus increases the financial stability of a project. Another reason is that the public party is able to make up the agreement and thus remain in charge of the project. This is confirmed by Eversdijk (2013), who states that DBFM(O) projects do not take away responsibility and control from governments and avoids different types of uncertainties.

Under a DBFM(O) contract, one private contractor controls the entire life cycle of a certain piece of infrastructure. The contracts are thus signed for a long period, usually the same as the life cycle of the infrastructure, during which it is the responsibility of the private actor to make sure the built object is fully functional. On paper, value for money is a big factor in preferring public-private partnerships, but in reality budgetary reasons have the biggest impact on political decisions (Van Garsse et al., 2017). The Dutch Court of Audit (Netherlands Court of Audit, 2013) conducted a research on contract management in Dutch DBFM(O)-projects and came to the conclusion that specifications often are not functional enough and still contain too much technical elements, decreasing flexibility.

Where in the Dutch planning arena DBFM has become the standard for large, complex infrastructure projects and D&C are the standard for less complex projects (Lenferink et al, 2013b), an alternative contract form in PPP are alliance type contracts. The latter is not heavily influenced by the strong contractual construct of a DBFM-project, but emphasises cooperation and managing planning processes. Especially complex projects with a similar contract type show an increase in innovation and multifunctionality (Verhees et al., 2015). Eversdijk & Korsten (2009) state that an alliance-form of PPP is preferred by scholars, but when speaking about infrastructure projects a concession-form of PPP is preferred, mostly in the form of a DBFM contract. The bigger the projects get, the more risk usually is involved so a contract that is better at controlling these risks is preferred. Contracts are steered on performances, this increases complexity when projects are multifunctional (energy-infrastructure). On top of that, contracts and financial arrangements should be adjusted so they can incorporate new technologies.

In September 2018, the Central Government Real Estate Agency issued a DBM&E contract for the first time. The E stands for Energy and the tender winner will not only realise the project but is also responsible for providing electricity to the object for a period of 15 years. The chosen tendering procedure is a competitive dialogue. This might be a promising approach for integrated contracting in future projects of the built environment, and might be useful for roads that need a lot of energy in the operational phase. This new integrated contract was discovered too late to be incorporated in the rest of the research.

Figure 5: Development of integrated contracts in the infrastructure project lifecycle (source: Lenferink et al., 2013b)




### 3.4.3 Early Market Involvement

In section 3.3.1 we learned in what stage to involve the market in the pre-contractual phase, in section 3.3.2 we learned in which way the private actors are involved when projects are tendered based on different types of contracts. We can draw two lessons from these sections. Firstly; early inclusion of a private actor into the project can lead to a higher quality of the tender and by doing so increase levels of innovation. Secondly; the type of contract chosen by the tendering party affects market involvement and, again, innovation. When aiming for innovation, as we have established earlier on in this chapter, it becomes evident that early market involvement helps to achieve this goal, but the question on how and when to properly engage the market in a project remains.

The long-term and rigid characteristics of a contract do not rhyme with the fast technological developments created by the market and dynamic context of the job market. An option to counter this is to let the market introduce products to public actors themselves since it is hard to specify a desired product up front when a public actor does not have the knowledge and expertise that the market does have. When the project design is agreed upon, the arrangement is not flexible enough anymore to incorporate such changes. It is vital to include this flexibility into the procurement process. When a (maintenance) contract that is spanning several decades is signed, both public and private actors should focus on strengthening the relationship between organizations instead of individuals that (temporarily) work on a project (Flemish Knowledge Institute for PPP, 2016). Interactions need to be improved, putting private and public actors together in the same physical spot can improve relations, the sharing of knowledge and decrease transaction costs. The increased knowledge levels that emerge from such a situation help future projects to be managed more efficiently and have a positive influence on public procurers. Another advantage can be gained by collective evaluations. PPP aims to create added value in projects that can be expressed in both social terms but also in economic or spatial terms.

Inflexibility in infrastructure contracts can be battled according to several scholars (Lenferink et al., 2012; Mosey 2009; Arts & Sandee 2005) by implementing early market involvement. It causes contractors be involved in the planning process before the route decision is finalized. The aims are to include space for creative solutions in projects, stimulate innovation and make a trade-off between added value and higher risks (Lenferink et al., 2012). This allows for a more effective implementation of D&C and DBFM-contracts. Added value is solely created if contractors experience enough freedom and are allowed to be flexible to propose innovations in a project (Lenferink et al., 2012).

An open structure is required to discuss project risks, leading to a discussion about the risk sharing (risk control) in cohesion with reward structures (percentage return on investment, bonus regulations). Next to that responsibilities, quality guarantees, time schedules, insurance and conditions should also be included in the dialogue (Flemish Knowledge Institute for PPP, 2016).

According to Lenferink et al. (2014) early market involvement can increase quality and deal with complexity in a stage where there still remain possibilities for strategic and operational choices. It is a fairly new phenomenon in Dutch planning practice (Lenferink et al., 2014), thus planning officials do not exactly know

how a private organization can improve the planning process, at what time they should be introduced in the planning process and how they should be incorporated. This provides this research with opportunities to search for a model that can help to determine how and when market involvement should take place through an area-oriented viewpoint where the goal is to incorporate photovoltaics with non-highway road infrastructure.

### 3.4.4 Regional/local context

A problem for improving procurement and contracting procedures is that many regional (political) contexts exist that all can have an influence on the project. There are different layers of government consisting of different political parties and different pillars within the governments that write policy and make decisions on infrastructure and energy. Next to that, there generally is less expertise at smaller political scale levels, leading to less effective procurement and contracting procedures, but when a government on a higher scale level (and more expertise) takes on a project, local context and networks are lost, also adding complexity to the planning process (Flemish Knowledge Institute for PPP, 2016). The inclusion of local stakeholders can add societal value as well instead of value 'just' for the public or private actor.

As we learned in chapter two, regional authorities often have quite ambitious goals when it comes to sustainability and/or the generating of renewable energy. Regional authorities, however, rarely express this desire when planning regional infrastructure. For the northern provinces of Groningen and Friesland this is even more remarkable since they have set energy transition goals that are more ambitious than the national goals (Province of Groningen, 2016; Province of Friesland, 2018), and thus theoretically should be aiming for transition gain wherever possible. This fact hints for an institutional reform in order to achieve maximum value for multiple functions in non-highway road infrastructure projects.

As we have established, it is useful to make use of local context so generated energy can be sold to citizens in the area that is neighbouring the project. When an energy cooperation is involved, both sides profit: on the one hand, local energy goals can be achieved, while on the other hand, net benefits flow back to the cooperation that can use those funds to invest in new sustainability projects.

According to the Netherlands Enterprise Agency, local initiatives are needed in order to scale up the share of renewable energy in the Netherlands. As said before, complexity is added to the project when a cooperation is involved, but it also provides opportunities to sell the generated electricity and opens up windows for local investments (Netherlands Enterprise Agency, 2016). Local authorities are bound to (European) tendering laws, but those can be bypassed. If a local authority decides the project should be tendered, there are different ways to stimulate involvement from an energy cooperation. The bidding criteria could for example have a low threshold, or awarding criteria could be altered so for example the ability to gather local support is a factor that weighs heavy (Netherlands Enterprise Agency, 2016) so energy cooperations can distinguish themselves in the bidding procedure (Eversheds, 2016). This means that projects are technically still awarded based on MEAT, and it is the responsibility of the tendering party to treat all bidders equally (Dutch Tender Law, 2012). According to the Notion of State aid, governments are allowed to support energy cooperations to find locations to generate renewable energy. It only becomes a problem when a transaction to acquire acreage or the grant of a leasehold estate takes place below competitive prices. A taxation by a third party could provide more transparency whether governments and/or cooperations take actions that are conflicting with the law. Another option for a government is to divide a project or contract into multiple plots so European tendering rules can be dodged since the price per plot will be lower (Eversheds, 2016).

The problem that occurs when introducing an energy cooperation into an area-oriented project is that the project will be exploited through an energy cooperation, but the acreage directly surrounding the infrastructure is usually owned by the government. There are three ways in which an energy cooperation can exploit governmental acreage; through the sale of land, a ground lease or leasehold estate (ibid.). Since we are dealing with road infrastructure it is safe to say governments will want to manage the plots themselves so the first and second option can be ruled out and a leasehold estate would be the common way to facilitate energy cooperations.

The granting of a leasehold estate by a governmental organization is not a government contract according to the Dutch tendering law (Dutch Tender Law, 2012), because a government is not procuring anything but is merely upholder and has no direct economic interest in the project. This means the energy cooperation can attain a location to develop an integrated project when a competitive price is paid, no additional

requirements are added to the leasehold estate, there is no direct economic interest in the realisation of the project for the leasing party and there are alternative locations available for other parties to realise other PV-projects (Eversheds, 2016).

**Leasehold estate**
A leasehold estate consists of the right to acquire or own buildings or works in, on or above real estate that is owned by another party. In most cases, the leaser is obligated to offer the owner a compensation. Through the instalment of a leasehold estate a legal border is drawn between the plot and the object that is built on it to avoid accession, where the owner of the land automatically becomes owner of everything that is built on the land. A leasehold estate is the main legal tool for energy cooperations to acquire positions for renewable energy projects (Eversheds, 2016).

Another important facilitating measure that has to be taken is to facilitate energy cooperations in their efforts to realise a projects. Energy cooperations largely are dependent on volunteers and are limited in time, resources and knowledge (Eversheds, 2016).

## 3.5 Best practices

When it comes to the successful integration of photovoltaic elements with infrastructure projects, a number of examples can be found within the Netherlands.

1. N211 and N470

The N211 and N470 are located in the province of Zuid Holland. The province explicitly wanted to make both roads a test site with lots of small innovations that together can be considered an area-oriented project. Both projects were tendered through means of a competitive dialogue, which was chosen because it facilitates innovation. For the N211, 21 innovations have been proposed by the contractor, of which three were required by the government, three other were meant to be pilots, stimulated by the government, the private actor came up with the remaining fifteen. The project was completed during the period this research was conducted, in November 2018. The N470 contains less of a test site-concept, but the implementation of photovoltaic elements is quite prominent in the plan designs (Province of Zuid-Holland, 2018a & 2018b).

2. N33

The section of the N33 between Appingedam and Zuidbroek in the province of Groningen is currently being redeveloped, the goal of all involved parties is to do that as sustainable as possible. This involves the circular use of raw materials, the use of bio-based materials and the use of photovoltaic elements. On top of that, an explicit goal is to create enough space for future developments. The project organization recognizes the fast development of technology, and do not want to hinder future development. To do so, the project policy is to search for a tendering procedure where the highest level of flexibility is achieved (N33 Midden, 2018).

3. A7 (Solar Wall Oostwold)

Despite not being an N-road and being in an early stage of the planning process, the Solar Wall Oostwold near the A7 is interesting to take into account since it involves an energy cooperation that wants to realise a noise barrier with solar panels to contribute to the village's sustainability, but also realise recreational functions behind the noise barrier. Despite the project is not being realised on governmental acreage, it can be seen as a best-practice for a bottom-up area oriented-approach plan (Solar Wall Oostwold, 2018).

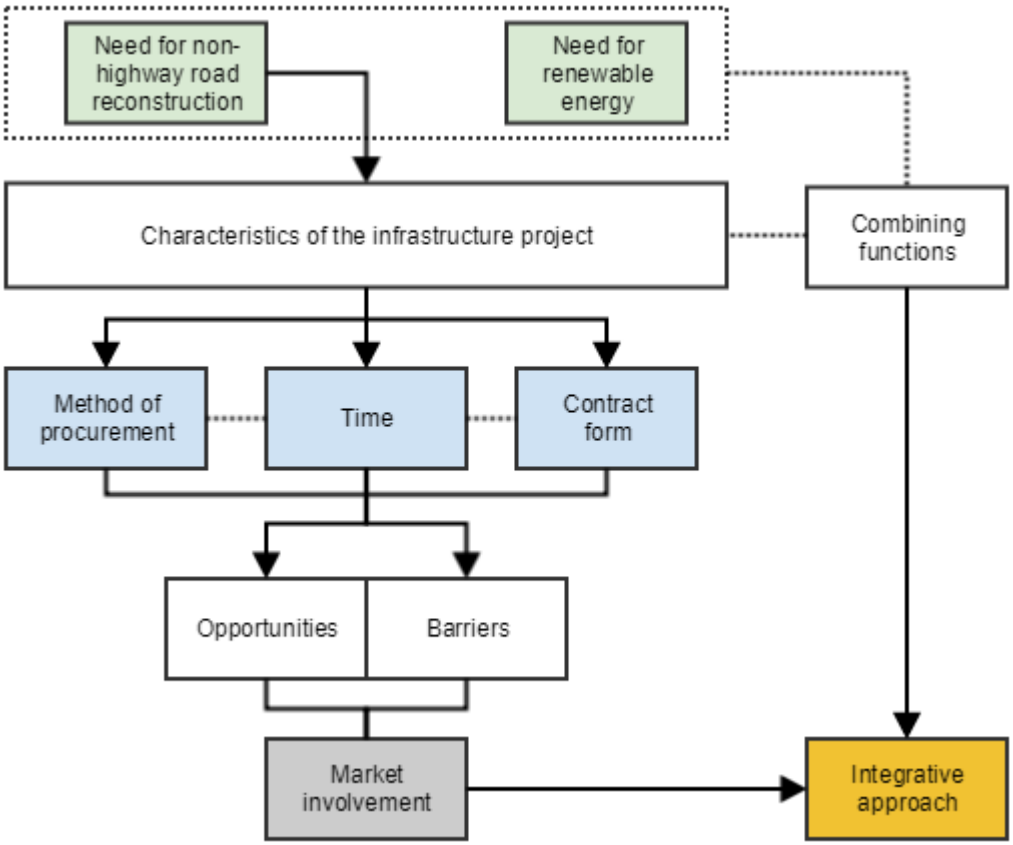
## 3.6 Conceptual model

The conceptual model below (figure 6) shows the interconnectedness between different paragraphs in this and the previous chapter. We have seen earlier that global context of climate change causes a need for a decentralized renewable energy system. Next to this, many roads in the Dutch infrastructure system will need reconstruction in the coming years. Each infrastructure project will have a different local context with different actors and different formal and informal institutions steering them. This defines the characteristics of each project and influences timespan, procurement and the contract form. These three factors all provide a project with different opportunities and barriers which can influence project success. The opportunities and

barriers should be carefully weighed in order to decide in which way and in which phase of a project a market party should be involved in the project.

A lot of resistance against different forms of renewables exist because of their impact on the landscape. To cope with this, the aim should be to combine photovoltaic elements with non-highway road infrastructure when there is need for reconstruction. The combination of functions will add value to the project and therefore the environment since the literature showed us a road should be seen as an integrative part of its surroundings. When these functions can be combined, it also affects the goals that tendering parties connect to infrastructure projects. The type of market involvement and the aim to add value to a project by combining functions increase complexity in a project, requiring an integrative approach.

Figure 6: Conceptual model. (source: author)



# 4

## CHAPTER FOUR: METHODOLOGY

This chapter discusses the methodology of this research and explains the choices for the research methods that are used to collect data. First a distinction will be made between the characteristics on quantitative and qualitative research methods and argued why a qualitative research approach is chosen. Then arguments are put forward for the chosen types of data collection, interviews and desk study. For the interviews, the choice of participants is elaborated upon. Fourthly, the way in which data is analysed will be explained. Finally, there are some short comments on the ethics of the research.

### 4.1 Research methods

O'Leary (2014) describes two main separate but mixable categories of research methods; quantitative and qualitative. Quantitative methods focus on gathering facts and variables and often use statistic methods to verify or falsify hypotheses. Qualitative methods focus on meanings, concepts and descriptions of the studied subject, or as Longhofer et al. (2015, p. 38) states: "Qualitative refers to data that describes an object's qualities or meaningful properties". Watkins & Gioia (2015) describe the difference between the perspectives as the difference between 'what' or 'how many'-questions and 'why', 'how' and 'under what circumstances'-questions. Since the main research question addressed in this thesis is

*"Which factors can help to successfully stimulate market involvement in the planning phase of photovoltaic installations in non-highway road infrastructure projects?"*

we can establish we are dealing with a how/under what circumstances-question. This means a qualitative research approach is suitable for this research.

There currently is little statistical data available for analysis on sustainable non-highway road infrastructure in the Netherlands, let alone the integration of photovoltaic installations. Taking this into account, qualitative methods are preferred when compared to quantitative methods for our study. According to Watkins & Gioia (2015), qualitative methods provide knowledge that cannot be acquired through quantitative methods. Qualitative methods are highly flexible since the data collection and analysis can take place simultaneously. There are downsides to a qualitative approaches however. Findings usually are in-depth and therefore cannot be used to make generalizations on other subjects. Next to that, qualitative methods are strongly subjective so a researcher can have a certain degree of influence on the findings.

According to Longhofer et al. (2013) practice research aims to understand circumstances or interactions. Practice itself cannot be looked at through some kind of theoretical scope, which requires the need to build a theoretical framework. This framework addresses the main concepts and relationships between concepts from (recent) scientific literature. The theoretical framework is a narrative representation of the literature review.

### 4.2 Qualitative data collection: interviews and desk study

Salkind (2010) distinguishes interviews and analysing documents as basic forms of qualitative data collection. Both forms are used in this research, the field research will be semi-structured interviews that deliver primary data which will be analysed whilst the desk research delivers secondary data. In the desk research, both policy documents and road infrastructure project documents will be analysed.

Next to the qualitative research methods mentioned above, a literature review is included. The main argument for including a literature review is so the reader gets an idea of why the research was worth the effort, to fill up an existing gap in the literature that has not been examined yet. Scholars differ on when to build the literature review at a point in the research: Silverman (2000, p. 230 in Brinkmann, 2013) argues that the literature review should not be written in an early stage of the review. Brinkmann (2013) himself counters this and states it is useful to write the theoretical chapter in an early stage because it has an inspiring effect on what (not) to do.

### 4.2.1 Interviews

Rapley (2001, in Brinkmann, 2013) stated that within the social sciences (and thus planning) qualitative interviewing is the key method that provides us with knowledge on all sorts of issues. Different styles of interviewing are possible, varying on a scale from receptive to assertive interviewer styles (Brinkmann, 2013). A receptive style is used by asking relatively few and relatively open questions. An assertive style comes closer to an interrogation and allows the interviewer to provoke and control responses, which causes a lower number of conversational exchanges. It is best to choose a semi-structured interview approach so there is a certain structure provided to the interview and the topic of conversation does not drift off, but on the other hand be flexible enough to have an in-depth conversation on topics that perhaps were not in the initial interview guide.

Brinkmann (2013, p. 46) argues that "a well-designed interview project has a thread that runs through the entire process and connects the research question with what goes on in the interview and also with subsequent transcription, analysis and reporting". This is a cyclic process because it is likely that research objectives and/or questions have to be reviewed after findings and analysis of initial data collection. This flexible and iterative setup should be taken into account by the researcher at all times. If one discovers that the interview guide is badly constructed, room for improvement is allowed, resulting in qualitative better interviews in the future. The interviews will be held in Dutch because that is very likely the native language of all participants. The interview guide will thus also be written in Dutch.

Group interviews or focus groups are really useful for the research because it allows for actors from both perspectives in the research (public-private) to engage in a conversation/discussion on issues in tendering and contracting in the reconstruction of sustainable road infrastructure. They are generally more difficult to organize than interviews, increasing in difficulty when the number of participants goes up (Gill et al, 2008).

### 4.2.2 Desk study

To get a grasp on the current national Dutch policy and different regional policies on the energy transition and on the role that energy generating road infrastructure can play in the energy transition, both national and regional energy policies need to be analysed. Some regional policies may differ and contain factors that can create possible incentives for increased market involvement or, on the other hand, increase barriers for market involvement. On top of that, Dutch policy on contracting non-highway road infrastructure projects should also be analysed. Different contract forms or tendering procedures can lead to different levels of innovation within non-highway road infrastructure projects (Leendertse, 2015). To gain the most profit from public-private partnerships, maybe award criteria for non-highway road infrastructure could be altered.

The integration of sustainability with road infrastructure networks is not something new. There are many examples of measures that can be taken to reduce the carbon footprint of (non) highway infrastructure projects like solar panels on a sound barrier or the usage of circular materials. The market is capable of innovative options, but currently the focus is still mainly directed towards making financial profits (Leendertse, 2015). By analysing policy documents on regional energy transitions, government contracting strategies and documents of completed non-highway road infrastructure projects in the North of the Netherlands, a better understanding of possible opportunities and/or barriers that one can run into when implementing different forms of renewable energy into road infrastructure projects can be identified. This can in turn help to construct a framework on how to successfully implement solutions that stimulate energy neutrality into road infrastructure projects.

I have chosen to gather a substantial amount of information to build the theoretical framework and context before the interviews start. In this way, the interviewer hopefully can gather more knowledge on the subject and avoid shallow questions and/or a shallow discussion. The goal of the research is to come up with an

advisory product which can be useful in practice, therefore the outcomes of the interview should not focus on which opportunities can be utilized or which barriers to avoid, but on how to utilize those chances and how to avoid those barriers.

## 4.3 Participants

After the initial theoretical framework is constructed and the methodology designed, the phase for the first data collection has arisen. In this first round of interviews some exploratory conversations will be held with actors from both public and private institutions that are professionals in the field of tendering and contracting in non-highway road infrastructure, policy makers or government officials. This provides us with some initial data, which will be analysed as explained in the section below, that can be compared with the findings of the literature study and theoretical framework. It is very much possible that some concepts that have not been fully explored in the theoretical framework come to light in those conversations. It is important to single those elements out, rewrite or restructure the theoretical framework where needed and adjust the interview guide where needed, preferably before the next interview takes place. When such a situation occurs, it is important to acknowledge the added value of the new topic whilst conducting the interview so more information can be gathered on the subject.

After the first round of exploratory interviews have taken place, the theoretical framework probably needs to be improved based on the findings. The definitive theoretical framework then should provide a solid basis for an adjusted interview guide for the second round of data collection, in which more professionals can be interviewed, including stakeholders from energy cooperatives or a manager of the power grid. Interviews also will be held with people that were involved in different best practice projects that showed the combination of infrastructure and sustainable energy generation is achievable.

To increase the number of participants, Longhofer et al. (2013) argue to increase potential participants in the research design to trigger enthusiastic responses. Next to the internship I'm doing at Witteveen+Bos, the Province of Fryslân also claimed to be interested in the research, which widens the network. To line up the research questions with the goals of Province of Fryslân might result in a higher number of participants and thus more data. A full overview of participants is given in table 1. The date and location of each interview is also provided. All interviews were conducted at places that were familiar with the participants so taking part in the research would be as easy as possible.

Table 1 List of participants

| Interview | Participant(s) | Organization | Expertise |
|---|---|---|---|
| 1 (01-08-2018, Leeuwarden) | Richtsje van Berkum<br>Hilde Kloosterziel | Province of Fryslân<br>Province of Fryslân | PV projects<br>landscape and spatial quality |
| 2 (02-08-2018, Heerenveen) | Marco Westhuis | Witteveen+Bos | procurement, tendering and contracts |
| 3 (15-08-2018, Burgum) | Willem de Boer | Province of Fryslân | infrastructure |
| 4 (20-09-2018, Utrecht) | Sander Lenferink | Rijkswaterstaat<br>RuN<br>RuG | area-oriented development, early market involvement, public-private partnerships, tendering |
| 5 (26-09-2018, Groningen) | Marco Pool | Rijkwsaterstaat | spatial planning and sustainability |
| 6 (08-10-2018, Amsterdam) | Paulien Hoogvorst | Witteveen+Bos | sustainable energy in infrastructure |
| 7 (12-10-2018, Deventer) | Floris Oosterhof | Witteveen+Bos | tendering, MEAT, contracts |
| 8 (18-10-2018, Groningen) | Sip Sixma<br><br>Wim Elzing | Solar Wall Oostwold<br>Hanzehogeschool<br>EAE<br>Hanzehogeschool<br>EAE | project group Solar Wall Oostwold<br>communication, behaviour and the sustainable society<br>communication, behaviour and the sustainable society |
| 9 (30-10-2018, Leeuwarden) | Marcel Doyer | Liander | strategic environmental manager |

## 4.4 Data analysis

Firstly, it is vital that the interview is recorded on audio or video in order to be able to translate the live experience to textual data by making a transcript (Longhofer et al., 2015). The transcript should then be coded. I have chosen for an inductive coding strategy, which means that the coding process is open-ended and the code list and which codes are assigned to which categories can change throughout time. It also means that the data retrieved is quite detailed and specific, but is used to build a general conclusion (Creswell, 2012).

The initial list of codes should be based on the theoretical framework, but it is important to regularly review the list of codes as new interviews may deliver new insights, new topics and thus require new codes. This implies that old transcripts should be re-read and re-coded once in a while.

The codes help to distinguish the experiences, opinions and perceptions that different actors with different backgrounds have on different topics. By doing this, comparisons can be made so an insight on where differences and similarities arise is provided on where differences and similarities arise. The similarities can act as chances for successful project partnership, and differences can be seen as chances where a gap needs to be bridged in order to increase project success.

There are quite a few steps to take in order for the researcher to draw conclusions from the retrieved data. Guthrie (2010) describes three stages of qualitative data analysis:

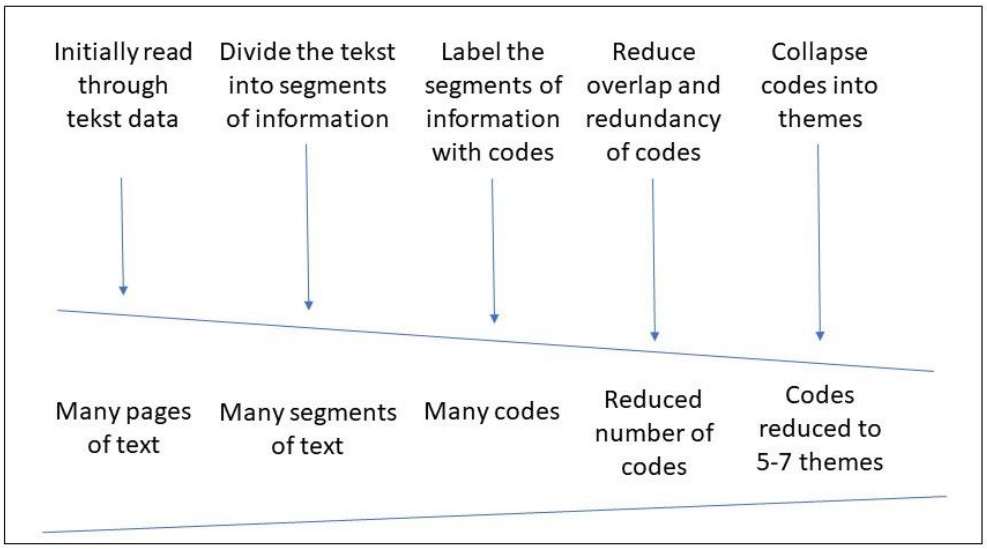
1. Describe. Clear descriptive reporting should be done on the interview. Furthermore, matters that are not relevant can be filtered out.
2. Classify. The material should be grouped so similarities and differences in data can be identified. This does not only apply for coding, but also for analysis; fragments of text should be broken up so each segment contains one main idea and the text as a whole does not get too complex.
3. Interpret. Key features that point out patterns should be picket out by separately interpreting the material.

An initial list of codes has been constructed after the first two interviews were transcribed. By starting to code the first interviews, it soon turned out that the list needed additional codes in order to properly label segments of text, as was expected. As can be seen in figure 7 as the coding process advances, the (initial) wide set of data becomes more structured so it becomes easier to generalize and analyse. By maintaining a wide variety of separate codes it becomes complex to compare data and therefore to interpret them is a challenging task. It becomes easier when codes are categorized under themes that can be more easily compared (Creswell, 2012).

The themes that carry the data analysis are based on the PESTEL-system, as briefly described in chapter three. PESTEL stands for political, economic, social, technological, environmental and legal influences. The PESTEL approach is multifaceted in nature and commonly used in management and business studies according to Kremer and Symmons (2015). It helps to provide insight on organizational activities by categorizing external forces in one of the six categories (Porter, 1980; Song et al., 2017). According to Porter (1980), these forces are not controlled by any organization.

As made clear by Khan (2005), local context factors influence project design and management. This is especially the case for non-highway road infrastructure, since they have a strong regional and local character. Flexibility is thus required from planning organizations to cope with these contexts. By picking a PESTEL-approach, contexts on different scale levels (for example ranging from local stakeholder management (Social) to European tendering rules (Legal)) can be taken into account when analysing data.

Figure 7: Visual model of the Coding Process in Qualitative Research. (source: Creswell, 2012, p. 244).




The codes are used to label fragments of text so they can be categorized later on. First, codes will be categorized in one of the PESTEL categories (by assigning one of the letters, using Ec for economic and En for environmental) so for each category comparisons can be made and a general image drawn. After that, each individual text fragment that falls into one of the six categories will be identified as either an opportunity or barrier, and will respectively get assigned an O or a B. An opportunity in the economic category, for example, could be noted as EcO2, whilst a barrier in the technological category could be noted as TB6.

We can identify what barriers exist for each one of the categories according to our participants, but also try to match those findings up with data within the same category that was gained through a conversation with a different participant as an opportunity. For example, where one participant may view political complexity as a barrier (PB), another may argue that political complexity provides an opportunity (PO) because it can facilitate an integrative approach to projects.

Originally the plan was to put opportunities and barriers per category in a table so an overview could be provided of which opportunities relate to which barriers and vice versa. By putting the barriers and opportunities into a table, it becomes easier to compare data and spot differences when, but it also provides opportunities to spot similarities which can strengthen the statements of respondents. This strategy worked for the first few interviews, but during research it became clear that the gathered data was very extensive and diverse in nature. The tables turned out to not provide a clear overview and were dropped from the data analysis strategy.

To generate enough data on each of the six perspectives, it is important to search participants that have different backgrounds. For example, interviewing only professionals in the field of legal and political will yield little results for the Environmental category. It is necessary to keep a well-balanced participant field into account when choosing participants so a proper PESTEL-analysis can be made. It is, however, important to note that when one of the categories starts to look promising for providing an answer to the main research question, the focus could lightly shift to that particular category.

Salkind (2010) and Longhofer et al. (2015) name Atlas.ti as a software that is useful to analyse qualitative data. The program helps to manage and retrieve textual fragments and other forms of qualitative data. In comparison to software that is built to handle quantitative data, the software itself cannot perform an analysis, which has to be conducted by the researcher. The Atlas.ti software has all the functions a researcher needs and is available for free through the download center of the University of Groningen, which makes it a logical choice for software to use.

## 4.5 Ethics

Before each interview started, the interviewer explicitly asked the participant for consent to make an audio recording of the conversation. The participant had the ability to stop the recording at any given point during the interview. Confidentiality of participants was guaranteed at all times by the researcher. There was an opportunity to remain anonymous for all participants. After the interview was stopped, participants could indicate if he or she desires to receive a copy of the transcript or the final product of the research. Some participants stated they were working on projects of which the details were not allowed to be included in this thesis. Whenever such a situation occurred, that part of the conversation was not included in the transcript and therefore did not land in this thesis.

# 5

## CHAPTER FIVE: RESULTS

In this chapter the data will be presented by approaching barriers and opportunities per PESTEL-category. As explained in chapter four, the collected data is categorized in six categories based on a system of codes. Next to a code, the data gets assigned a label so a distinction can be made on whether a text fragment can be seen as an opportunity or a barrier in one of the six categories. An overview of all the found opportunities and barriers and which interview(s) delivered the data can be found in appendix I. After each section, a short overview of the most important opportunities and barriers per category is given.

Each sector will address a different PESTEL-category. During the research it became clear that some barriers or opportunities can fall into both categories or strongly interface with one another. In order to maintain structure, barriers and opportunities are kept in the sector they most strongly identify with according to the author, but it is mentioned when opportunities and barriers that fall into different categories link. By doing so, the research remains verifiable and reproducible.

### 5.1 Political

One main political barrier for stimulating market involvement in the planning phase of PV in non-highway road infrastructure projects that was recognized was the pillarization within the government. The departments of energy and road infrastructure are separated across all different layers of the government and usually do not interact. They have their own budgets, making it hard to build an integrated business case and develop a project in an integrative way. The following quote embodied this finding:

> *"They say they think there is some budget available, but they do not know where to go. In their own organization they do not even know who to talk to. They also do not know who should agree for such a budget." (Interviewee 7)*

The organogram in figure 8 shows the relevant relations between departments (and separate provincial deputies) when trying to connect solar energy to road infrastructure projects. First, the infrastructure department decides whether a road should be built or redeveloped. Higher costs in the pre-delivery phase can decrease maintenance and operation costs since quality is usually increased. A balance has to be found, based on this balance the infrastructure department can contact the department of finances to have a project budget allocated to them. This barrier can be countered by adapting a framework where someone from the department of renewable energy (preferably solar) and someone from the landscaping department is present, as long as these departments have enough employees to spare, implying potential capacity barriers. Two interviewees that were employed at a regional government stated that a few years back, under a different political coalition, they were involved more often and the nature of (road) infrastructure projects was more integrative. A new political coalition chose to deprioritize this approach. Where one might think that the inclusion of both parties would be a step in the right direction, the following quote makes it clear that by trying to choose an integrative approach, project complexity can increase.

*Interviewee 1: "From an energy standpoint, I think it's a nice bonus to include some renewable energy into infrastructure projects". Interviewee 2: "But I think to myself: what is more important? Energy or the landscape?"*

The importance of the nature of a political coalition was also stressed by another interviewee that was employed by a regional government. According to the participant, everything starts with discovering what it

exactly is you want as a government (the combination of functions) and then determine what the feasibility is (the costs to connect the project to the grid, what is necessary to gather enough public support, operating and maintenance cost) before you build it into a project design and build a viable business case. As can be seen in chapter three, in order to be innovative, enough space should be included in a project to experiment and implement creative ideas. This contradicts with the earlier statement that a government should exactly specify their needs. The second part of the finding above, on feasibility, was underlined through an interview with strategic environmental manager, who said the following:

*"You should do a check from a spatial planners perspective, but also from the perspective of the energy infrastructure, right at the very beginning, to see if a location is feasible." (Interviewee 11)*

A senior manager of a contractor who is involved in a PV project where PV is integrated into a noise barrier added the quote below, which illustrates the fact that in order to implement integrated projects, you are largely dependent on the willingness of public actors.

*"I am glad Rijkswaterstaat started a pilot. […] It is also exciting for them. The tricky side of things is you only have one client, the government, you are dependent of and they act this way. You can ask yourself if that is a good thing or a bad thing." (Interviewee 12)*

All participants named above agreed on the fact that the provinces have the most potential to stimulate sustainable road infrastructure in order to contribute to regional energy goals, even though they agreed on the fact that provinces currently are not the designated organization to orchestrate (local or regional) energy transitions. Two interviewees emphasized that while governmental organizations do not necessarily have to take the lead in the energy transition, they at least should try to facilitate local initiatives:

*"Local energy initiatives, we see them pop up everywhere. How can a government help? A little basic funding, they need a room, a computer, a website, which does not have to be very expensive especially if you succeed to link the local club to an educational institution like the university. You can get a lot done, but the whole thing needs to be orchestrated." (Interviewee 10)*

Provinces and municipalities have on many occasions expressed the ambition to compensate the energy needs of their buildings, fleet and other energy consuming installations that are property of a governmental organization like traffic lights or moveable bridges. In order to generate the electricity to do that they will need to use their own acreage to their advantage. A part of this acreage is in the near vicinity of infrastructure or located on vacant lots. The barrier that can be observed here is a needed shift from an internal focus (facilitate own needs) to an external focus (facilitate other's needs). Another participant stated that a provincial organization is traditionally more integrated than the national government and therefore it is easier to combine functions in regional infrastructure projects.

Another observed barrier was the fact that municipalities all develop policy for themselves to create an integrative vision where they prescribe goals on the way photovoltaic installations can be integrated into the environment. In most projects and governmental organizations, the potential addition of PV to a road infrastructure project is made based on project characteristics instead of coherent policy. This means no need exists to develop such a policy, as is made clear by the following quote

*"We make considerations when we are working on a project. […] The States-Provincial could have chosen to prioritize sustainability goals over other goals. We recommended not to do so, but make a decision when you start to work on a project." (Interviewee 2)*

The problem is that where two municipalities share a border, environmental visions can easily differ due to different political coalitions. Where one municipality chooses for an approach where solar panels are integrated in the landscape, a neighbouring municipality may choose to facilitate the construction of traditional solar farms with a more autonomous character, leading to a fragmented environment on a provincial scale. Next to that, through reorganizations municipalities grow in size, making it harder to develop an integrative vision. An advantage that is gained according to a participant from a province is that municipalities that grow in size also grow in capacity, making it possible for them to deal with sustainability issues better compared to smaller municipalities. In order to develop a coherent environmental vision, provinces should facilitate and set boundaries for municipal interpretation of the environment.

Five interviewees expressed that currently no coherent policy on the implementation of photovoltaics in infrastructure on any scale level in The Netherlands exists. This means that in every project where officials aim to combine those functions one has to start from scratch, leading to a more complex project and risks in terms of time schedule and project finances.

Six interviewees stated, in accordance with what has been established in chapter three, private actors possess a lot of knowledge and creativity which then can be incorporated into the tender, as will be explained further in the section on legal barriers and opportunities. Therefore it is wise to consult the market in an early stage of a project, but the question on how and when exactly to consult remains. An interviewee that is involved with a regional infrastructure project shared the following quote:

*"We would like to be very sustainable, but nobody told us in which way we should attain that." (Interviewee 6)*

Here lies a core issue. Sustainability is more than just renewable energy or the circular use of materials, it is a catch-all term, often used by politicians to window-dress projects. When projects then start to get complex because of these goals in sustainability, they are easily deprioritized or brushed to the side. One interviewee from a consultancy firm said the following:

*"There is a big contrast, they aim for a point on the horizon, far away, they want to get there, but not in their own project. Even if they want to get there in their own project, they intentionally keep it as vague as possible so they do not exactly know what their tasks are, so it is not their fault." (Interviewee 7)*

In addition to this quote, another interview delivered the following quote:

*Interviewee 10: "I have been talking to government officials, they have high ambitions on sustainability, but when it starts to get specific in a project, they back off. […]" Interviewee 9: "That is a bottleneck. We need someone who jumps on the wagon, but this someone does not work in the government. Nothing at the expense of government employees though, because I understand you ca not take all sorts of decisions autonomously."*

Still, the fact that sustainability became a more important factor in projects over the past decade has contributed to more knowledge among government officials that encountered sustainability in projects according to two provincial employees.

According to another interviewee, an opportunity lies in the fact that not in all instances experience and knowledge is shared between government officials. A situation where an opportunity is discovered can occur, but when the project advanced in terms of time and spent budget (and thus decreased in flexibility) the opportunity cannot be taken into account anymore. The knowledge on said opportunity should then be shared internally and externally so it can be utilized in future projects.

When trying to combine the functions of photovoltaics and road infrastructure, and thus utilize an area-oriented approach as shown in chapter three, another department has to be included. The chapter also explained how fragmented departments of energy or sustainability can be since sustainability is a catch-all term, and sustainability in projects can be measured in a number of different ways. Within the sub department of solar energy, the distinction between traditional photovoltaics (solar farms or roofed photovoltaics) and innovative products needs to be made. With innovative PV, the author means to describe PV elements that use innovative techniques, but also innovative ways in which PV elements can be placed in the landscape, where the fourth department comes in, again with a different deputy. This means the success of a project is also dependent on the relations and political backgrounds between and of deputy's, as will be elaborated upon in section 5.3.

In order to eliminate political barriers and make the most of political opportunities it is vital to ensure the (local) authorities prioritize their own energy agenda, which can be realised by either installing a political coalition that prioritizes sustainability (top-down), or by increasing public pressure (bottom-up), as will be explained in section 5.3. This means they'll look for the combination of functions wherever they can, and by systematically introducing a representative of the landscaping department you could ensure the photovoltaic energy installations are properly integrated in the environment.

*Figure 8: Organogram for combining photovoltaics and infrastructure in provincial context (source: author)*

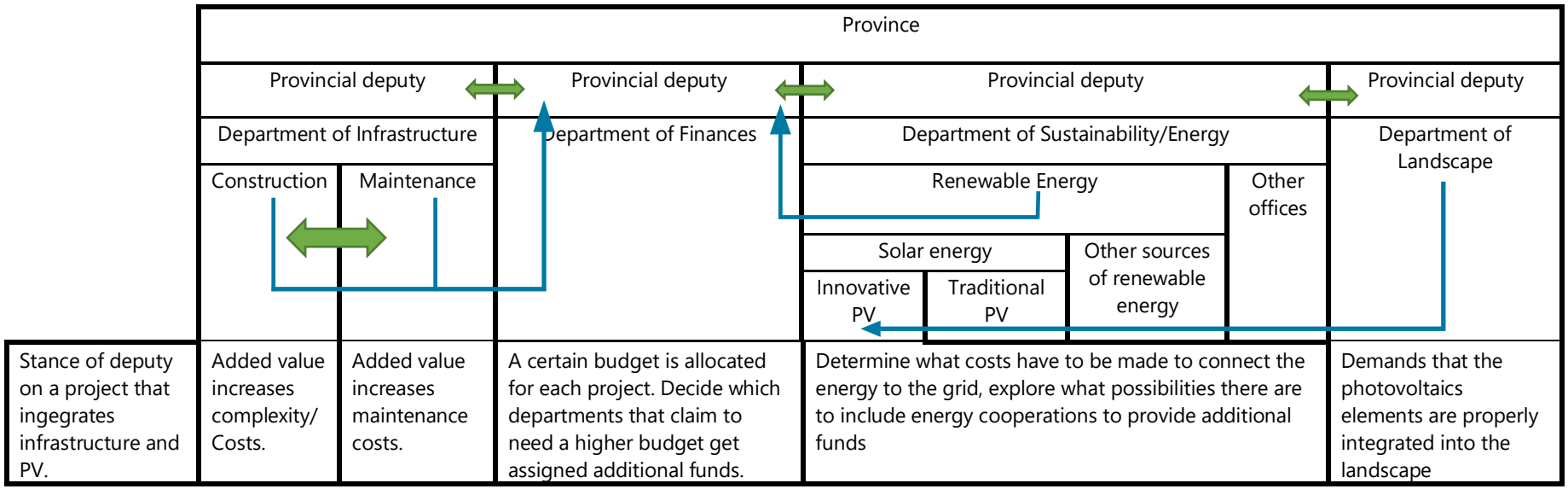


Table 2 Overview of most important political barriers and opportunities

| Political | |
|---|---|
| Opportunities | Governments have to rely on market parties for efficiency and innovation.<br>A province is a more integrated organization than the state.<br>Bring in someone from the department of sustainability in each project phase. |
| Barriers | Infrastructure and renewable energy have different offices within governments.<br>There currently is no coherent policy for the integration of PV with road infrastructure.<br>Sustainability in projects can be easily deprioritized.<br>Political coalitions can change relatively quickly, increasing uncertainty and complexity |

## 5.2 Economic

A participant from a consultancy firm distinguished another kind of pillarization, namely the separated budgets of infrastructure construction and maintenance. Currently, public actors are tempted to choose the cheapest short-term option, leading to projects of less quality which bring higher maintenance costs in the long term. This involves the implementation of an integrated contract, which will be explained further on in section 5.6 on legal opportunities and barriers.

These separated budgets can raise complexity in project financing, which in turn is increased further when photovoltaics are added to the mix. A way this can be resolved is to take the total costs of ownership into account through a life cycle costs analysis, as supported by four other interviewees. This way, you can consider design, construction, maintenance and demolition of a project instead of separating the budgets for construction and maintenance. A qualitative design with an appropriate lifespan can be made which will not need as much maintenance or a costly reconstruction.

By increasing the lifespan of a project the inclusion of long-term maintenance in the project contract becomes a possibility. This can decrease depreciation costs. When integrating photovoltaics with non-highway road infrastructure, the photovoltaic installations themselves also need maintenance. This provides an opportunity to include them into the maintenance contract. An option can be to replace the panels with new ones when yields go up.

It furthermore proves to be problematic to connect photovoltaic elements to the grid. When a cable needs to be installed over a large distance, project costs heavily increase. Most interviewees acknowledged this can heavily influence the business case and agreed these costs need to be identified as early as possible in the project in order to determine the feasibility and viability. This is not the case in every single project, the generation of solar energy can also take place on a smaller scale. It is still possible to realise integrated projects because the road itself needs energy (bridges, lighting etc.) to be operated. An interviewee from a consultancy firm acknowledged this:

*"Bigger projects have scale advantages, but it gets tricky on the administrative side. On the other hand, if you want to make objects energy neutral, it's too narrow, you ca not get enough profit out of that." (Interviewee 3)*

In addition to the quote above, two interviewees mentioned the difference in energy tariffs between governmental organizations and consumers:

*"What stands out to me is it is better for a third party, not a public actor, to be responsible for exploitation of the energy. […] Governmental organizations have a low energy tariff, […], consumers pay extreme amounts of taxes over their energy bill." (Interviewee 7)*

*"It has to do with energy tariffs, you need the consumer because you receive 22 cents per kWh. RWS now is around 12 cents per kWh, they used to buy energy for 4 cent per kWh. We are too far away from the 12 cents, so I need to bring the energy to consumers." (Interviewee 12).*

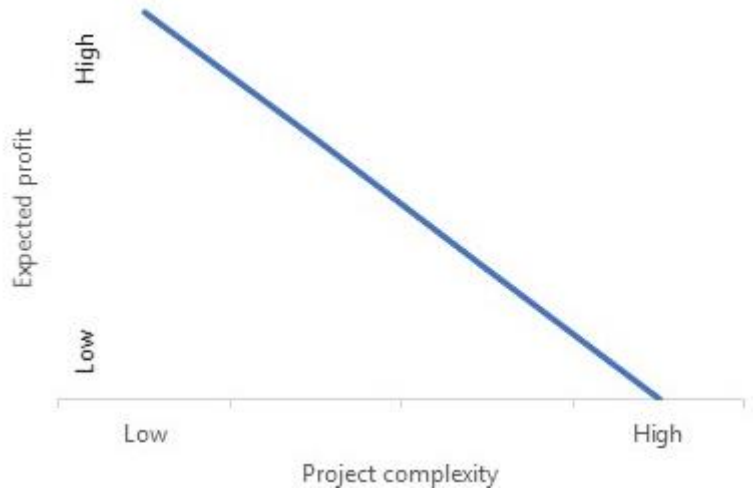
Both interviewees also stated that whilst they thought the addition of consumers positively influences the business case of projects where the functions of PV and road infrastructure are combined, complexity can severely increase when such a choice is made:

*"You create an extra step which costs money. […] Do you want 20 different parties that all want to exploit renewable energy on your acreage, when they all have to contact the grid provider?" (Interviewee 7)*

*"We have been talking to an energy cooperation, they want our energy, but it creates a complex structure. […] The municipality wants to exploit the energy for their citizens, but they are not allowed to do so due to jurisdictions." (Interviewee 12)*

We are faced with another dilemma: the trade-off between decreasing complexity and designing a project in such a way it maximizes environmental profit, as visualized in figure 9. A possible solution can be to accommodate the joint purchase of renewable energy to facilitate the energy demands of different local governments. This way, more budget is available to put into one project and the total demand for energy is higher, resulting in economies of scale. This implies that different municipalities need to go back to their own political arena to decide whether they would support such a cooperation, making the process lengthy.

Figure 9: The complexity-environmental profit trade-off. Source: author




In four interviews it was made clear that for projects that are limited in size, as is quite often the case on a provincial scale, there is not enough budget to complete a project in an innovative way. A way this can be sorted out is by acquiring subsidies when incorporating a renewable energy component into an infrastructure project.

Multiple interviewees expressed their trust in innovative power of SME's for the combination of PV and road infrastructure. Since they are able to compete in the tender phase of projects of a limited scale, and since SME's often are just subcontractors, they do not have enough power within a project to actually implement high innovation rates.

An interviewee from a consultancy firm recognized an opportunity that can be achieved by connecting a business or innovation department to a project. Additional budget to stimulate innovation then becomes available so SME's can be stimulated. The way in which SME's can be facilitated in project organizations to contribute towards innovation is described further in section 5.6.

Another barrier that was observed is the lack of financial reward for integrating PV with infrastructure. From a financial point of view, it is not necessary to add PV to a road to generate income. Next to that, yields are not high enough when compared to traditional solar fields; the PV-elements are limited in terms of optimal positioning towards the sun, in terms of acreage and the presence of shadow casting objects. According to multiple interviewees, a main argument against the integration of photovoltaics into non-highway road reconstruction is the fact that yields are lower when compared to traditional solar fields. This argument can be countered by the acknowledged fact that combining photovoltaics and infrastructure allow for an integrative design, leading to less public resistance.

Project costs can also be increased by introducing parallel design trails. With parallel design trails, alternative solutions are considered for a project, usually with a traditional, risk-controlling track and an innovative track that provides more complexity and uncertainty to a project. This means costs up front will inevitably rise, but there is always an alternative to fall back on when an initial innovative option cannot be realised in a project. In this way, less time and budget is lost instead of redesigning a part of a project which halts development.

Finally, while in the contemporary Dutch planning context it might be very complex to integrate PV into road infrastructure projects, it is possible to create incentives and increase market volume for future developments. This can be illustrated with a quote about the company WattWay in France, which produces PV elements that can be integrated in road surfaces:

*"A company in France, Wattway, has received a contract for the future. They have market volume in the future so they act now to get there. They said to the company: in the future you get to build roads, given certain conditions. […] It stimulated that company to develop their product, they are doing it on a global scale. The first question was: company, can you develop something for the future?" (Interviewee 12)*

This proves it is possible to stimulate innovation and developments whilst not having to directly invest in the development of a specific product. On the downside, when a firm has patented an innovation and no alternatives are available from other private actors, public actors are confronted with a vendor lock in.

Table 3 Overview of most important economic barriers and opportunities

| **Economic** | |
|---|---|
| Opportunities | Using life-cycle costs allows for more efficient management of project budget.<br>The sense that the lowest bid is not the best bid needs to spread.<br>SME's can add higher levels of innovation into a project.<br>Create future market volume and stimulate innovation by guaranteeing future contracts. |
| Barriers | Connecting PV elements to the grid can be very expensive.<br>Relatively small projects do not have enough budget to be innovative.<br>Construction and maintenance have different budgets. |

## 5.3 Social

The addition of PV-elements to any type of infrastructure directly influences the environment of households that reside near the project. In chapter three, the examined relevant literature showed us that it is crucial to involve local stakeholders in an early phase of the project to gain public support and explore possibilities for financial participation in a project. There is quite some interest from the public for financial participation, as one participant stated:

*"I can tell you that within communities, where different groups are involved with the sustainable development of their community, they ask […] if it's possible to put solar panels on a noise barrier." (Interviewee 4)*

This can be seen as an opportunity; households are willing to contribute to projects if it enables them to meet their renewable energy needs or is financially attractive. Other arguments that revolve around communities is that integrated projects help local communities reach their own energy goals so liveability is improved. The fact that visible PV-elements integrated in the landscape can spark awareness on sustainable development adds to this and can stimulate the integration of photovoltaics into future projects. This proves exploitation of solar panels by surrounding communities could be promising, even though three participants said the exploitation of energy through use of current instruments like the zip code arrangement is quite meagre. On top of that, when you choose to exploit the power to a third party, you add a layer of management and organization, increasing complexity and costs.

The influence of individuals in a project can also be seen as an opportunity in the social category; if a particular government official decides road infrastructure projects should contribute to the sustainability goals of his or her government, the project is effected in a positive way. This is equally true for individuals in the community that are able to spark local enthusiasm and support. On the other hand, government planners are afraid of innovations since it increases risk while they are responsible for the success of the project. Combined with the conservative character of the building sector, this can be a big barrier for the realisation of an integrative project, whilst both the literature as three interviewees stated that the privatized character of the Dutch executive sector is well-suited to innovate, given certain stimuli.

Depending on the context, this can thus be seen as both a barrier and opportunity. When it is seen as a barrier, a top-down solution could be to have (local) politicians construct a framework that forces projects to contain sustainable components. A bottom-up solution can be for the public (represented by an energy cooperation) to (financially) participate in solar panels along the route. Such an initiative can contribute to project finances, regional energy goals and knowledge within governments, market parties and the public on how to approach projects that combine road infrastructure and solar energy.

A question that should be asked is if it would be a wise idea to let these developments and thus overall project success depend on one particular individual. A multitude of interviewees stated that local contexts, both social and environmental, differ from project to project, meaning that local networks need to be mapped to decide which key stakeholders are capable of generating enough public support for the exploitation of the solar fields when they are integrated with road infrastructure. One participant said the following about public support:

*"I believe sustainability is a term people nowadays are bombarded with. It's a catch-all term. People don't really care about sustainability because of these reasons. What's different in our community is that we have a lot of goodwill. Goodwill is vital in projects like this." (Interviewee 9)*

The social category also incorporates informal institutions like administrative cultures. These may differ between provinces and municipalities, but interactions between infrastructure and sustainability departments in local and regional governments can be improved. This is especially the case for the national government since provinces and municipalities usually are more integrated organizations according to one interviewee, with enough local expertise to manage stakeholders in a more efficient way than market parties. Like on many occasions, this can also be translated to a dilemma: while these lower scale-levels governments may be more integrated, they possess less knowledge on how to correctly manage a project. A government official with no experience in the field of consultation might not know how to behave correctly. On the other hand, a lack of experience is not always indicative for the success a market party will have in a project. This will be explained further on in section 5.6.

When opting for subcontracts to stimulate innovation, flexibility and the amount of SME's that are involved in a project, the relationship between subcontractors becomes important. If that relationship is damaged or communication is flawed any other way, you have a huge disadvantage and a project manager will have a lot of cleaning up to do after the project is built.

One interviewee expressed the importance of aligned goals for both private and public actors in a project organization. If, for example, both parties aim for the control of risk, the project is influenced in a positive way. To achieve this, it is possible for a private actor to point out regional energy goals or other sustainability policy documents to point out the urgency of using a project to achieve those goals, and possibly sign a letter of intent so involved parties and stakeholders share the same vision and ideas, as was perceived in two interviews.

Table 4 Overview of most important social barriers and opportunities

| **Social** | |
|---|---|
| Opportunities | Bottom-up initiatives are looking for acreage to realise PV projects.<br>Individuals can act as a catalyst for realising integrated projects.<br>To engage key stakeholders, local networks need to be mapped out in an early phase.<br>A letter of intent can help aligning goals of involved stakeholders. |
| Barriers | Individuals can halt integrated developments when it conflicts with their political agenda.<br>Less experienced governments are not used to adequate tendering procedures. |

## 5.4 Technological

In multiple interviews participants stated that infrastructure automatically has energy demands, for example through the inclusion of lighting or bridges. Some of the photovoltaic elements can be utilized on a small

scale so the energy the road needs is balanced with the energy the road generates, but multiple participants argued that such an approach to integrative infrastructure planning would not provide a substantial contribution to regional or local energy goals. A problem that arises is that sustainability is a much broader definition than the generation of renewable energy, and provinces thus try to incorporate sustainability through a different lens into their projects, for example CO2 reduction in the building phase or the circular use of building materials.

A different barrier that was encountered in three interviews is the cold feet for unproven technologies and combination of functions. Examples are Building or Road Integrated PV (BIPV/RIPV), the Solar Noise Barrier (SONOB) or solar panels with altered colours. The renewable energy sector is developing in an astonishing pace, one participant stated that current technologies quickly become obsolete (especially when compared with the long life cycles of infrastructure projects) and therefore not fully profitable. This might provide an additional opportunity when a long-term maintenance contract is signed. This allows the replacement of panels when the yields and efficiency of new panels exceed those of current panels, as is realistic to be expected according to several interviewees. The cold feet towards the integration of PV in infrastructure projects is also increased by the fact that traditional solar fields usually are easier and cheaper to realise, decreasing the relative benefit that integrated solutions might provide.

Two interviewees stated that the renewable energy market is not heterogenous. This causes technical complexity. In order to solve this complexity, you need to take a step back in an early project phase, which offers a possibility to search for matching opportunities through a market consultation. On the topic of renewable energy technologies, and PV in particular, some interviewees mentioned bad experiences when it comes to the realisation of energy projects, especially on the time it takes to realise a project:

*"Even if there is enough budget and you want to realise such a project, you run into technical limitations. There is not enough manpower, you need to request permits and all sorts of things. In order to get something done, you have to deal with a lot of fuss." (Interviewee 7)*

*"We have a very big problem, it is not just us but also the construction sector, the manufacturability as they call it. We have a shortage of technical personnel to fix everything at the same time. We try to […] get involved as early as possible, […] so we can indicate what makes sense from a grid perspective, or provide other smart solutions." (Interviewee 9)*

This implies the renewable energy market is not fully matured, meaning additional risk when PV functions are added to a road infrastructure project. The interviewee whom is employed by a grid provider made clear that the personnel barrier can be flattened by making sure no energy is wasted by developing plans for photovoltaic installations on locations where they are not technically feasible in terms of connecting a photovoltaic installation to the grid.

Table 5 Overview of most important economic barriers and opportunities

| **Technological** | |
|---|---|
| Opportunities | A road needs electricity in its operational phase.<br>B/RIPV and SONOB and other new technologies have a lot of potential.<br>The PV market develops rapidly, innovations will become profitable eventually. |
| Barriers | Developments are halted by cold feet for unproven technologies.<br>Grid provider does not have enough capacity to timely complete projects.<br>Technology develops so quickly that developments and investments become obsolete. |

## 5.5 Environmental

Another important thing to keep in mind is that the realisation of photovoltaic elements does not necessarily has to be in the direct vicinity of the road; a project can take on an area-oriented approach where local strengths are exploited so maximum value is added to a project. Part of this is to explore possible synergies that can be attained through the inclusion of energy cooperations so local households can benefit from of

the energy generated by the road so a project contributes to local sustainability goals and a governmental organization avoids becoming an energy distributor, as explained in section 5.3.

Most of the interviewees stated that when trying to search for suitable locations that can be used to generate renewable energy, one has to look for the combination of functions since practically every square meter in the Netherlands already has a function. The following quotes confirm this statement:

*"We stimulate the careful use of space and combination of functions, because we think it's important and take that into account in all our assignments. […] We think health and safety are topics that always should match when we get to work. On the main lines you should always put those principles into practice, and you make them specific when you are working on something." (Interviewee 2)*

*"Look for matching opportunities in projects. […] It has to have a function from a road perspective, but also in another perspective. […] It is not always possible, but I think you should aim to look for such opportunities." (Interviewee 11).*

*"You should not walk away for such a question with the mindset that it cannot happen, it will never work, so we are not going to do anything. You have to dive into it as a province, a municipality or together with an energy cooperation or energy provider, get around the table and see where the matching opportunities are." (Interviewee 4)*

It was interesting to hear some other interviewees state that surrounding road infrastructure there is a lot of space that currently has no function, which provides opportunities to realise PV initiatives. Examples of this are futile corners at cloverleaf intersections. Both interpretations, where the combination of functions is a requirement or a possibility can be seen as an opportunity, where the former members of the project team should always try to integrate PV into a road infrastructure project, whilst the latter gives project team members the task to search for futile corners in or around the road infrastructure.

A main argument to detach PV and infrastructure functions is that in order to protect the landscape everything you add to the already barrier-like infrastructure has an environmental impact, which is the opposite of the desired functional integration of PV and road infrastructure. Autonomous roads with a less regional character are already quite present in the landscape and less sensitive for the addition of PV, whereas roads with a historical character will be affected more negatively according to two interviewees.

As has been showed in section 5.1, some can argue it is wise to decide a political course for each project, since each project is different in nature and characteristics. This is also true for the social context and environmental context, as three interviewees also expressed. You need to take environmental qualities into account (both in terms of valuing the landscape and suitability for the installation of PV) for each project.

Earlier it was mentioned that sustainability is a catch-all term, making it difficult to decide in which ways sustainability can and should be included in a project. This also means when incorporating sustainability into a project, as is often the case nowadays as had been made clear out of the interviews, it is difficult to rule out solar energy. In the literature review and an earlier section of this chapter was mentioned that an early market consultation stimulates innovative power and project success, therefore the market should receive total freedom from the public actor, which means there is enough room to explore the possibilities for the combination of PV and road infrastructure functions.

Table 6 Overview of most important environmental barriers and opportunities

| **Economic** | |
|---|---|
| Opportunities | A lot of space without function is available around infrastructure.<br>When an energy cooperation is involved you contribute to local sustainability.<br>The grid provider should be contacted to determine project feasibility. |
| Barriers | Everything you add to a road has a spatial impact and thus adds complexity.<br>PV installations can affect the safety of road users.<br>Local contexts differ, so decisions should be based on individual project characteristics. |

## 5.6 Legal

### Tendering

A main problem which fits into the legal category that was encountered was the knowledge disadvantage for governments when compared to private actors in terms of tendering and contracting in infrastructure projects. Most interviewees claimed that a private actor usually has an advantage over a public actor in terms of knowledge of technological advancements in the market, but also knowledge on procurement and contracting. One interviewee added that knowledge gradually started to increase because government officials gain experience with similar projects where they deal with procurement, tendering procedures and contracts.

Still, due a lack of knowledge it automatically becomes difficult for a public party to specify the project. Consulting one or more market parties in the early stages of a project so a client is able to specify what they want in a project on forehand is very useful, according to different interviewees, both in the public and private sector. The problem is you are never 100% sure how a project will unfold, so you cannot take that into account in your tendering procedure and are always left with a bit of uncertainty.

Quite a few interviewees stressed that a competitive dialogue is a useful tool to gain knowledge and add value through innovation to a project. They also stressed the tendering method should correspond with the project size and budget, and that the dialogue should focus on the innovative part of a road, in this case the addition of photovoltaic elements to non-highway road infrastructure. This is illustrated by the following quote:

*"I think a competitive dialogue is promising, I think the principle is fantastic. But my recommendation is to restrict the dialogue to the parts that should be innovative.* […] *Try to keep it as scoped and short as possible, because you want the exchange of ideas and knowledge but take into account project characteristics. "*
*(Interviewee 5)*

In other words, a light version of a competitive dialogue can be set-up. A danger that could arise is that in such a consultation or dialogue, you can only test tenders and cannot make a judgement yet. Four interviewees agreed that transaction costs for a full competitive dialogue are high and often not worth the effort for small project. Therefore it is useful to keep in mind not all projects are suited for early market involvement.

One of the interviewees with a background in a consultancy firm provided the following quote:

*"The idea that the best bid is not necessarily the cheapest bid by definition is not a well-recognized fact".*
*(Interviewee 3)*

Another way to potentially increase the innovative quality of bids is to communicate a fixed price or ceiling amount to the bidders, so the project can be awarded based on quality. Awarding on MEAT alone might not be enough according to another interviewee, since that can either mean best value procurement, total costs of ownership or lowest price. This implies that the bids should be fairly similar in terms of price, and the best way to attain that is to clearly communicate the awarding criteria. On the other hand, provinces and municipalities are afraid to leave the MEAT-criteria too open because the notion exists market parties will make more expensive bids. This is not true for all projects, since market parties know lowest price is still an important criterium in a variety of projects and thus firms are reserved on making high bids and, especially a few years back, aggressively compete to win tenders. An option is to state your problem or project goals as nice-to-have, to which the market can respond with innovative options. A barrier is that you cannot use innovative ideas from a party that did not get the project awarded to them.

The paragraph above showed that MEAT is no guarantee for an innovative project or the incorporation of PV. This can change however by making sustainability (or in the light of this thesis, a PV component), a requirement for entering the tender. According to two interviewees from a consultancy firm, additional award criteria can be included in order to stimulate innovation provided by SME's or the exploitation of energy by local cooperations.

### Contracts

In terms of contracts, it might be wise to split up the project in multiple satellite-contracts which are individually more easily manageable. Innovative concepts add risk to a project and by separating them from the main contract, complexity and costs can be reduced. Splitting up the contract means interface control between contracts is crucial to the success of a project, a private actor usually can manage this more effectively than a public organization can, according to an interviewee that was involved in an infrastructure project and an interviewee that is an expert on public-private partnerships and early market involvement.

Over the past few years, the government has stressed the importance and usage of DBFM(O)-contracts among Dutch provinces. Present day the government recognized a wide DBFM(O) is not such a wonderful solution after all: you become largely dependent on private actors which is not desirable in all projects. The government came to terms with the fact that most projects need a tailored-fit approach. This does not mean DBFM(O) contracts have no place in the Dutch planning arena, but implies a careful approach whether project characteristics are suitable to carry such an integrated contract form. One interviewee stated the following:

*"[…] if you want to outsource maintenance and operation phases […], interface control needs to be well-organized, market parties are capable of doing that […], but it only works if the market receives the right stimuli." (Interviewee 5)*

Another interviewee had the same opinion and thought integrated contracts that span over the project lifecycle are promising if done right:

*"Innovation can lead to different maintenance and operation costs, but if you solely give out the construction phase to a contractor there is a limited incentive to retain maintenance and operation costs […]. It is the challenge to link a project with a project organization and project budget for the construction and a certain goal to the party that executes maintenance and operation with a different budget." (Interviewee 8)*

It seems evident that in order to look at the total costs of ownership and utilize a life cycle cost approach, the use of an integrated contract that is adjusted to the lifespan of a project has a positive effect.

As we have established in section 5.2, SME's are capable of innovative designs and bids. It is possible to include SME's into a project organization if a construction team is chosen as a contract form. The SME solely focuses on the scope of innovation (in this case the integration of photovoltaic elements), while other members of the construction team have other tasks so project efficiency is increased. Two quotes, both from private actors, strengthen this hypothesis:

*"If there is flexibility in an UAV-GC contract and you want to innovate, risk is increased. You will not win if you increase the risk budget since lowest price is very decisive. Construction teams are more suitable, because you award on different criteria, the winner that gets to be in the construction team can add innovation." (Interviewee 3)*

*"[…] in a normal selection phase you can select based on references and experience of a party. We did not think it was relevant for our selection because parties work towards a construction team. References and experience do not have to be a decisive indicator for how well a party will perform in a construction team." (Interviewee 8)*

The first quote underlines the fact that when the demand for an innovative project is high, a construction team could be a suitable contract form. The second quote expands on the first quote and makes clear that SME's, who often lack in experience and references compared to bigger firms, have fair chances to become part of a construction team.

As has been explained in section 5.4, future yields of PV will go up, the maintenance contract of the PV elements should therefore have enough flexibility to replace panels when yields go up, but also stretch the technological lifespan to achieve maximum cost efficiency. The problem is that it is hard to predict when that turnover point will be and thus what timespan your contract should have.

### Legal boundaries

An institutional barrier in the legal category is the fact that it is not possible for a governmental organization to become an energy provider. To dismantle this barrier, one can try to incorporate an energy cooperation into the project in order to sell the energy local and try to avoid European tendering rules. As has been shown in section 5.3, there is plenty of interest for bottom-up solar initiatives. A problem is you cannot express preference when enabling the exploitation of PV on governmental acreage available. As a planning official said:

*"As a regional or national government, you cannot say: you will receive free energy because that road will be doubled." (Interviewee 6)*

Next to this legal barrier, it takes a lot of administrative effort when you want to include a third party to exploit the generated energy. You can also try to make your own regional government energy neutral by compensating the CO2-emissions of your own buildings and vehicle fleet, but when the generated MW potential is higher than what you actually need, you could try to purchase extra energy together with other municipalities. A downside to this is that you then again have to deal with different budgets from different municipalities.

The most effective yet difficult way would be for the national government to recognize quick wins can be realised when this barrier is relieved and third parties are allowed to realise PV-structures on acreage that belongs to the government.

Table 7 Overview of most important legal barriers and opportunities

| **Economic** | |
|---|---|
| Opportunities | A competitive dialogue can be used cost-effectively when the scope is solely innovation.<br>Through a leasehold estate, a third party can exploit PV on governmental acreage.<br>Subcontracting makes a project more manageable and decreases complexity.<br>Sustainability should not be a criterium in MEAT but a requirement for entry. |
| Barriers | Governments do not have enough knowledge on contracting and tendering.<br>As a government, you are prohibited to become an energy provider.<br>Lowest price is still fairly decisive, so innovation-oriented tenders do not have much effect. |

## 5.7 Synthesis

We have seen that for each PESTEL-category different opportunities and barriers can be named. In the tables at the end of each section an overview of the most important opportunities and barriers per category is given. This does not mean all opportunities and barriers are equally important when conclusions have to be drawn from the research findings. The technological category, for example, had only five opportunities and six barriers in total, whilst the legal category had thirteen opportunities and fourteen barriers. A reason for this difference could be due to the background and knowledge of participants but also the scope of every conducted interview. The nature of this research is not very technical and focusses largely on other barriers and opportunities.

The categories with the least data were the social, technological and environmental categories. Multiple arguments can explain this. First, a lot of the opportunities that were found could theoretically fit in multiple categories. An individual that is able to act as a catalyst within a project organization belongs in the social category, but when that individual is a government official, the opportunity can also be placed in the political category. Opportunities and barriers often interrelate, which is what makes it so difficult to draw conclusions. Second, the order of which participants were interviewed influenced the number of opportunities and barriers. The final three interviews have been conducted with professionals from a grid provider, a contractor and two professionals with a background in an energy cooperation and knowledge on communication and behaviour in the energy transition, mainly corresponding with respectively the technical, economic and social

categories. Due to the research strategy, findings from the later interviews that were not encountered in earlier interviews could not be tested by professionals from different backgrounds.

All main and secondary research questions have elements of two or more PESTEL-categories in them, so they can only be answered through combining findings from one of the six categories. Whilst emphasis on categories differs per research question, it became clear that a multitude of factors steer the nature of different problems and thus the questions that can be derived from those problems. It also means that in order to answer one of the research question, a combination of opportunities and barriers from different categories has to be dissected. The findings from the interviews need to be compared with the concepts that flowed from chapter three.

# 6

## CHAPTER SIX: CONCLUSION

In this chapter, the secondary and main research questions will be answered through the insights that have been provided by the reviewed literature in chapter three and data analysis in chapter five. As concluded in chapter two, there is a demand for renewable sources of energy to combat global climate change. The Dutch government expressed the ambition to generate renewable energy by facilitating regional and local authorities. Since a lot of space in The Netherlands is already heavily contested, synergies can be realised when functions are combined according to the recently presented Dutch climate accord. One of those synergies can be realised by combining the functions of road infrastructure and PV.

The non-highway road infrastructure network potentially offers a lot of opportunities to combine said functions. There are multiple reasons for this. First, a lot of provinces have more ambitious energy agendas than the national energy agenda, as can be seen in chapter two. Theoretically, these regional authorities should be aiming for synergies and exploit opportunities to generate renewable energy generation wherever possible. Secondly, the total length of non-highway infrastructure is much higher than the total length of the highway network, potentially providing more opportunities to let an area-oriented approach add value to plots of land. It therefore would be logical to expect that such integrated projects would be not omnipresent in the landscape.

Our literature study in chapter three showed the Dutch infrastructure domain can be complex. Different procurement strategies, tendering procedures and types of contract have different effects when paired with the local context, which is looked at through six different lenses. The political, economic, social, technological, environmental and legal factors influence every infrastructure project. Together they form the PESTEL-backbone of this thesis. The author found it becomes hard to truly grasp an integrative approach for non-highway road infrastructure projects, since they are often limited in size, (financial) capacity and scope. In order to identify and possibly remove barriers and identify and optimize opportunities, the secondary questions were brought to life.

All main and secondary research questions have elements of two or more PESTEL-categories in them, so they can only be answered through combining findings from one of the six categories. Whilst emphasis on categories differs per research question, it became clear that a multitude of factors steer the nature of different problems and thus the questions that can be derived from those problems. It also means that in order to answer one of the research questions, a combination of opportunities and barriers from different categories has to be dissected. The findings from the interviews need to be compared with the concepts that flowed from chapter three.

In chapter five e have seen that for each PESTEL-category different opportunities and barriers can be named. In the tables at the end of each section in chapter five an overview of the most important opportunities and barriers per category is given. This does not mean all opportunities and barriers are equally important when conclusions have to be drawn from the research findings. The collected data turned out to have a large focus on the political, economic and legal categories; the answers on the research questions are therefore based on the opportunities discovered in these categories. The technological category, for example, had only five opportunities and six barriers in total, whilst the legal category had thirteen opportunities and fourteen barriers. A reason for this difference could be due to the background and knowledge of participants but also the scope of every conducted interview.

## 6.1 Secondary research questions

**What is the influence of procurement and tendering policy and energy policy on the realisation of renewable energy generating road infrastructure projects in the Netherlands?**
Because of the nationally defined energy goals, the stance of the Dutch national government on energy policy is clear. Regional governments also have their own energy policies, but they generally less capacity and knowledge to efficiently take measures and implement components that contribute to sustainability into the environment according to the explored theories in chapter three. This is remarkable since the selected literature that we studied in chapter three has showed us the vision of the national government is for the regional governments to play a key role for translating policy to a local context.

In contemporary Dutch infrastructure planning, projects are awarded based on the most economical advantageous tender, or MEAT. This can mean a project is awarded on best value procurement, total costs of ownership, or to the lowest bid. When the goal is to realise a project through an area-oriented approach that combines the function of renewable energy with non-highway road infrastructure, lowest price should be ruled out. It is important to keep in mind that not all projects are suitable for the combination of said functions. Factors that influence said suitability are a low budget, the inability to generate public support to locally exploit the generated energy, or when the knowledge, experience and creativity of market parties is not introduced in the earliest stages of the project.

Governments are obligated to stick to European tendering laws, meaning that big projects require an European tendering procedure. When an integrative approach is chosen and the sustainability goals in a project are made hard, meaning for example  a certain amount of megawatt has to be generated through PV-energy, the larger project could be divided in separate plots. The PV installation can be realised on one of the plots, where an energy cooperation can step in to contribute to the sustainability of the project, whilst avoiding a heavy tendering procedure.

It is also possible to avoid tendering procedures when realising PV. A government cannot express preference, meaning they cannot build an energy generating road and donate the excess energy to a neighbouring community. This can be dealt with through bottom-up initiatives, usually started by energy cooperations. There is plenty of demand for suitable locations where renewable energy generation can take place to make local communities energy neutral. Through a leasehold estate third parties can build PV installations on governmental acreage, and as long as a competitive price is paid, the government and the energy cooperation can avoid a tendering procedure, increasing chances to realise an integrated project.

According to the studied theories in chapter three, local and regional authorities have a knowledge disadvantage compared to the private sector on a couple of subjects, including procurement, tendering and contracting. The results in chapter five confirmed this. To decide which procurement strategy, tendering procedure and type of contract are best suited for the characteristics of each project, a market party should therefore be included at the beginning of the planning phase.

**Which steps are needed to include an area-oriented approach in non-highway road infrastructure projects?**
The literature we have examined in chapter three has shown us that an area-oriented approach can help build integrated solutions between road infrastructure and other functions. Multiple steps can be taken to increase the amount of area-oriented approaches in non-highway road infrastructure planning by various actors. For each of the actors (public, private and communities) these steps are explained.

First, government officials can take steps by considering the total costs of ownership for each project. By bringing the budgets of design, construction, maintenance and demolition together and set it off against the technological lifespan of a project, the pillarization between construction and maintenance vanishes. Because of this it becomes easier to adjust the focus of a project budget to maintenance or budget, but more importantly, when a renewable energy project is realised additional cashflow is generated, which can add to the project budget and be used for the design and build phases of a project, leading to a more qualitative product. Otherwise the cashflow will take place in the maintenance phase and politicians see that as a discount instead of additional budget to add more value to a project.

Secondly, they can introduce employees from other departments like landscape, solar energy or business and innovation into the project to weigh out project strategies and decide whether the project can carry innovation and if so, which innovation. Building on the research question above, it is important to consult a market party in an early stage. This goes the same for the officials of other departments. Path dependency can limit flexibility in a project, so early involvement of market parties is the best option as we have established in chapter three. Chances for provincial or municipal organizations can be found here because they are naturally more integrated organizations when compared to organizations on a national scale. The urgency to involve market parties becomes even bigger since on a lower scale level governments usually have less capacity and knowledge.

Two ways in which communities can contribute were defined in this research. First, they can either vote for parties that prioritize sustainable (and thus area-oriented) developments instead of budget-driven political parties, but there has to be noted that this is a lengthy process and not realistic to expect when the main goal is to make road infrastructure energy neutral. It is better to view this as a long-term solution to increase sustainability in projects based on public awareness. Looking from another angle, a more realistic and short-term solution is for energy cooperations to interact with local and regional governments so the chances of them being included in energy goals of an infrastructure project increases.

Finally, market parties can contribute in a number of ways. First, when they are involved in a project it is vital for them to be up to date with the energy and sustainability goals of the involved governmental organization. This way governments can receive a stimulus to add quality to a project and look for ways to utilize possible synergies in the area, instead of a focus on budget and the management of risks. Secondly, when working on non-highway road infrastructure projects, it is important to know the local context. This can be split up into four parts. First, it means knowing what chances there are when it comes to local energy cooperations. Secondly, it is vital to have knowledge of who to consult within your own organization as well as within relevant governmental organizations. Third, enough knowledge of the technological advances in the PV market should be possessed. Finally, it is vital for a market party to have the ability to identify risks and how to control those risks in a project.

**Which possible synergies between different actors in the planning phase of non-highway road infrastructure can be created and which steps are necessary to reach the full potential of these synergies?**
Like stated above, synergies can arise in a number of ways between different actors. When we categorize the actors in three groups, namely governmental organizations, market parties and local communities, three synergies can be thought of.

A synergy between governmental organizations and market parties can be created by involving multiple market parties in the earliest phase of a project. Through constructing dialogues, which are essentially a light version of a competitive dialogue, governments can gain knowledge and are better able to add innovation to a project. It is important to limit the scope of the dialogue to just the innovative added value. Intellectual property should be protected and when a project is not awarded multiple options exist to compensate the market party. This can be a financial compensation to cover made costs, but could also be a notional discount on a future tender so chances of getting awarded a project are bigger.

Market parties and local communities can share a synergy when market parties share their knowledge and creativity to stimulate public support. In both the theoretical chapter and the section that answered the first research question, we have already seen that early involvement is important in all kinds of domains. This is also true for the relationship between market parties and local communities. By engaging in a dialogue with local stakeholders in an early phase of the project, possibly by signing a letter of intent, the project will be delivered in a way maximum value is achieved for the local community while the market party still can make profit.

Finally, a synergy between governmental organizations and local communities can be realised when the government helps to facilitate local energy initiatives. This can be by appointing a contact person where energy cooperations can address their questions on financial or legal processes or facilitating a place to hold meetings. Next to that, as explained above, there are quite some opportunities to get around Dutch and European tender laws and increase chances for local energy cooperations to be involved in an infrastructure project. An example can be to set a requirement for a party to be able to generate local support for a project.

**Which obstructions that limit the innovative power of market parties in the planning phase of energy generating non-highway road infrastructure can be observed?**
Just like the opportunities, the main barriers that were observed in this research could be sorted in one of the six PESTEL-categories. Markets are capable of creative and innovative ideas when given the right stimulus as we learned in chapter five. The private sector is driven by profit, which is not a barrier itself since it increases competition and thus allows the chance to excel in delivering quality. It is then vital that enough project budget is available to reward these innovative options or to increase chances of winning in a future project. Another limitation is the fact that the Dutch planning system is prone to influences of power. An individual with a personal or political agenda can have enough decisive power to halt innovation. These institutional barriers can be dealt with by increasing top-down pressure and increase the importance of quality in a project as an awarding criteria, or installing a ceiling amount or fixed price where market parties are given enough flexibility to come up with creative ideas.

**Which incentives can be implemented to stimulate the innovative power of market parties in the planning phase of energy generating non-highway road infrastructure projects?**
One of the incentives that can be implemented to stimulate innovation in non-highway road infrastructure projects is to increase financial stimuli for market parties when they are involved in an early phase but do not get the project awarded to them, confirming what we have seen in the theoretical chapter. Another option is to choose a construction team as a type of contract, where SME's are included to add innovative technologies.

On the side of public actors, a positive contribution would be to include functional specifications where possible. By stating the requirements you need for a road and the functionalities you would like to add to the infrastructure (such as generating energy or stimulating local business), private actors can fill in the blanks themselves and utilize their expertise that way. This again requires an institutional transformation since government officials on small scale levels have the most experience with technical specifications that limit flexibility and thus innovative power. This finding was already mentioned in chapter three and confirmed by some of the interviewees in chapter five.

Lastly, when opting for split contracts on separate plots to add PV to a non-highway road infrastructure project, it can help to insert parallel design tracks. Even though this raises initial costs, it decreases risks while still providing enough opportunity to insert innovation into a project.

All secondary research questions in this thesis have now been answered. This means we can focus on answering the main research question in section 6.2.

## 6.2 Main research question

**Which factors can help to successfully stimulate market involvement in the planning phase of photovoltaic installations in non-highway road infrastructure projects?**
It is impossible to grasp all the factors that can successfully stimulate market involvement in the planning phase of photovoltaic installations in non-highway road infrastructure projects. Factors, divided in opportunities and barriers, can interlink and influence each other. Project characteristics can greatly differ depending on the political, economic, social, technological, environmental and legal context of a project. It therefore is impossible to give one universal answer that is able to generalize all success factors, but in this research I tried to gather the most relevant factors in a Dutch planning context. These relevant factors can be used as a tool by stakeholders to improve the way in which planning processes are structured so infrastructure projects can contribute to regional renewable energy goals.

It is possible to identify multiple important success factors that, when separately discussed, each can contribute to successful market involvement in the planning phase of photovoltaic installations in non-highway road infrastructure projects. Therefore the main research question will be answered by making seven recommendations.

### Recommendation 1: Invest in stakeholder management
National, regional or local governments are able to formulate ambitious energy goals, market parties are capable of producing innovative technologies and consultancy firms have much knowledge and expertise on procurement, tenders and contracts. When an area-oriented approach is chosen as described in chapter

three to realise PV in non-highway road infrastructure projects, at some point the building phase ends and the generated energy needs to be distributed. Assuming the acreage is property of a government this can prove a problem since it is illegal for a government to become an energy provider. The energy thus needs to flow back to a community, which in Dutch context will nearly always be an energy cooperation. Therefore it is important to know and map what local networks exists, which individuals and/or what organizations are key actors and what the relationship between these actors is.

### Recommendation 2: Use a life-cycle cost approach

By utilizing a life-cycle cost approach in a project, different phases in the lifespan are merged and total costs of ownership is the main factor on which a project budget is put together. This means a more qualitative product can be realised that needs less maintenance. In the case of adding PV to a non-highway road infrastructure project, when a leasehold estate is given for a plot of land, an additional cashflow is brought in. The additional budget can be added to discover possible combinations of functions through an area-oriented approach. When adding PV and no split contracts are involved, it is important to consider the technical lifespan of the PV installation since the moment where yields of new panels exceed the yield of old panels plus the costs to replace the old panels will probably be shorter than the technical lifespan of the infrastructure.

### Recommendation 3: Use the knowledge and creativity of the market by constructing a dialogue, but keep it scoped towards innovation

The market is heterogenous but a project can be awarded to only one market party or consortium. This means that dialogues can take place where a government gathers knowledge and expertise and develops the plan and further procurement strategies, but not all innovations can be incorporated in the final design. As we have seen in chapter three, a problem is that a full competitive dialogue is a heavy tendering procedure for a lot of local and regional governments in terms of time and budget. It is important to then scope the dialogue to just innovative ideas on how to utilize the area-oriented approach so less time is needed and less budget consumed. It is best for a skilled, experienced and independent actor to manage the dialogue. This actor can be a consultancy firm so the power of political agendas in a dialogue can be diminished. Next to that, consultancy firms are usually more qualified to engage in such dialogues and properly value bids when compared to local government officials.

### Recommendation 4: Use split contracts to maximize opportunities for SME and energy cooperations

When split contracts are used in a project, an energy cooperation does not have to be part of the project team of the infrastructure project that formed the base of the PV-project. This also provides opportunity to avoid European tendering laws or a tendering process after all, on certain conditions given earlier in this chapter.

### Recommendation 5: Look for matching opportunities in the earliest phase of a project

In the theoretical chapter and in some of the above sections in this chapter, early involvement has been a recurring theme. It is not just vital for market parties to be involved as early as possible, but also for local stakeholders to join the table. Only when all parties transparently express their intentions and how they think maximum value can be achieved in a project, involved stakeholders can discover matching opportunities which add value to a project.

### Recommendation 6: Reward sustainability in project bids

Here lies a task for governments. Private actors are mainly driven by profit, which conflicts with the complexity that is implied by an integrated project. Despite ambitious political goals on sustainability, private actors experience that there is not enough financial incentive to shift their focus from profit to sustainability. Governments can contribute to this transition by including award criteria on sustainability in their tenders or by using fictional discounts to reward bids that contribute to regional energy goals.

### Recommendation 7: Recognize the importance of individuals

As made clear in section 5.3, which addresses and analyses the discovered social opportunities and barriers, the influence of individuals can both act as an opportunity or a barrier. Governments should therefore appoint government officials that prioritize sustainability and can act as an ambassador for sustainable development in the region. The right individuals in local communities can spark initiatives that act as a catalyst and contribute towards the integration of PV in road infrastructure projects. Market party employees

also have different agendas, depending on the involved individual this can steer a project away from or towards a situation where contributions to regional energy goals are made.

## 6.3 Relevance for planning practice

Our literature study in chapter three showed us that the contemporary Dutch planning system can lead to complex planning processes. Society, public and private actors need to work together in order to add value to projects and create an environment where synergies are achieved. The data that was collected and analysed in chapter five confirmed this hypothesis. The secondary and main research questions that were answered in sections 6.1 and 6.2 helped to build understanding on how to achieve these synergies, which opportunities can be seized and which barriers should be avoided. The recommendations that flow from this understanding can be shaped toward the actors that can be encountered in planning practice, namely society, public or private actors. The way this research contributes for planning practice in each of these three categories is described below.

### Society

Citizens learn from this research that they can play a role when combining non-highway road infrastructure projects with PV elements. They have the power to vote and steer political coalitions. Since individuals, especially in the case of a provincial deputy, can have a big effect on the scope of a project, this should not be underestimated. Secondly, citizens can learn that their participation is vital for project success. They hold the key to engage public support which can also act as a catalyst on an integrative project. The public demand for energy positively contributes to a business case when compared with the low energy tariffs that a governmental organization would pay.

### Public actors

Planning officials can provide opportunities for combining the functions of PV and road infrastructure by integrating energy goals in their tenders for infrastructure projects. This can be done by using a fictional discount or even a requirement to enter the tender. Since infrastructure is usually built on governmental acreage, (local) governments need to issue a leasehold estate so legal complexities can be avoided by letting a third party exploit the PV installation. In line with the recommendation for society, it is important for local or regional governments to appoint one or more sustainability officials that are able to spark local enthusiasm and act as a catalyst in projects.

### Private actors

First of all, there has to be noted that private actors can also take part on the public side of planning when a public actor lets them manage a tender or contract. Some of the relevant points for public actors therefore also apply to private actors.

When a private actor plays the role of contractor, it first becomes important that the firm has a good network and is able to combine efforts with SME's, which generally are able to be more innovative. Secondly, an employee of a bidding firm should have knowledge of the energy and sustainability goals of the client if those are not elaborated upon in the tender. This way governments are reminded of their duty to stimulate sustainable developments for the communities they represent.

# 7

## CHAPTER SEVEN: REFLECTION

### 7.1 Quality of data

For this research, a qualitative research approach has been chosen. Through a series of conversations with professionals from different organizations, with different backgrounds and expertises, the author tried to gain insight in which factors can limit or benefit the innovative potential of market parties when combining solar energy projects with non-highway road infrastructure projects. Despite the vast amount of data that has been collected and the results and conclusions that have been drawn from that data, there is some room for discussion on quality of the data.

In chapter three, some best practices were discussed. I was able to get in touch with actors from all projects, but only interviews were conducted with actors that were involved with the N33 and Solar Wall Oostwold A7. For the N211 and N470, for both which the Province of Zuid-Holland is in charge, there has been contact but it became clear that the project teams for those projects are overwhelmed with requests of other students and researchers and therefore have chosen not to prioritize individual students but organize a symposium on the very day the author aims to finish this thesis.

Furthermore, since the legal component is vital in a part of chapter six, interviewing a professional with a legal background would have been useful. Despite the fact the legal component was part of the PESTEL-analysis, the author laid the focus in that particular category on contracting and tenders. On a positive note, this provides us with an opportunity for further research, where legal frameworks for energy cooperations that want to realize PV projects on governmental acreage near infrastructure projects can be looked into.

The categories with the least amount of defined opportunities and barriers were the social, technological and environmental categories. Multiple arguments can explain this. First, a lot of the opportunities that were found could theoretically fit in multiple categories. An individual that is able to act as a catalyst within a project organization belongs in the social category, but when that individual is a government official, the opportunity can also be placed in the political category. Opportunities and barriers often interrelate, which is what makes it so difficult to draw conclusions. Second, the order in which participants were interviewed influenced the number of opportunities and barriers. The final three interviews have been conducted with professionals from a grid provider, a contractor and two professionals with a background in an energy cooperation and knowledge on communication and behaviour in the energy transition, mainly corresponding with respectively the technical, economic and social categories. Due to the research strategy, findings from the later interviews that were not encountered in earlier interviews could not be tested by professionals from different backgrounds.

### 7.2 Own process

Despite best efforts for starting the internship in February, following the normal schedule so to speak, some unforeseen circumstances contributed to a delay. The first two assigned supervisors stated their schedules were already full and they could not guarantee to deliver quality feedback on time. Third time's the charm apparently also works for thesis supervisors and progress on the research proposal could be resumed. Luckily this delay did not interfere with any plans I made for the period that the internship was completed. Through the network at Witteveen+Bos, many participants could be included in the project but in a later stage than initially desired.

Looking back at this research, there are some things the author encountered which influenced the research. First there was the timing of the research. Due to circumstances, the research internship started at the end of May, which meant that the research for a large part had to be conducted in the summer months. It sometimes was difficult to get in touch with professionals and schedule an appointment for an interview. As a matter of fact, the last interview was conducted the week before my internship contract ended after an initial interview date was postponed. Luckily the difficulties this provided for the research could be countered by making sure the framework for data analysis was well constructed so the findings from the last interview could be incorporated into chapters five and six after finishing the coding process. I could have improved by conducting the last three interviews earlier so they could have been incorporated in the concept version of this thesis.

As announced in chapter four, the initial plan was to put the gathered data on different opportunities and barriers into a matrix to be able to compare them. It turned out this method only increased fuzziness and did not provide the clear overview I was looking for. It was a helpful and fitting lesson for me to realise that initial plans or strategies do not always work as you thought they would and you need to have a positive mindset and allow yourself to be flexible and search for alternative solutions to deal with uncertainties. You could say I experienced a big dilemma in contemporary planning first hand by completing this research.

The software that I used to code the transcripts was Atlas.TI. It helped me great and was very user-friendly, but there has to be noted that only basic functions of the software were used for this research. I have no doubt I missed a lot of functions which could have resulted in a higher quality of the research or would have saved me time. Luckily this did not form much of a barrier since I had enough time to finish the thesis. The same goes for Microsoft Excel, which I used to gather every opportunity and barrier of every interview before putting them in the list that can be observed in appendix I.

My plan originally was not to do research on the topic that I wrote so much about in this thesis. After reconsideration based on conversation with my supervisors, I focused my shift to sustainable road infrastructure, which was a research topic that still was too broad. The topic was then narrowed down to the generation of solar energy along non-highway road infrastructure, since another graduate student at Witteveen+Bos was already looking into the same combination of functions on a national scale. I was excited to start on my research. After all, how hard could it be to add a few solar panels to a road? As you may have guessed after reading this thesis, it turned out to be quite difficult.

Using the PESTEL-model has brought insights in which barriers should be lifted to speed up the implementation of photovoltaics into road infrastructure, with some results that are very tangible like the use of parallel design tracks or making sustainability an entry requirement in tendering. Other recommendations, like a shift in administrative culture, increasing knowledge of government officials or decrease the shortage of technical personnel with contractors and grid providers can greatly contribute to future project success, but realistically, this thesis will not solve these societal problems.

Despite the fact stated above, I feel I can proudly say that I am happy with what I have managed to achieve over the spell of this research. The internship at Witteveen+Bos did not only provide me with a crucial network of professionals, it also gave me a sense of what my career might look like after I receive my master degree and increased my practical knowledge in ways which would not have been attained without the internship.

## 7.3 Recommendations for future research

This research also opens doors for future research. A recommendation could be to further examine the influence of each of the PESTEL-categories on this topic for students that are for example especially interested in the political, economic or legal components of this research. It would be beneficial to sell generated energy through the implementation of PV along non-highway road infrastructure to consumers since they pay a higher price per kWh than governments, strengthening a business case. To do this, legal barriers have to be resolved.

Another recommendation is for students to take a look at sustainable road infrastructure at a specific regional or local government. By mapping where connections to the energy grid can be realised fairly cheap and simple, which roads may need redevelopment and whether the energy can be sold locally, potential

synergies can be discovered. This saves future efforts so the recommendations in chapter six can be utilized in planning practice.

A third recommendation is to look at a specific technique of photovoltaics like the solar noise barrier (SONOB) or road integrated photovoltaics (RIPV). Currently, yields are not high enough to compete with traditional PV, but the PV industry rapidly develops and it will be a matter of time before these techniques can be implemented in road infrastructure projects.

As briefly mentioned in chapter three, the Central Government Real Estate Agency (2018) created a new integrated contract in cooperation with the ministry of Finance, the DBM&E contract. It is based on UAV-GC 2005 and the contractor that wins the tender is in charge for the design, build, maintenance and energy provision of the object over a span of fifteen years. It is an experimental contract form but might be promising for future projects. A final recommendation for future research can therefore be to examine the potential of DBM&E contracts in road infrastructure projects.

# 8

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# Appendices

# INTERVIEW GUIDES

Each interview had the same opening and closure, which are mentioned below. For each interview, only the questions are mentioned.

*Opening*

- Ask for approval to record the interview.
- Introduction to the thesis and research questions.
- Short introduction by interviewee.

*Closure*

- Thank interviewee for contributing to the research.
- Mention all data is confidential and parts of the transcript can be left out of the interview if desired by the interviewee
- Ask if the interviewee would like a copy of the transcript and/or the full thesis if it is completed.

### Interview guide 1

1-8-2018, 13:30, Province House Fryslân, Leeuwarden
Richtsje van Berkum, Province of Fryslân
Hilde Kloosterziel, Province of Fryslân

- How can you match PV projects to the redevelopment of non-highway road infrastructure in the organizational structure of the Province of Fryslân?
- How can you translate regional sustainability goals to policy in the infrastructure sector and how does this pillarization influence policy and tenders?
- Is there, generally speaking, enough knowledge of the market, tendering and contract procedures within the government to guarantee an innovation-oriented approach for infrastructure projects?
- What examples of projects can you give where early market involvement had a strong influence on the planning phase of a project, and if so, in which ways did this influence the project?
- How can you step away from a traditional revenue model to include more flexibility in a project? How difficult would it be to step away from these traditional ways of doing things in your organizational structure?
- How do innovation and contract type steer each other in the combination of PV and infrastructure projects?
- How can the Province of Fryslân allure market parties to make innovation-oriented bids, and how do you weigh innovation when awarding a project?

### Interviewguide 2

02-02-18, 15:45, Witteveen+Bos, Heerenveen
Marco Westhuis, Witteveen+Bos

- Is there, generally speaking, enough knowledge of the market, tendering and contract procedures within the government to guarantee an innovation-oriented approach for infrastructure projects? If not, how can a market party fill that void?
- How can you make the transition of awarding projects based on lowest price towards awarding projects based on quality and added value?
- Which role does the conservative character of the construction sector play in the lacking level of innovation in the building sector, and how can innovation be stimulated in project bids?

- How do you experience effects of pillarization within the government, and thus separated budgets, in the case of an project that tries to integrate infrastructure and PV?

### Interview guide 3

14-08-2018, 9:45, Project bureau De Centrale As, Burgum
Willem de Boer, De Centrale As, Province of Fryslân

- How can you translate regional sustainability goals to policy in the infrastructure sector and how does this pillarization influence policy and tenders?
- Is there, generally speaking, enough knowledge of the market, tendering and contract procedures within the government to guarantee an innovation-oriented approach for infrastructure projects?
- How do innovation and contract type steer each other in the combination of PV and infrastructure projects?
- What are your experiences with market involvement in previous projects, and how did this influence the project?
- How can you step away from a traditional revenue model to include more flexibility in a project? How difficult would it be to step away from these traditional ways of doing things in your organizational structure?

### Interview guide 4

20-9-2018, 10:00, Utrecht CS, Utrecht.
Sander Lenferink, Rijkswaterstaat, Radboud University Nijmegen, Rijksuniversiteit Groningen.

- Is there, generally speaking, enough knowledge of the market, tendering and contract procedures within the government to guarantee an innovation-oriented approach for infrastructure projects? If not, what is the effect on a project, what is lost in which phase of the project?
- Recently a few projects were tendered through a competitive dialogue. Does such a dialogue have future for projects on a local or regional scale?
- In a project where a combination between PV and infrastructure is made, you come across separated budgets for construction, maintenance and PV. How does this pillarization influence a business case and what influence does that have on the contract phase?
- The lowest price often is a decisive awarding criterium, so constructors avoid risks and thus innovation. Which steps can a client take to increase innovation in bids while still managing risks?

### Interview guide 5

26-9-2018, 12:30, Province House Groningen, Groningen
Richard Pool, Rijkswaterstaat.

- On the site of the N33 project it is made clear the project organization aims to leave space in the tendering phase for future developments. How does this ambition contribute to the tendering and contract phase of the project?
- When trying to take into account future developments, how can you create flexibility and space in your plan regarding costs and complexity?
- The project aims to be energy neutral in the construction phase. To realise this, seven hectares of PV needs to be installed. Where does the generated electricity flow back to?
- How can the electricity be delivered back to the power grid?
- How are your experiences with regards to participation and public support in the project area?
- Construction and maintenance have different budgets in infrastructure projects, the same goes for PV. How does this influence your project and how does this influence the tendering and contract phase?

### Interview guide 6

05-10-2018, 13:30, Witteveen+Bos, Amsterdam
Paulien Hoogvorst, Witteveen+Bos

- An integrated project starts with the wish of a client. Does the client have enough knowledge of the market to specify their own wishes regarding to a project?

- When PV installations are constructed on governmental acreage, how can one exploit the generated electricity to the grid or the surrounding area?
- The budgets of construction, maintenance and PV are separated. Can a life cycle cost approach help break through this pillarization, and how would this influence a project?
- Bigger projects have more budget, but provinces naturally have a more integrated organizational structure. How can you utilize such an advantage in integrated projects?

### Interview guide 7

12-10-2018, 14:00, Witteveen+Bos, Deventer
Floris Oosterhof, Witteveen+Bos

- A competitive dialogue is for a project with a limited scale a heavy way of tendering. On top of that, not all government officials are experienced with this type of tender. How does this influence the project?
- The N737 wants to increase chances for SME's, next to that the project has a regional character. What advantages for such a project can be observed in comparison to bigger projects and how can these advantages be translated to bigger projects?
- To incorporate innovation into a project you need to rely on functional specifications, but governments usually don't possess the knowledge to do so. How can you increase this knowledge and thus innovation in future projects?
- Your project aims to reduce maintenance and operational costs to reduce the influence of separated budgets on a project. Should such an integrated type of contract be the standard for future projects?
- Price is still a fairly decisive factor when awarding a project based on MEAT. The sense that the tenderer that can offer the lowest price is not the best option needs to grow among planning officials. How can you speed up this process?
- To stimulate innovation it is possible to divide a project into multiple split contracts since risks can be managed more efficiently. How promising do you regard this approach?

### Interview guide 8

18-10-18, 12:30, Energy Academy Europe, Groningen
Sip Sixma, Energy cooperation Oostwold, Hanzehogeschool Groningen
Wim Elving, Hanzehogeschool Groningen

- The Energy Cooperation Oostwold will own, exploit and maintain the complete PV installation, directly adjacent to acreage owned by Rijkswaterstaat. Who owns the acreage, how did the permit trajectory come about and how was communication with Rijkswaterstaat, the Province of Groningen and the municipality shaped?
- You hired a market party to do the design and another one for construction. In which phase of the project did you start interacting with these parties, why at that moment and what was the effect of this choice on the project?
- The public support in Oostwold positively contributes to the projects. Which key factors that contribute to building public support can you identify?
- The solar wall will be built with soil that becomes available with another project, the southern ringroad of Groningen. How decisive is this matching opportunity for your project?
- The solar wall has a finite lifespan. How do you take this into account when planning maintenance and exploitation?
- What is the biggest stumbling stone in the project and how did the project team cope with that?

### Interview guide 9

30-10-18, 14:00, Province House Fryslân, Leeuwarden
Marcel Doyer, Liander.

- What experience do you have with realising PV installations on governmental acreage? Which stumbling stones does that generate?
- Which period do parties that wish to realise PV take into account? Do they look at the life cycle costs of the project, and if so, how does that influence a project?

- When a project is exploited through a local energy cooperation, which success factors contribute to project success, and what can trigger these success factors?
- Does your company have enough capacity to facilitate all projects that are instigated? If not, how can that gap be filled?
- If a government decides to redevelop a road and develop PV in the same project, in which phase of the project should different actors (grid provider/environment/constructor etcetera) be involved?

### Interview guide 10

31-10-18, 13:30, Witteveen+Bos, Deventer
Ronalt Folbert, Heijmans BV.

- Lowest price is still a fairly decisive factor when awarding projects. Which stimuli can a market party give to a government to switch the scope from lowest price to added value and combining functions?
- When a province or municipality is the client in a project, which advantages offered by the local context can be exploited when compared to projects on a bigger scale?
- To realise matching opportunities a shift in culture and behaviour is needed. Should this transition be facilitated top-down or bottom-up?
- The grid provider does not have enough capacity to connect PV projects to the grid in time. How important is this factor for an innovative approach in a project?
- Do clients have enough knowledge of the market to use functional specifications in a project and start an innovation-oriented tender? If not, what opportunities does this provide for the market to fill up this knowledge gap?
- Construction, maintenance and PV have different budgets in infrastructure projects. How promising is a life cycle approach for integrated projects?
- How important is it to develop parallel design trails to manage risks when searching for innovation and matching opportunities?

# II

## LIST OF PESTEL-OPPORTUNITIES AND BARRIERS

In this appendix, an overview is given for each opportunity and barrier that was extracted from the data. The first capital refers to the category with a 'c' added to the E for Economic and 'n' added for Environmental, the second capital if it is an opportunity (O) or barrier (B), the number is used to distinguish the different opportunities and barriers. The opportunities and barriers are in no particular order. The numbers before the barrier itself refer to in which interview the opportunity of barrier came about.

### PESTEL-Opportunities

#### Political

PO1 1+6+9+10: Provinces and municipalities have sustainability goals, every little bit contributes towards these goals.
PO2 1+3: The easiest way would be for the province to take initiative.
PO3 1+5+10: Politicians have to be willing to invest in sustainability.
PO4 1+5+6: Bring in someone from the departments of sustainability in each phase of the project.
PO5 3: Municipalities get bigger so capacity grows.
PO6 3+10: Determine the desirability, then feasibility, then viability, otherwise you do not know what is necessary in terms of finance.
PO7 3: When a matching opportunity is discovered too late, but is promising for future projects, that knowledge should be shared.
PO8 3+4+6+7+8+10: The market possesses knowledge, as a government you should be aiming to retrieve this knowledge. Preferably in an early stage, otherwise you ca not optimize your area-oriented tender.
PO9 4+9: The province is naturally a more integrated organization than the national government. It therefore should be easier to look for the combination of functions in projects.
PO10 1: Knowledge on sustainability is growing among government official since they encounter it in a variety of projects.
PO11 8+9: Governments should facilitate local energy initiatives with advice and/or funding.
PO12 9: A PV initiative should first tend to spatial planners in order to see if a project can be realised on the desired spot. After that they need to contact the grid provider.
PO13 9: Flexible rules for grid providers should be constructed so connections do not necessarily have to meet the most elaborate standards

#### Economic

EcO1 1: Grid provider should be contacted as soon as possible to determine costs of connecting a project to the grid, since it is a vital part of the business case.
EcO2 4: When big companies form an alliance with SME, the latter can provide innovation while the bigger enterprise is in charge of financial efficiency.
EcO3 2+6+10: With subsidies in markets that are not mature yet you can smooth out budgetary issues.
EcO4 2: Bigger projects provide economies of scale, lowering the price.
EcO5 2+6: Joint purchase of energy can provide economies of scale since you can locally distribute power and do not need to include a cooperation.

EcO6 2+4+5+6+7: When you are working with a life-cycle cost approach, you can use your project budget more efficiently since you take into account the design, construction, maintenance and demolition of a project instead of separate budgets for construction and maintenance.
EcO7 2+7: The sense that the lowest bid is not necessarily the best project needs to be spread among politicians.
EcO8 4: SME is more innovative than big companies.
EcO9 7: By connecting the business/innovation department to a project, additional budget to stimulate innovation becomes available.
EcO10 10: A government can create future market volume by procuring a product on long-term. This stimulates market parties to innovate.
Eco11 10: Investments based on the future value of an innovation can increase engagement from investors.

### Social

SO1 1: By combining PV and infrastructure a project contributes to liveability, the yields should then flow to the local community.
SO2 1+3+5+8+10: Individuals can act as a catalyst in a project organization.
SO3 1+3+9+10: Early stakeholder involvement is important to stimulate public support and participation.
SO4 3+5: From the perspective of energy cooperation and villages there is a demand for acreage to build PV-projects.
SO5 3+8: When realising energy projects, energy policy becomes more visible and the community is stimulated to think about sustainable themes and possibly participate in further projects.
SO6 4: The privatized executive sector in the Netherlands is able to be innovative when given the right stimulus.
SO7 5+8: A letter of intent can positively contribute to the behaviour of involved actors.
SO8 6: A private actor can point out that a public actor has a certain ambition and then use that as an opportunity to integrate innovation into a project.
SO9 7: Experience of a tendering party is not always indicative for the success the party will have in a project.
SO10 8+9: An involved energy cooperation should have a diverse background in order to maximize public support
SO11 8: Stakeholders need to understand how complex choices related to the energy transition are, and decisions can be only made together.
SO12 8+9: Appointing a capable environmental manager and providing transparency to stakeholders that are involved in a project is key to project success.

### Technological

TO1 1+2+3+4: A road needs electricity in its use phase, it would be logical to generate that electricity near the road.
TO2 1+6+9: Integrated technologies (BIPV/RIPV/SONOB) hav a lot of potential.
TO3 3+7: A heterogenous market causes technical complexity. You need to take a step back in an early project phase, which offers a possibility to search for matching opportunities.
TO4 4+9+10: Solar technology is developing at a high rate, efficiency/yield is going up
TO5 6: A project should be realised in such a way maximum energy generation is achieved.
TO6 10: Install a cable parallel to a road when it is being redeveloped to increase flexibility in future projects.

### Environmental

EnO1 1+5: Realisation does not have to occur in the direct vicinity of the road, it is important to choose an area-oriented approach when reconstructing a road and create additional value for the environment. The sustainability is then a direct result from the reconstruction of the road.
EnO2 3+6+9+10: Every square meter in the Netherlands already has a function, it therefore becomes necessary to combine some of these functions.
EnO3 1+3+5+7: There is a lot of space that currently has no function, this provides opportunities to realise PV.
EnO4 1+9: When combining PV with road infrastructure, there should always be a search for opportunities to integrate the PV elements into the landscape.

EnO5 5+6: Sustainability is such a broad term that it's difficult to rule out solar energy when trying to incorporate sustainability goals into an infrastructure project.
EnO6 1+3+5+6: When you involve a local energy cooperation you contribute to local sustainability goals and avoid becoming an energy distributor as a government.
EnO7 9: Try to combine and cluster different energy projects so they can make use of the same connection to the grid.
EnO8 9: Approach the grid provider in an early stage to check whether realisation is possible against what costs and what the time frame of instalment will be.
EnO9 6+10: Involving consumers into the business case will deliver more profit since then energy is sellable for €0,22 per kWh, whilst governments purchase energy at much lower tariffs.

### Legal

LO1 1+2+5: By maintaining a ceiling amount during procurement, the most innovative design can be awarded the project.
LO2 2+4+6+7+10: Before the tendering and contract phases start, a province or municipality needs the help of a private actor (set up a market consultation) to maximize innovative potential.
LO3 2+4: Enrolling a construction team as a contract type, where a SME is included to add innovative ideas.
LO4 3+4: Opportunities are provided when a project is split into different (satellite) subcontracts. It makes a project more manageable and decreases complexity.
LO5 4: DBFM used to be a centrally steered trend, but governments are starting to realize projects need a tailor-fit approach.
LO6 4+5+6+7: A competitive dialogue could be executed cost-efficiently if the scope of the dialogue is the added innovation.
LO7 3+4: The links between different build/maintenance phases of the contract should be well-organized, which the market can do.
LO8 5+7+10: By adopting parallel design tracks for a traditional and an innovative alternative you can switch more easily between the initial design and a back-up if the initial design does not
LO9 4: Replacement of photovoltaic elements should be included in the long-term maintenance contract (stretching to technological lifespan) to decrease depreciation costs, but with room to replace panels when yields go up.
LO10 6+7: Sustainability is a theme in MEAT, but should be incorporated as a requirement for entering the tender
LO11 6+7+8+9: Through a leasehold estate, a third party can exploit solar panels on acreage that is owned by the government.
LO12 7: You can state your problem as nice-to-have, paired with MEAT, the market can then respond in an innovative way.
LO13 7+10: It's possible to include awarding criteria or fictional discounts in a tender that increase chances for SME and/or energy cooperations.
LO14 10: A DBM&E contract could be a logical next step for a DBFM(O).

## PESTEL-barriers

### Political

PB1 3: Municipalities become bigger, so it becomes harder to develop an integral environmental policy.
PB2 1: The construction of PV is not seen as a task that a province or municipality should execute.
PB3 1+2+8: The political coalition decides the strategy and main goals in a project and can choose not to prioritize PV and infrastructure.
PB4 1+2+4+6: Infrastructure and energy have different offices within the government. This means they have separate budgets, leading to conflict, but also makes it unclear on who to consult within an organization
PB5 1+3+5+6+8+9: There is no coherent policy between (different layers of) government for the integration of PV with (non-highway road) infrastructure. Implementation differs from project to project.
PB6 2: If energy is purchased jointly by a multitude of municipalities, each municipality has to ask their own constituency for feedback, leading to a slow project.

PB7 3+5+6: Municipalities and provinces have their own policy which can change relatively quick, a fragmented situation can arise since different policies do not necessarily correspond with each other.
PB8 4+5+6+8: It's easy to deprioritize sustainability when you do not meet your own energy transition goals as a governmental organization.
PB9 4: Some projects can be seen as a form of window-dressing.
PB10 9: To attain all the required permits and to wait for a government to decide on possible investment causes risk because the schedule is pressurized.
PB11 9: By not timely informing government officials or stakeholders of a proposed project or plan, political or public resistance can be generated.
PB12 10: The only client is a government, so the market is dependent on what their views on sustainability and innovation are.

### Economic

EcB1 1+2+4+5+6+8+9+10: Connecting PV to the grid can be costly.
EcB2 1+1+0: Business case is meagre when a project is exploited through PCR.
EcB3 1: From a financial point of view it's not necessary to add PV to a road to generate income.
EcB4 1+4+10: Yields are not high enough when compared to traditional solar fields.
EcB5 5: When a project is financed by multiple actors (province and state for example), complexity is increased.
EcB6 3+4+5+7: When a project is not big enough there is not enough budget (without subsidies) to complete an innovative regional project.
EcB7 3+4: Procurement is focused on the lowest price, which means firms aggressively compete.
EcB8 4+6+7: Transaction costs for a competitive dialogue are high and often not worth the effort for small projects.
EcB9 6+8: If you involve a third party (like a cooperation), you are getting another management club involved, leading to extra costs.
EcB10 4: SME's are often just subcontractors and therefore do not have enough power within a project to actually implement high innovation rates.
EcB11 5+: Parallel project design trails involve higher costs.
EcB12 7: If you put a contractor in charge of just the building phase, you have to create an additional incentive to reduce maintenance and operation costs, or a big risk budget has to be created.
EcB13 7+10: Fear of a vendor lock-in.
EcB14 9: An energy provider is obliged to stick to N-1 redundancy policy and requires the PV installation to be able to deal with peak electricity, both causing a project to be more expensive.
EcB15 8: If acreage needs to be bought to realise a project, the project is delayed and will turn out more expensive.

### Social

SB1 1+2+4+8+10: Project specifications can be influenced dependent on the responsible individual (political agenda).
SB2 3+7: By implementing subcontracts (SME) you are dependent on the relationships between different (sub)contractors and contracts.
SB3 4: Local governments are better at managing the environment, it's not certain that the market provides the best value-for money for that part of a project.
SB4 2+4+5+6+10: The building sector is not innovative enough.
SB5 7: A government official with no experience in the field of dialogue and consultation might not know how to behave correctly.
SB6 9: There is no clear indicator on exactly when to engage stakeholders into a project, it comes down to experience and finesse to judge a situation.
SB7: 9: Despite all good intentions, some local energy initiatives lack knowledge, capacity and professionalism to positively contribute to a project. When the project grows, these shortcomings also increase.

### Technological

TB1 1+3+5+8+10: Sustainability is a catch-all term, broader than the integration of PV. Criteria on sustainability are taken into account in projects but on other grounds. Next to that, local communities ca not grasp the phenomenon or are tired of hearing about sustainability.

TB2 1+5+6+10: Cold feet for unproven technologies.
TB3 2+5: Not much yield is to be made when the generation of renewable energy is just limited to make the object (the road or individual lighting/bridge) energy neutral.
TB4 3+8: Technology develops in such a high pace that technologies quickly become obsolete and not fully profitable.
TB5 4: There should be a threshold within the maintenance contract on replacing the panels when the yields become higher.
TB6 6+9+10: Grid providers have not got the capacity to deal with all requests for renewable energy projects, this can cause a delay in integrated projects.
TB7 10: Energy demands require grid stability. PV does not provide that desired stability, increasing risk.

### Environmental

EnB1 1+3+7+8: Everything you add to a road has a spatial impact and adds complexity if you want to incorporate it into a plan.
EnB2 1: If no major projects are planned in the near future, the chances of efficiently implementing PV into an infrastructure project are limited and thus no need to develop special policy for combining these functions.
EnB3 1: Some roads have a historic character that will be negatively affected once you add PV.
EnB4 3+5+6: Local context differs from project to project, so it's necessary to make considerations based on the characteristics of each individual project.
EnB5 2+4+5: The scope of projects remains too limited when the goal of added PV is to make the object itself energy neutral. Therefore the attention towards PV/combining functions stays behind.
EnB6 5+7+9: PV installations can interfere with the safety of road users.
EnB7 9: It is difficult to cluster or combine different renewable energy projects that can make use of the same connection to the grid.
EnB8 10: Incorporating flexibility in a project has consequences for time scales and increases risks.

### Legal

LB1 1+3: As a province you cannot express preference when making the exploitation of PV on governmental acreage available.
LB2 1+5+10: When you want to include a third party to exploit the generated energy it takes a lot of administrative effort.
LB3 2: Provinces and municipalities are afraid private actors will make high price bids when MEAT-criteria are too open.
LB4 2+6+7+10: When you provide power to the grid as a province or municipality you become an energy provider, which is prohibited by law.
LB5 2+4+10: For innovation-oriented procurement methods the lowest price is decisive, private actors know that and make low bids despite MEAT.
LB6 2+9: The project initiator is not sure how the project will unfold or which solutions the market has to offer, so they do not know how to specify their questions and cannot take that into account in your tendering procedure.
LB7 3+4: Subcontracts increase costs when interface control is not 100%.
LB8 3: Project characteristics should be suited for early market involvement.
LB9 1+2+4+6+7+10: Provinces and municipalities have not got enough knowledge and expertise in forms of different contract types and procurement methods (and how they translate to practice) to put an innovation-oriented project on the market.
LB10 4: When a DBFM-contract is chosen, a governmental organization becomes (too) dependant on the market.
LB11 7+10: You cannot use innovative ideas from a party that did not get the project awarded to them
LB12 7: EMVI does not automatically mean quality is the main criterium. It's either BVP, LCC or lowest price.
LB13 7: In an (early) consultation phase you can only test tenders, you cannot judge them yet.
LB14 9: In order to realise the project on a desired location owned by a different party, the owner of the plot has to agree.