Master thesis

Disparities in investment cost of renewable energy technologies

A case study exploring solar PV projects within the SDE+

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Colophon

This thesis is written as part of the master Sustainable Development, track Energy and Materials. Research was carried out during an 8 months internship at Planbureau voor de Leefomgeving (PBL), located at The Hague.

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Summary

Renewable energy technologies (RETs) have reduced in costs due to learning and economies of scale. Despite this, a wide range of investment costs (euro/kWp) is observed for these technologies. The aim of this thesis is to identify the causes for disparities in investment costs based on the costs which investors indicate to need for their RET investment.

To identify the causes for disparities, this thesis focuses on photovoltaic solar projects in the Netherlands for which subsidy (SDE+) was requested. Interviews were conducted with SDE+ applicants, which were divided into sub-groups consisting of projects with low, average and high costs. Additionally, intermediaries that are hired by SDE+ applicants to assist with the application were interviewed as well.

The results indicate that the most important cost-increasing[1] factors are the grid connection, differences between buildings and the PV technology considered for the cost estimation. The most influential cost-decreasing factors are the do-it-yourself approach, the search for cheaper options, and experience from previous projects. Other factors, such as the cost components which are included in the cost estimation, the orientation of the panels, the PV mounting system and roofs with shadows have a small impact on the disparity in investment costs. Additionally, some investors found higher payback periods acceptable as for them the benefits of being seen as a green energy producer exceeded the financial considerations. This factor was found to have a small impact on disparities. There are also differences between intermediaries and investors. According to the investors, the reported investment costs reflect their actual costs, while intermediaries stated the contrary. Additionally, investors made project-specific cost estimations, while some intermediaries stated to use a standard cost estimation for different projects. If and how much this differs in case specific cost estimations would be given is not analyzed in this research. Consequently, the impact of the difference in used methods for the cost estimation, the role of the intermediary and the reliability of the self-reported costs on the disparities remain uncertain.

Given these findings, it is recommended to reduce information search costs for investors and to draw more information from investors regarding the build-up of the total costs. As the impact of certain factors could not be explained, the use of the investment costs reported by the investors might need careful interpretation when used for determining SDE+ base rates.

[1] Cost-increasing is defined as higher costs compared with the average costs.

Samenvatting

Als gevolg van leren en schaalvoordelen, zijn de kosten voor hernieuwbare energietechnologieën gedaald. Desondanks wordt er voor deze technologieën een spreiding in investeringskosten (euro/kWp) geconstateerd. In deze thesis worden de oorzaken van de spreiding in investeringskosten die investeerders aangeven nodig te hebben geïdentificeerd en toegelicht.

Voor het verklaren van de spreiding in investeringskosten, richt dit onderzoek zich op fotovoltaïsche zonne-energieprojecten in Nederland waar subsidie (SDE+) voor was aangevraagd. SDE+ aanvragers werden geïnterviewd, waarbij ze werden onderverdeeld in drie subgroepen op basis van de aangegeven kosten behorend bij hun project, namelijk laag, gemiddeld en hoog. Ook zijn intermediairs die door SDE+ aanvragers worden ingehuurd om de aanvraag voor te bereiden geïnterviewd.

Uit de resultaten blijkt dat de belangrijkste kostenverhogende[2] factoren, de kosten voor de grootverbruikersaansluiting, verschillen tussen gebouwen en de gekozen PV-technologie zijn. De belangrijkste kostenverlagende factoren zijn de doe-het-zelf benadering, zoektocht naar goedkopere opties en ervaring door voorgaande projecten. Andere factoren zoals de meegenomen kostencomponenten in de begroting, de oriëntatie van de panelen, het PV-montagesysteem en daken met schaduw zijn van kleine impact op de spreiding in investeringskosten. Verder vonden sommige investeerders een hogere terugverdienperiode acceptabel. Dit kwam doordat deze investeerders een grotere interesse hadden in een duurzame imago, waardoor de financiële overwegingen niet meteen de prioriteit hadden. De impact van deze factor bleek klein te zijn. Verder verklaren de investeerders dat de opgegeven investeringskosten de werkelijke kosten weerspiegelen, terwijl de intermediairs het tegenovergestelde van mening zijn. Daarnaast bleken investeerders projectspecifieke begrotingen te maken, terwijl sommige intermediairs aangaven één standaardwaarde te gebruiken om een kostenindicatie voor verschillende projecten in beeld te brengen. Indien en hoeveel dit verschilt in het geval dat specifieke begrotingen gemaakt zouden worden is niet onderzocht. Als gevolg hiervan blijft de impact van het verschil in gebruikte methoden voor de kostenindicatie, de rol van de intermediair en de betrouwbaarheid van de opgegeven kosten onduidelijk.

Gezien de resultaten, wordt het aanbevolen om de zoekkosten voor investeerders te verminderen en meer informatie van investeerders te verzamelen qua opbouw van de totale kosten. Aangezien de impact van bepaalde factoren niet is verklaard, zou rekening gehouden moeten worden bij het gebruik van deze kosten voor de bepaling van de SDE+ basisbedragen.

[2] Kostenverhogend is gedefinieeërd als hogere kosten ten op zichte van het gemiddelde.

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List of abbreviations

BIPV	Builing Intergrated Photovoltaic
BOS	Balance of the System
DSO	Distribution System Operator
ECN	Energieonderzoek Centrum Nederland
FiP	Feed-in-Premium
FiT	Feed-in-Tariff
(k)Wp	(kilo)watt-peak
MEP	Milieukwaliteit van de Elektriciteitsproductie
PBL	Planbureau voor de leefomgeving
PV	Photovoltaic
RETs	Renewable Energy Technologies
RPS	Renewable Portfolio Standard
RVO	Rijksdienst voor Ondernemend Nederland
SDE+	Stimulering Duurzame Energie

1. Introduction

1.1 Background

To facilitate a transition towards sustainable economic development, utilizing renewable energy is vital (Lehmann & Söderholm, 2017). In comparison with fossil fuels, renewable energy allows for reduced greenhouse gas emissions, which is key to combatting climate change (Pineda, Boomsma & Wogrin, 2018). To make the energy production more sustainable and to lower the dependence on fossil fuels, the EU has set a target at 20% final energy consumption from renewable energy in 2020 through the Renewable Energy Directive 2009 (European Commission, 2018).[3] To achieve this, the 20% target has been translated to binding agreements for each member state (European Commission, 2018). Government interventions play a key role in achieving these targets because while several Renewable Energy Technologies (RETs) have made considerable progress, others have not yet reached their maturity level nor an adequate level of economic performance (European Commission, 2018; Lehmann & Söderholm, 2017). Additionally, their weather dependent production can sometimes prevent them from being completely competitive in a liberalized electricity market (Pineda et al., 2018). Therefore, to achieve these targets and to compete with fossil fuels, RETs often need renewable energy support schemes (Lehmann & Söderholm, 2017). By creating these incentives for renewable energy producers, technical change and the learning process are stimulated which enables costs to be brought down to a level where it is economically competitive (Menanteau, Finon & Lamy, 2003). Hence, virtually all EU member states have employed renewable energy support schemes (Lehmann & Söderholm, 2017).

Renewable energy support schemes are classified into price-based support schemes and quantity-based support schemes. Currently, most of the price-based support schemes are feed-in-tariffs (FiT) and to a limited extent, feed-in-premiums (FiP) (Pineda et al., 2018). FiT is characterized by a fixed price, while FiP can be either fixed or dependent on the market electricity price (sliding FiP) (Alberici et al., 2014). In the FiT scheme, energy suppliers or energy distributors are obliged to purchase renewable energy at production costs. In the FIP scheme, the electricity generated by the producers is sold on the market by themselves for which they receive a government premium to cover the difference between the market price and the price for fossil-based energy (Roelofs et al., 2015). Most quantity-based schemes are Renewable Portfolio Standards (RPS) (also known as quotas) combined with tradable green certificates, for which certificates are obtained for each produced MWh. These renewable energy support schemes are important for increasing the production of renewable energy (Mignon & Bergek, 2016; Pineda et al., 2018).

1.2 Problem definition and knowledge gap

Given the rapid growth of RETs, there have been efforts to track developments in the markets and to improve understanding of changes in costs and price trends over time (Davidson & Steinberg, 2013). Generally, renewable energy support instruments such as FiT and FiP, rely on several parameters such as the investment costs, operation and maintenance cost, interest rate and expected return on

[3] In 2018, the commission, the parliament and the Council have reached a political agreement for a new binding target of 32% final energy consumption from renewables in 2030 (European Commission, 2018b).

equity to determine the tariff levels (Klein, Held, Ragwitz, Resch & Faber, 2010). To track the investment cost for PV systems, policy makers rely on market information which usually consist of self-reported data. For instance, in the U.S., the Lawrence Berkeley National Laboratory (LBNL) gathers information on solar PV investments from project-level data reported to state agencies and utilities that administer PV incentive programs, solar renewable energy credit (SREC) registration systems[4], or interconnection processes[5] (Barbose et al., 2017; Davidson & Steinberg, 2013). The collected data contains costs indications of PV projects that are self-reported by installers and consumers and are used for tracking the PV developments within the U.S. market (Nemet et al., 2017a). Based on the solar PV cost information gathered by institutions such as LBNL, studies have been conducted that indicate that amid the rapid decline of the mean costs, there is also considerable heterogeneity in these costs (Nemet et al., 2017a). For instance, Goodrich, James & Woodhouse (2012) conducted research on the disparities in investment costs of PV systems in the U.S. Regional and site-specific cost factors were stated to be responsible for significant variations in costs. For instance, the wide range of labor rates in the U.S. and installer productivity (experience) can have an impact on the installation costs varying from 5-8%. Additionally, New Jersey which has one of the lower priced markets in the U.S. had 18% lower median residential investment cost compared with California, which is one of the higher-priced market in the U.S (Seel, Barbose & Wiser, 2014). The study also showed that the overhead costs differ depending on whether the PV system concerns a residential rooftop, commercial rooftop or whether it is a ground-mount utility system. For residential systems, the cost increase from the retail price can be up to 30%, while for commercial systems and utility systems the costs can increase up to respectively 20% and 10% from the retail price. The lower costs for utility systems stem from more efficient supply chains and economies of scale (Goodrich et al., 2012). More recently, Nemet et al. (2017a), investigated characteristics of the lowest priced PV systems (the lowest 10th percentile). The study found that low-priced systems are associated with experienced installers, markets with few active installers, customer ownership, large systems, retrofits, thin-film and Chinese modules (Barbose et al., 2017). These studies help in getting a better understanding of why the total PV costs still remain high (and did not reduce with the same pace as the module costs) despite the reduction in module costs. Additionally, they help explain why differences in costs depending on the case are noticed.

Although these studies can explain possible disparities in investment costs, their link to renewable energy support schemes is not well-addressed as the main focus is on the involved costs in solar PV systems such as in the studies by Nemet et al., (2017a), Goodrich et al. (2012) and Seel et al., (2014). Furthermore, studies focusing on dealing with unharmonious information (i.e. the investment costs in this case), its implications on renewable energy support schemes while considering the investors' perspective are not yet well-explored in the scientific field. In previous research quantitative analysis were used to identify reasons for disparities. However, no study has been found which includes the investors' perspective. This is surprising considering the key role of investors in this problem. Inability in tackling disparities in investment costs may lead to less effective support schemes as well as a shaken confidence of investors due to unsatisfactory financial support. Identifying reasons for

[4] An SREC is a credit that can be earned from produced renewable energy and is a tradable commodity. To meet RPS standards, electricity providers must obtain SRECs. An SREC registration system, registers the solar PV projects which will be started (New Jersey's Clean Energy Program (NJCEP), 2018).

[5] Interconnection standards are a set of requirements for utilities and PV investors in the U.S. which mandates how renewable energy systems can be legally connected to the electricity grid (NREL, 2018).

the disparity in investment costs may also lead to getting better insights into whether information on renewable energy projects provided by investors are reliable to use for policy makers. Although other countries also rely on self-reported financial information, the reliability of this information has not been questioned in previous studies. This research will therefore assess the reliability of self-reported financial data as well as explain disparities in costs which exist. Hence, this research will aim to bridge this knowledge gap.

1.3 Research objective and research question

In line with the problem definition and knowledge gap, the research objective is to identify and explain the causes for disparities in investment costs which investors claim to need for their RETs investment. Additionally, recommendations will be proposed on how to tackle these disparities. This leads to the formulation of the following research question:

"What causes disparity in investment costs of renewable energy technologies and what does this mean for renewable energy support systems?"

In order to answer the main research question, this research will focus on the investment costs disparities prevalent within the Dutch FiP scheme (referred to as Stimulation of Sustainable Energy Production/ Stimulering Duurzame Energieproductie (SDE+)) for the category "solar photovoltaic (PV)". Beurskens and Lemmens (2017) conducted and published a data analysis of the investment costs of 2060 investors in solar PV (see Figure 1)[6]. This figure shows the range (minimum and maximum values) in specific investment costs (in euros/kWp) per project category indicated with black lines, while the majority of the projects are in the blue boxes, where also different ranges are seen per project category. In this context, the investment cost is understood as the cost an investor indicates to need for their PV project. As Figure 1 depicts, relatively less disparity is observed with project sizes larger than 250 kWp, which might be the result of economies of scale and experience related cost reductions (Goodrich et al., 2012). Economies of scale may be associated with price reductions on volume purchases and the ability to spread fixed cost over larger installed capacities (Barbose et al., 2015). However, the investment costs for project capacities smaller than 250 kWp show large disparities.

[6] The number of applications per sub-category can be found in Appendix A.

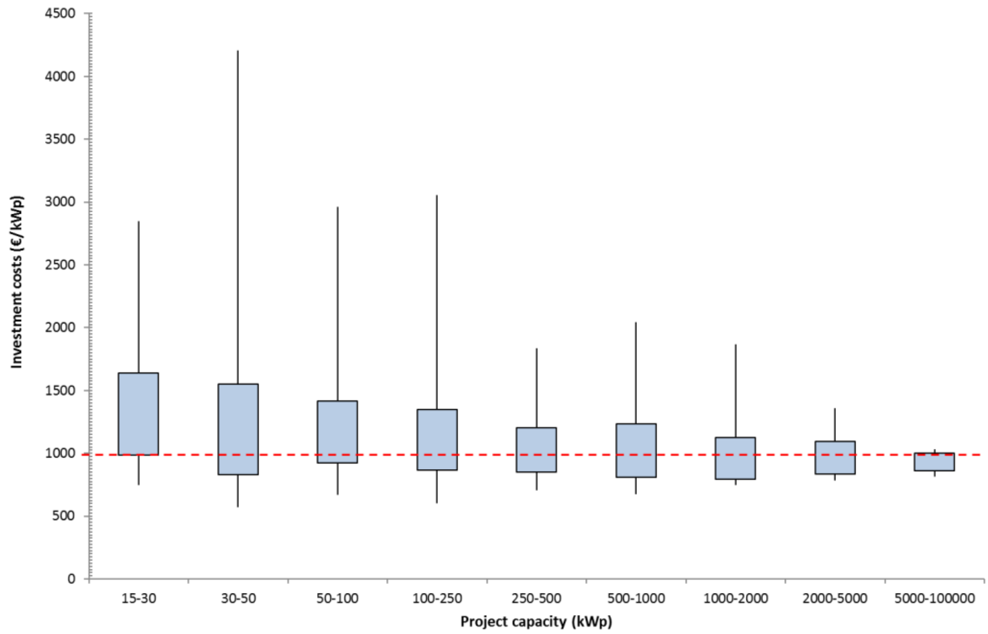

Figure 1. Investment costs of solar PV projects according to their project size (autumn application round 2016). The blue bars depict the range between the median and the standard deviation with the vertical lines depicting the dispersion between the minimum and maximum values. The red dotted horizontal line indicates the specific investment cost of the reference installation for the SDE+2017. *Source: Beurskens & Lemmens (2017).*

The presence of disparities in costs imposes a problem because for the preparation of the subsidy advice in the Netherlands, information from the market is collected which consists of information that investors provide to the Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland (RVO)). This information is used to characterize a reference system for each RET, based on which the subsidy rates are determined (Lensink & Cleijne, 2016). The technical-economic parameters for a reference system (e.g. project size, debt-equity ratio) are selected so that they reflect the majority of the projects. The investment costs of the renewable energy projects are also part of the information which firms provide to RVO when applying for subsidy. Based on the investment costs which the majority of investors claim to need, a range for the investment costs of the reference system is determined. The final investments costs used for determining the base rates lie within this range. Additionally, the final value of the investment cost for the reference system is determined by other parameters as well such as the learning rate and other market developments (S.M. Lensink, personal communication, April 24, 2018).

Given that this thesis focuses on disparities found within the SDE+ category "solar PV", the following sub-questions are formulated to facilitate answering the main research question:

1. Which factors lead to high projects costs?
2. Which factors lead to low project costs?
3. Which factors are leading to disparities according to intermediaries?
4. Which strategies are there to address the investment cost disparities?

1.4 Scientific relevance

From a scientific perspective, this research will provide useful insights into the factors that can cause renewable energy investments to differ among investors. In section 1.2 it was already mentioned that disparities in costs for solar PV are not only prevalent in the Netherlands. This research will thus provide useful insights as currently limited research on this is done and the research on this focused only on disparities in the U.S, where other factors such as regional labor costs and state and federal policies might play a bigger role than in a country such as the Netherlands (Gillingham et al., 2016). The markets also differ from each other. Therefore, by presenting the problem from a different country might lead to new insights regarding the causes for disparities.

1.5 Social relevance

Commitment, stability, reliability and predictability are aspects that aid the confidence of investors and influence the decision-making process of an investor whether or not to invest in a certain technology (Masini & Menichetti, 2012). As mentioned before, to ensure that RETs are deployed and investments by the investors are made, subsidy schemes can be useful. However, the link between renewable energy investments and renewable energy support schemes is not so straightforward. For instance, although they positively influence each other, support schemes can also pose as a risk factor. When policies and support schemes change, or even worse are ended, the profitability of investments is put at risk (Masini & Menichetti, 2012). Therefore, a good working subsidy scheme is relevant for the current and future renewable energy investors. Providing adequate and sufficient stimulation to these investors is crucial considering that they are important for achieving a transition towards a more sustainable energy system (Mignon & Bergek, 2016). A staggering renewable energy development as a result of insufficient renewable energy incentives will result in a society which is less sustainable. To do so, the proper design of the scheme is essential to boost confidence and security in investing in RETs (Couture & Gagnon, 2010). By achieving a better understanding of what causes the investment cost for one PV project to be higher than another, this research may exert its social influence. This research may also contribute in attaining a better understanding of the extent to which the information from SDE+ investors are reliable. This can be useful for evaluating whether future subsidy tariffs can rely on this information.

1.6 Reading guide

Chapter 2 contains the theoretical background. The first section explains in general terms how the SDE+ works and how the subsidies are determined. This section also describes the renewable energy support schemes put in place prior to the SDE+. The second section presents a literature review of possible causes for the disparities in investment costs.

In chapter 3, the method used in this research is described. It is described why and how 3 groups of investors, investors with high costs, low costs and average costs, are selected. The motivation for choosing the selected method is provided.

In chapter 4, the results containing the main factors leading to disparities within the SDE+ category “solar PV” are presented and discussed. The chapter first presents the reasons for high project costs and low project costs. These results are presented in the form of statements made by investors as well as the practical examples they provided on their past projects. Statements of investors with average costs are also incorporated where relevant.

In chapter 5, the methodological limitations are indicated. This chapter additionally contains recommendations for further research and some suggestions for policy makers are provided as well.

In chapter 6, the conclusion of this research can be found.

2. Theoretical background

This chapter contains two parts. The first part looks into the renewable energy scheme of the Netherlands, known as the SDE+. The second part of this section presents the factors leading to disparities based on a literature review.

2.1 Renewable energy support in the Netherlands

In this section, the SDE+ is introduced. Relevant background information is provided and the working mechanism of this subsidy scheme is explained.

2.1.1 Introduction to SDE+

In 2003, the Environmental quality of the Electricity Production (MEP) was introduced in the Netherlands. MEP was aimed at providing firms with long-term subsidies up to ten years. In this scheme, there was no maximum on the subsidy budget for renewable energy investors (Niesten, Jolink & Chappin, 2017). This scheme has been effective till 2006[7]. Between 2006 and 2008, no renewable energy support scheme was present in the Netherlands. In 2008, the MEP scheme was replaced by the SDE. The SDE was characterized by budgets per renewable energy category. Due to high subsidy applications for wind energy and solar energy, the budgets allocated to these categories were completely run out, thus not every SDE+ applicant could receive subsidy. On the other hand, the budgets for other categories were not utilized (Roelofs et al., 2015). After the SDE, the current renewable energy support scheme of the Netherlands, the SDE+, is introduced in 2011 (Niesten et al., 2017). For this scheme, one budget is available for all technologies combined except for mono-digestion of manure and offshore wind which have a separate budget as well as application procedure (RVO, 2018a; RVO, 2018b). Tender applies for these categories as the Ministry of Economic Affairs and Climate is of the opinion that these technologies would not be developed at all or on time without a tender (Roelofs et al., 2015).

The budget which is reserved by the Ministry, are commitments. This is the maximum budget which can be spent on subsidy expenditures for renewable energy projects. The commitments can differ from actual expenditures. The SDE+ can be differentiated in several aspects from its predecessors. MEP only addressed electricity production from renewable energy sources, while the SDE included biogas production as well. The SDE+ also supports the generation of heat from renewable sources and considers fluctuations in energy prices which the MEP did not take into account. The latter means that investors receive fewer subsidies when the energy price increases and vice versa (see Figure 2). This is incorporated to avoid overstimulation. Overstimulation occurred in the past when energy prices exceeded the forecasts which were used to determine the fixed subsidy amount (Roelofs et al., 2015). For instance, in the MEP, the average of the electricity price for 10 years ahead was taken into account. In the same year of the forecasts (2004), the energy prices were low. However, in the period before the economic crisis in 2008, there was an economic boom leading to high electricity prices. As a consequence, the expected revenues from electricity sales which the government calculated were much lower than actual profits from the electricity sales on the market

[7] Although MEP was halted in 2006, the projects for which subsidies were requested prior to 2006 still continued to receive subsidies.

by renewable energy investors. This resulted in high profits for the investors (S.M. Lensink, personal communication, February 2, 2018). As mentioned before, in 2006, MEP was abruptly halted. The MEP was formally said to be halted because the Ministry stated that the 9% renewable target of 2010 would be met and therefore, no MEP subsidies would be provided for new projects (Minister van Economische Zaken, 2006). However, after a year, research was published by the Algemene Rekenkamer (2007) in which it was revealed that the MEP had several shortcomings. One of these shortcomings was that the government had difficulties in estimating the budgets needed for the coming years as it got out of hand (Algemene Rekenkamer, 2007). Overstimulation through MEP led to a lack of faith, and thus a lack of commitment in the subsidy scheme (S.M. Lensink, personal communication, September 28, 2018).

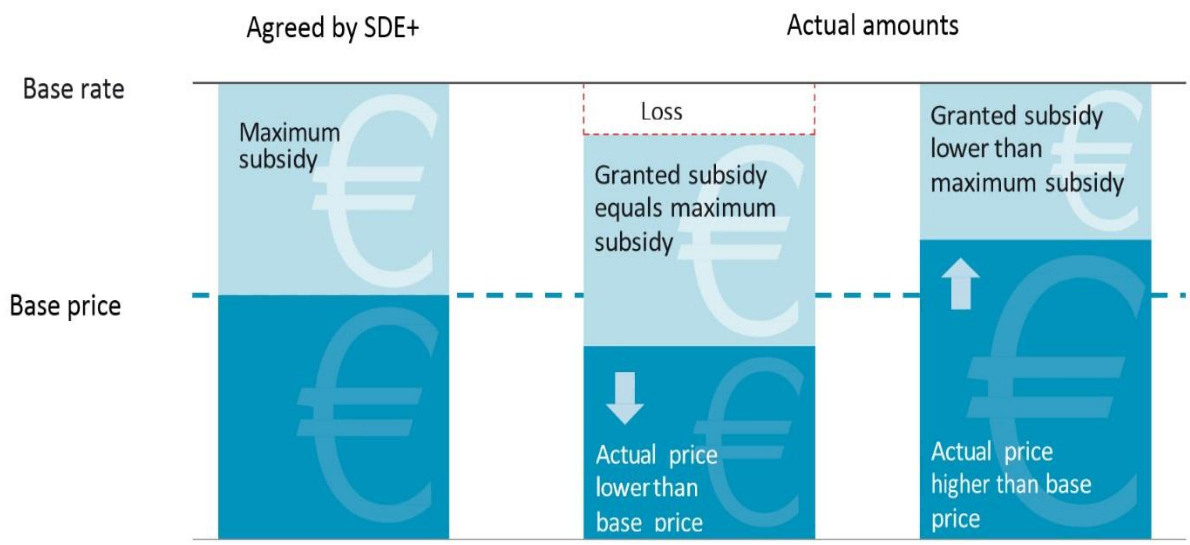

Figure 2. Subsidy variation based on energy prices. *Source: Roelofs et al. (2015)*

Currently the SDE+, together with the tender for mono-digestion of manure and offshore wind, are the most important renewable energy support schemes implemented to achieve the renewable energy target of 14% in 2020, which is the target of the Netherlands based on an agreement made within the EU as well as the Netherlands' own target of 16% renewable energy in 2023 (Roelofs et al., 2015).

2.1.2 Features of the SDE+

The SDE+ is a sliding FiP system, meaning that producers receive an additional payment on top of the market price for the production of renewable energy which varies depending on the market electricity price development (see Figure 2; International Energy Agency (IEA), 2018). Additionally, renewable energy producers have to sell their electricity on the market themselves (Alberici et al., 2014). The SDE+ is targeted towards companies and (non-profit) organizations that are interested in producing renewable energy such as farmers, horticulturists, power companies, local authorities, and businesses (Roelofs et al., 2015; RVO, 2018c). As the price of producing renewable energy is currently higher compared with fossil fuels, it is not profitable for investors. SDE+ thus subsidizes the difference between the cost of renewable energy production (base rate) and the market value of energy (correction rate). Since 2018, for the category solar PV, a distinction is made between electricity which is fed into the grid (referred to as "grid delivery") and electricity not delivered to the grid (referred to as "self-consumption"). Hence, solar PV has two correction rates. Solar PV also has two base rates: one for a category between 15 kWp and 1 MWp and another one for a category equal and larger than 1 MWp (RVO, 2018c). The SDE+ base rates are calculated using a "financial gap model" (onrendabele top model) from the Energy research Centre of the Netherlands (Energieonderzoek Centrum Nederland (ECN)) which is transferred to PBL as of January 2018. This model is a spreadsheet based cash flow model and can be seen in ECN (2018a). The base rate of the SDE+ applies to the entire duration of the subsidy. The duration of the subsidy is dependent on the technology in question (RVO, 2018c). To estimate the base rates over the period of 15 years, the expected cost reductions are included based on historical learning curve analysis and market projections (Beurskens and Lemmens, 2018a). As mentioned before, for each category, a reference installation is defined based on which the base rates are calculated. The reference installation consists of a particular technology or combination of technologies combined with a typical number of full load hours (Lensink & Cleijne, 2016). The assumption for the reference installation for solar PV is "the cheapest but qualitatively sufficient PV panels available in the global market" (Beurskens and Lemmens, 2018a). The reference installation is selected so that it represents the majority of projects. For the SDE+2017, a project capacity of 250 kW was assumed as the reference (Lensink & Cleijne, 2016). This is adjusted with SDE+2018 as there are two base rates for solar PV and therefore two reference systems. The reference system does not include all possible costs, such as additional costs needed for building integrated PV systems. To be able to receive the SDE+2017, the applicant should provide the quotations for solar PV panels and other parts within one year to proof that they are implementing the project. To adjust for this one year, the calculations, for instance for the SDE+ 2017, are based on the expected price level in 2018 (Beurskens and Lemmens, 2018a).

The correction rates are calculated twice per year: in spring and autumn. In autumn the provisional correction rates are determined for a year ahead and the final rates of the previous year are announced in spring. The provisional rates are used for the advance payments of the SDE+, while the final rates are used for the full payment of the subsidy over the elapsed year[8] (ECN, 2018b). This means that the ultimate subsidy payments are calculated each year depending on the amount of energy produced and the actual energy price (RVO, 2018c). The correction rate is determined differently for each category. In the case of solar PV (≥ 15kWp), the correction rate for grid delivery is determined by the $APX_{base\ load}$ multiplied by the profile factor. For self-consumption, the correction rate is determined by the $APX_{base\ load}$ multiplied by the profile factor plus the energy tax (Lensink & Van Zuijlen, 2015). The correction rate also has a lower-limit called base (energy) price. This value is set at 2/3rd of the expected correction rates, based on the long-term development of the energy prices (Lensink, Wassenaar, Mozaffarian, Luxembourg & Faasen, 2013). This is a cap on the subsidy level which is put by the government if the market energy price drops below a certain level. The risk of this is borne by the renewable energy investors (Roelofs et al., 2015). Whenever the calculated correction rate for any of the categories is lower than the base energy price, then the correction rate equals the base energy price. The base energy price is also determined per category and similar to the base rate, it applies for the whole subsidy duration (Lensink, 2016b).

[8] Note that the actual final settlement of the SDE+ subsidy will only take place after the end of the subsidy period.

The Ministry of Economic Affairs and Climate Policy asks since 2018, PBL[9], supported by ECN (which is part of the Netherlands Organization for Applied Scientific Research (TNO)) and Det Norske Veritas Germanischer Lloyd (DNV GL) advice on the SDE+ base rates each year (Beurskens & Lemmens, 2018b). A market consultation phase is organized by PBL where the Ministry and various parties react to the SDE+ rates and the concept advice. These reactions are used to come to a final advice (Lensink & Cleijne, 2017a). At the end of the year, the Ministry decides the categories which will be opened up and the associated base rates (Beurskens & Lemmens, 2018b).

After opening up of the categories, investors can apply for subsidy and have to indicate the expected investment costs. This is done through an online application form. Other information which this application form contains can be seen in Appendix B. There are two rounds of SDE+ applications, which are divided into 3 phases. Each phase is subjected to a maximum phase rate. “Less expensive” technologies may apply for the subsidy in the first phase. The amount of subsidy applied for should be lower than or equal to the base rate for the technology in question. Subsidy applications lower than the base rate fall within the so-called “free category” and are included to support innovative investors (RVO, 2018c). Investors are encouraged to produce electricity at the lowest cost possible. For instance, firms may apply for the SDE+ in the first phase if they think that they are able to produce their renewable energy at a price lower than the one calculated by PBL on behalf of the Ministry. These SDE+ applicants (or investors)[10] will have a greater chance of their application being approved by doing so. If investors wait to submit their application in one of the later phases, then the possibility exists of the budget being run out (Roelofs et al., 2015). Regarding the SDE+ application, the investors can choose to prepare and submit it themselves or they can hire an intermediary to assist with part or the whole process. Hence, the investors can give the intermediary the responsibility (i) to only prepare and submit the SDE+ application, (ii) to assist the investor with the preparation and application until a final decision on the subsidy is made by RVO, or (iii) it can be chosen to place the entire responsibility of the whole subsidy duration on the intermediary (RVO, 2018d).

2.2 Disparities in investment cost

As mentioned before, one important information item investors indicate on their application form is the expected investment cost needed for their renewable energy investment. However, disparities in these investment costs are seen. To identify possible factors for disparities in costs of RETs, a literature review was conducted. The literature review consisted of (i) scientific articles from Scopus and the Web of Science database, (ii) governmental reports and (iii) reports from independent research institutions. The search covered titles, abstracts and keywords of articles and used combinations of the following key words: “investment cost”, “renewable energy”, “photovoltaic”, “disparities”, “causes” and “factors”. The first section will focus on PV cost differences between countries and the latter part will focus on the factors leading to disparities within one country.

[9] Prior to 2018, ECN was responsible for providing the advice.
[10] The SDE+ applicants will be referred to as the investors. This will be done to avoid any confusion as the SDE+ applicant can also be the intermediary.

2.2.1 Influencing factors across countries

Barbose et al., (2016), compared the total PV system costs per kWp between various countries. The findings show that costs for small non-residential PV systems (<500 kWp) in the U.S. are 65% higher compared with Germany, Australia (54%), France (50%) and 40% compared with Japan and France (Barbose et al., 2016). These differences in total investment cost among some countries can partly be attributed to non-module costs also known as the balance of the system (BOS) costs (Seel et al., 2014). The BOS costs include all remaining costs of a PV installation apart from the PV modules. While modules and other hardware items can be purchased at similar prices across countries, the BOS costs can vary among countries (Barbose et al., 2016). For instance, for small commercial PV systems, BOS costs accounted for 39% of the total system costs in Japan, whereas they accounted for 66% of the total system price in the U.S based on cost data of 2013 (Friedman, Margolis & Seel, 2016). Furthermore, the installation cost, which is one of the most important cost components of the BOS costs, is higher in the U.S. than in countries such as Germany, Australia, Japan and France (Gillingham et al., 2016). The differences in these costs may be partly attributed to differences in market size based on the theory that larger markets facilitate cost reductions through learning-by-doing and economies of scale which enables cost reductions (Barbose et al., 2015; Gillingham et al., 2016). This can explain why the total PV investment cost is higher in the U.S. than in Germany and Japan as the latter countries have a higher cumulative distributed PV capacity. However, Australia and France – which have both relatively lower costs than the U.S. – have a much smaller distributed PV market in absolute terms[11]. Therefore, other factors apart from the absolute market size can contribute to differences in PV system investment costs. These factors range from demographic variables, labor wages and building architecture to permitting processes. For instance, among demographic variables, household density was observed to positively correlate with the PV system costs. This might be partly explained by a demand effect as more densely populated regions may have a higher demand leading to an increase in costs. Another demographic variable, income is also found to positively correlate with system prices. This might be partly explained by a less-binding budget constraint for high-income households or a higher information search costs they may come to face (due to the perception of time as valuable) (Gillingham et al., 2016). Over the years, the wide range in investment costs for PV systems is narrowing. This can be attributed to a matured market with an increased competition among installers and vendors and by better-informed consumers. Additionally, the scale and experience of firms are important (Barbose et al., 2015). Firms in a particular country that have more experience in installing solar PV reduce the price of PV. This reduction is around 14% of the total system costs (Gillingham et al., 2016).

2.2.2 Influencing factors within one country

In section 1.2 it was mentioned that the system size of a PV project is an important aspect which can lead to disparities. Larger projects benefit from economies of scale and have consequently lower costs per Wp (Goodrich et al., 2012). However, there are other causes for the disparities if looked at a single country. According to Barbose et al., (2015), there is no single "cost" that characterizes the PV market, even within a single size category and country. The potential underlying causes for this are numerous such as project specific details and characteristics of the regional/local market (Barbose et al., 2015). In order to investigate factors that can possibly lead to disparities in costs, a

[11] If a per capita comparison is done, then Australia's market is larger.

literature review is conducted. Some studies have identified factors leading to disparities from contexts different from the one considered in this research. However, they can still potentially explain cost disparities in the case of solar PV investors. For instance, Nemet et al. (2017b) looked at disparities in costs which consumers have to pay for solar PV. From the literature review, the following factors are identified which can explain disparities in costs:

I: Technical factors

PV mounting system

The study by Goodrich et al. (2012) shows that the investment costs can differ depending on the PV mounting system. Ground-mounted systems have both an advantage and a disadvantage over rooftop installations. They can be advantageous as the available area is larger, which can increase the capacity. However, if it considers a small ground-mounted system, costs can increase due to additional costs such as security and site acquisition (Lensink & Cleijne, 2018b). Apart from the traditional mounting systems, a PV system can also be integrated into the building known as building integrated PV (BIPV) systems. BIPV systems also lead to a price increase (Nemet et al., 2017a). For instance, BIPV systems often include flashing[12] to ensure building protection from various weather conditions. However, the deployment of BIPV remains low compared with traditional PV systems (James, Goodrich, Woodhouse, Margolis & Ong, 2011). Another mounting aspect which can cause different levels of investment costs are PV tracking systems. As the optimum orientation changes throughout the day owing to the movement of the sun and on a seasonal basis due to changes in the height of the sun above the horizon, tracking systems can be added to the PV arrays to optimize the output (see Figure 3). A maximum PV output can be achieved when the solar panels are oriented perpendicular to incoming sunlight. These dynamic tracking systems can either be single-axis or dual-axis designs. A design with a single axis follows the daily east-west arc of the sun, while the dual-axis design follows the hourly east-west tracking as well as the seasonal north-south tracking (U.S. Energy Information Administration (EIA), 2013). Despite the increase in yields which these tracking systems provide, a recent review has indicated that in comparison with the additional electricity yield, the investment into these systems is not yet beneficial (Al-Rousan, Isa & Desa, 2018). For instance, the study by Gillingham et al. (2016) has shown that tracking can increase the price by almost 63%. Therefore, investors who choose PV tracking systems with the aim of increasing yields, while not considering the disadvantage it brings in terms of costs can have higher project costs per Wp. As of now, for rooftop installations, PV panels are placed in fixed racks on the roof tops. In case the roof is not already pitched at the local latitude angle, the power output of the system can be increased by tilting the racking to be closer to the latitude angle so that more sunlight can be captured. The PV system costs can also differ depending on whether it concerns latitude racking or flat racking systems. Systems with latitude racking are more expensive compared with flat racking systems as the former requires more hardware, assembly and labor to be involved. The flat-racked systems are less expensive, however the modules are also 20%-30% less efficient compared with latitude racked PV systems (EIA, 2013).

[12] Flashing refers to the additional materials used to cover and protect the roof, especially against leakage (James et al., 2011).

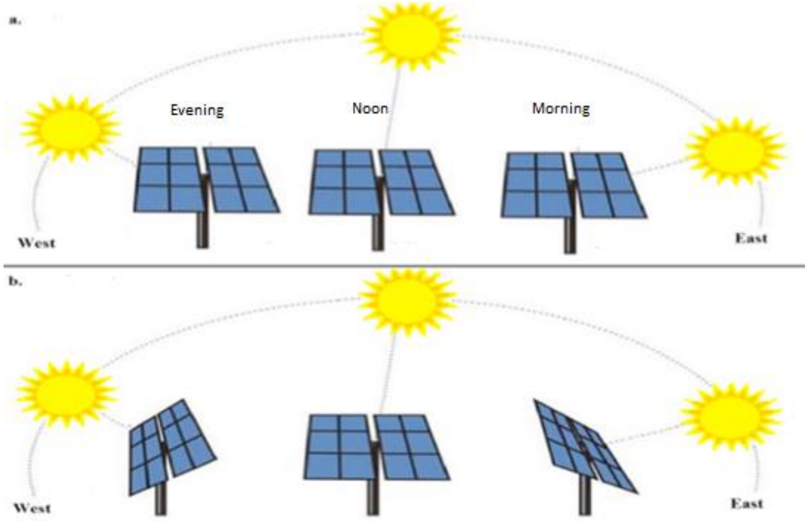

Figure 3. a) Solar PV system without a tracking system. b) Solar PV system with a simple East-West tracking system. *Source: Al-Rousan et al. (2018).*

PV cell technology

Several types of PV cell technologies are available on the market today (Barbose et al., 2017). They are usually classified into three generations based on the basic material used and the level of commercial maturity (IRENA, 2012):

- First generation PV systems: These are fully commercial and use the wafer-based crystalline silicon (c-Si) technology, which can be single crystalline (sc-Si), or multi-crystalline (mc-Si). These PV systems are relatively mature, have the best commercially available efficiencies and have a wide range of well-established manufacturers. Although the costs of the basic materials used for these technologies are relatively high, significant cost reductions occurred in recent years.
- Second generation PV systems: These are in the early market development stage and are based on thin-film solar cells. These technologies generally include 3 main types: (i) amorphous (a-Si) and micromorph silicon (a-Si/ μc-Si), (ii) Cadmium-Telluride (CdTe), and (iii) Copper-Indium-Selenide (CIS) and Copper-Indium-Gallium-Diselenide (CIGS). These technologies have low material and manufacturing costs, but also have lower efficiencies compared with the first generation PV systems. Their market share is limited and these PV systems are mostly used through utility-scale systems.
- Third generation PV systems: These include PV cell technologies that are still under demonstration and are not yet commercialized. They also include novel concepts under development such as concentration PV (CPV), dye-sensitized solar cells (DSSC) and organic cells. Among all the PV technologies, concentration PV has the highest possible efficiencies although it is not clear at what cost. The rest of the technologies are at the R&D stage and are low cost, low weight, or offer free-form shaping. However, they also offer low efficiencies (IRENA, 2012).

Hence, the choice of PV technology can also lead to different levels of investment costs due to the level of market maturity of the solar panel (Barbose et al., 2017).

Grid connection or expansion

Within the SDE+ category "solar PV ≥ 15kWp", a grid connection for large scale consumers is required to be able to apply for subsidy. This is a grid connection lager than 3 × 80 Ampere (RVO, 2018e). Costs for the grid connection can be very case specific. For instance, a solar PV system installation on a rooftop of a firm in an inhabited city will likely not require a new grid connection although upgrading it might still be necessary. On the other hand, a PV system which will be installed on a new or not yet constructed building will require a new grid connection (Fürstenwerth, Pescia & Litz, 2015). Hence, investors with buildings that do not yet have a grid connection and investors with buildings that need an expansion of the grid connection will have to make additional investments (RVO, 2018e). These costs are dependent on the capacity of the grid connection. Table 1 shows the grid connection costs for three distribution system operators (DSOs): Liander, Stedin and Enexis. It can be seen that there are some differences between the fees DSOs charge. As DSOs do not have competitors, the authority for consumers and markets (Autoriteit Consument en Markt (ACM), yearly determines the maximum prices each DSO is allowed to charge (ACM, 2018; HIER opgewekt, 2014). Therefore, DSOs cannot misuse their monopolistic position in the market (ACM, 2018). Apart from the one-time connection fee, investors have to pay periodic grid connection fees and electricity transport fees as well (HIER opgewekt, 2014).

Table 1. An example of grid connection costs between DSOs

	Capacity (c)	Grid connection costs (in euros)*	Costs for extra cable (in euros per meter)**
Liander	3 x 80A ≤ c ≤ 3 x 145A	4300	45
Stedin	3 x 80A ≤ c ≤ 3 x 125A	4115,15	46,10
Enexis	3 x 80A ≤ c ≤ 3 x 160A	2498	36,70

*Indicated prices are valid for 2018 and include a standard 25m cable for the grid connection. VAT is excluded. **Indicated prices are valid for 2018 and exclude VAT.

Source: Liander (2018), Stedin (2018) and Enexis (2018).

II: Methodological factors

Varying methods

To allow an investor to make the right decisions regarding the size of the investment needed for the project as well as the feasibility of the project, realistic cost estimations are fundamental (Torp & Klakegg, 2016). Using different methods for making cost estimation also tend to lead to different results (Sundqvist, 2004). For instance, some investors or intermediaries might assume one value for the total investment costs per kWp for different projects, while others might make project specific cost estimates (RVO, personal communication, March 30, 2018). Some firms may also use experience data from other projects to estimate their own cost (Hall & Delille, 2011).

The included cost components

Another factor which can lead to disparities is the extent to which all relevant cost components are covered in the cost estimation (Sundqvist, 2004). As mentioned before, the investment costs for solar PV investors consist of the PV module cost and non-module (BOS) cost. The PV module cost is determined by raw material costs e.g. silicon prices, processing/manufacturing of the cells and costs associate with the assembly of the module (IRENA, 2012). In the BOS costs, many cost components are included, such as the inverter[13], installation labor cost, permit and insurance fees, site acquisition and preparation costs—if it concerns a ground-mount system (IRENA, 2012; Goodrich et al., 2012). PV modules experienced a significant growth and internationalization of the manufacturing of it. As a result, modules have increasingly become a global commodity that can be purchased at very similar prices in the large and mature PV markets around the world. However, the BOS costs are difficult to determine since it is the product of various cost components and can therefore vary per project (Seel et al., 2014). Section 2.2.1 mentioned that around 66% of the total costs of commercial solar PV systems in the U.S. consisted of the BOS costs in 2013 (Friedman et al., 2016). A cost breakdown of these BOS costs reveal that several aspects are included for these costs such as racking (28%), site preparation (16%), supply chain cost (16%), structural and electrical installation (16%), inverter (14%), and wiring and transformer (8%) (IRENA, 2012). Although the BOS costs are lower in Germany, they still consist of a significant portion of the total costs estimated at around 53% in 2016 (see Figure 4). These BOS costs are also important because while the module costs have decreased over the years, the BOS costs have seen relatively less reduction. For instance, the modules used to consist of a large part of the total system cost at round 71% in 2006, which reduced to 47% in 2016 (see Figure 4). For larger PV systems, the module costs consist of a larger part of the total system costs as the BOS costs are spread over the project capacities (Wirth, 2018). Since the BOS cost are determined by various cost components, the set of cost components embedded in the total investment cost may vary across projects (Seel et al., 2014). Furthermore, investors that include all BOS cost in their total cost estimations, can have higher cost estimations. This can occur as there might be a difference in what the investors consider to be costs of solar PV. For instance, some investors might include aspects such as re-roofing costs in their estimation as from the investors' perspective they are part of his investment costs of "going solar" (Barbose et al., 2016).

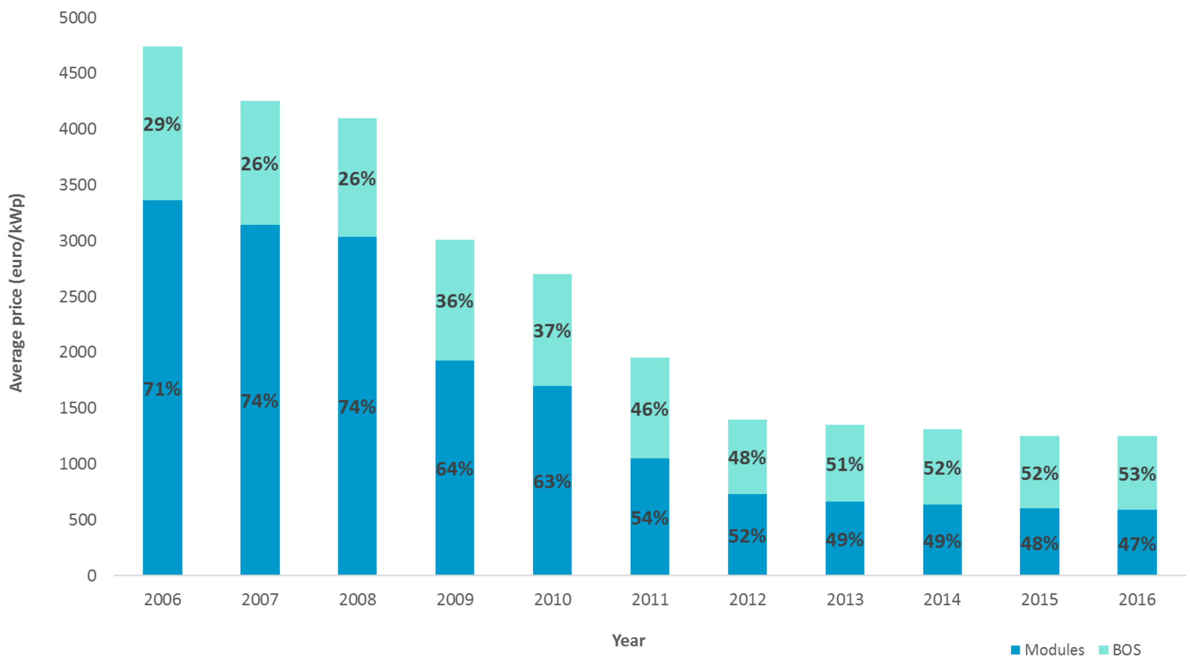

Figure 4. Yearly mean investment costs for solar PV rooftop installations concerning projects between 10kWp and 100kWp in Germany. *Source: Wirth (2018).*

[13] Converts direct current (DC) from the PV modules into alternating current (AC).

III: Situational factors

Role of the intermediary

As mentioned before in section 2.1, investors can assign intermediaries to assist with parts, or with the whole SDE+ application process. The intermediaries are usually consultancy agencies specialized in providing subsidy advice and assisting with sustainability projects (RVO, 2018d). Intermediaries might also have interests of their own (RVO, personal communication, March 30, 2018). According to RVO (2018d), some intermediaries can estimate high investment costs in order to increase their own payment which is based on the estimated investment costs and not the actual costs. Therefore, if an intermediary negotiates a percentage of the subsidy requested as payment (usually this is 5-15%), this may lead to the intermediary estimating high investment costs as they will receive a high payment afterwards due to this (RVO, 2018d).

Experience

Whether a firm is going to invest in renewables for the first time or has experience in it, can impact the investment cost estimations. Investors with previous installations benefit both from knowledge gained from experience and scale (Nemet et al., 2017b). However, this learning effect can work two-ways: while investors with experience can benefit economically due to knowledge and scale, this experience can also lead to the identification of more components where a cost is associated with. This can lead to higher total estimations (or a more correct estimation of costs) (Sundqvist, 2004).

IV: Uncertainty factors

Reliability of information

Uncertainties can also be accounted for in the cost estimations. Uncertainty is the gap between the information needed to make a decision in certain and the information actually available at the time of decision-making (Torp & Klakegg, 2016). According to Torp and Klakegg (2016) *s*ome investors can account for uncertainties in their estimations as (i) “they do not have all information about the future” and (ii) “assumptions they make today may come out differently in reality as the project progresses” (p.1). By taking the uncertainties into account, investors aim to make their profit acceptable (Goodrich et al., 2012). Projects also have a dynamic nature. For instance, despite that tools and methods which take uncertainties into account are implemented, in reality projects with cost overruns are seen time and again (Torp & Klakegg, 2016). Circumstances such as permitting delays, an unexpected rooftop or building features can contribute to cost overruns (Goodrich et al., 2012). On an individual level, people think differently about similar issues and they perceive and assess risks and uncertainties differently (Teigen, 1988). Therefore, disparities can arise when uncertainties are estimated and taken into account from the perspective of various investors. The difference in this perspective might affect the reliability. Furthermore, as the project is not started when investors make cost estimations, the accuracy of the estimated costs can be low. The accuracy changes when the project becomes mature and this is also when the investor has insights into the actual costs (Hall & Delille, 2011). This can lead to different investors making different estimations of investment costs (RVO, personal communication, March 30, 2018).

2.3 Synthesis of factors

Summarizing the theoretical review as presented in section 2.2.2, Figure 5 gives an overview of the possible factors leading to disparities.

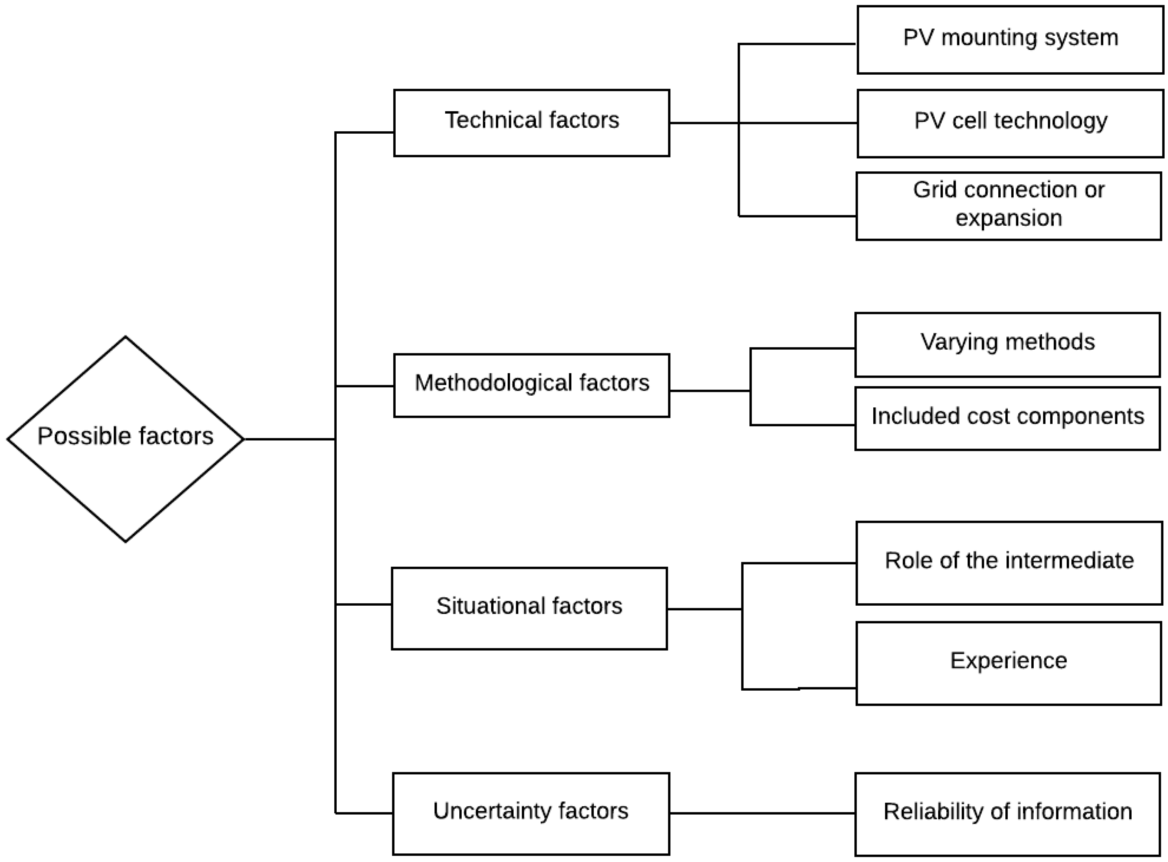

Figure 5. Synthesis of possible factors leading to disparities in investment cost.

3. Methods

While the literature review was presented in the previous chapter, in this chapter the research boundaries, data collection and analysis methods are described. Additionally, the reliability and validation of the results are described. Figure 6 shows the research framework. The development of this framework will be further explained in the next sections.

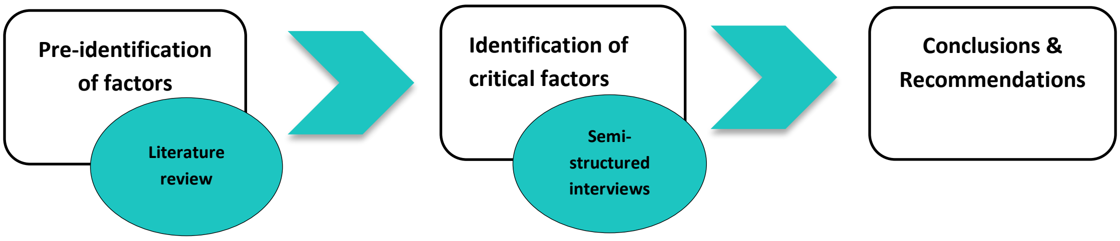

Figure 6: Research framework.

3.1 Research boundaries

This study focuses on disparities in investment costs seen within renewable energy projects of the Netherlands. The financial information of these projects is collected through the SDE+ scheme. This scheme has several categories as mentioned before, but this case study focuses on solar PV projects. A case study method is used as they (i) explore the real context in which the problem prevails making a better understanding possible and (ii) provide detailed empirical data which enables the possibility for an in-depth explorative analysis (Mignon & Bergek, 2016). Although disparities in investment costs are also found with other RETs, they are more prominent with solar energy. Therefore, this research will focus only on solar PV. For the autumn round of SDE+2017, the Ministry of Economic Affairs and Climate Policy granted support for 4215 projects with a total budget of 6 billion euros (Rijksoverheid, 2018). Around 38% of the budget came from solar PV. Solar PV also has the largest amounts of SDE+ applications with an overwhelming 94% (see Table 2). The implications of disparities in investment costs for solar PV investors will therefore be larger as a pool of SDE+ applicants will be affected by this. Despite the focus on only solar PV, this research will provide useful insights into explaining disparities in investment costs which could also help understanding disparities for other forms of RETs. The investment costs are particularly relevant in the case of solar PV as large upfront investments are required, but low operation and maintenance costs. This means that most costs are made upfront, before the system becomes operational. From an investor's perspective, this means a high risk and insufficient financial incentives will only add to the risk (DiaCore, 2016). From the government's perspective, the effectiveness and efficiency of the designed policies, which are both crucial aspects of the subsidy scheme for the government, might be reduced in case greatly dispersed investment costs exist. A less accurately estimated base rate could lead to a lower realization of projects affecting the effectiveness of the subsidy scheme. On the other hand, a less accurately estimated base rate could lead to overstimulation of projects affecting the efficiency of the subsidy scheme (Goodrich et al., 2012; S.M. Lensink, personal communication, November 6, 2018).

Table 2. Number of SDE+2017 projects and the associated budget in the autumn round

Category	**Projects**	**Budget (× 1million)**
Onshore wind	215	2763
Solar PV	3945	2321
Solar thermal	5	1
Geothermal	5	493
Biomass heat and co-generation	36	272
Bio-gas	6	188
Hydropower	3	<1
Total	4215	6038

Source: Rijksoverheid (2018)

3.2 Data collection

Intermediaries

As mentioned before, intermediaries assist investors with their solar PV project. To identify what the causes for the disparities according to intermediaries are, 3 semi-structured interviews with intermediaries were carried out (see Appendix C for the interview list). These interviews were also conducted to identify whether intermediaries come across disparities in costs and what the explanations for this are. The initial idea was to select intermediaries with a large amount of SDE+ applications as the expectation was that they would be more able to tell about disparities within these different projects. However, when these intermediaries were approached for participating in this research, most of them were either not responsive or not willing. The reason for this might be no time availability, participating in this interview would not be beneficial to them, or they did not want to talk about how they develop their clients' business case. Therefore, only two intermediaries who were involved in several SDE+ applications were interviewed. The third intermediary was an intermediary of one of the investors who was asked for an interview. However, this investor stated to not know about their project and approached his intermediary to participate in the interview. The intermediaries were contacted by the researcher. The interviews lasted between 50 and 60 minutes and were conducted face-to-face.

Investors

To analyze and understand the factors leading to disparities in investments costs, 11 cases concerning small PV projects were analyzed. This was done through semi-structured interviews as it enabled to get an in-depth understanding of how the decision-making is developed (Mignon & Bergek, 2016). In total 13 interviews with investors were conducted, but two were excluded from the analysis for reasons considered valid by the researcher. One concerned an interview with an investor who hired an intermediary and did not know much about the specific project. The other interview was with an investor who wanted to use the opportunity to express his opinion about the government and energy taxes. As these two interviews took different directions as compared to what the aims of this research were, these interviews have been excluded by the researcher[14]. The list of the remaining 11 investors can be seen in Appendix D. The investors were partly contacted by RVO as they wanted to ensure that confidentiality of the investors is protected. However, as this

[14] Although information from these interviews could not be included in this research, the information from those interviews has been anonymously passed over to researchers at PBL.

process was time consuming, the researcher also contacted the investors.[15] RVO publishes a list with all investors that requested SDE+ subsidy which is publicly available online. This list does not contain the investment costs and project capacities. Therefore, despite that investors were selected from the online database, the additional required information (i.e. the investment costs and project capacities) was retrieved from the database which RVO provided. The interviews with the investors were conducted face-to-face or through phone. Not all interviews could be conducted face-to-face because the location of the firms was often at a large distance and time constraints led to some interviews being conducted through phone. The interviews with the investors lasted between 25 minutes to 1 hour and 15 minutes. This difference in interview duration can be explained by the fact that the longer interviews were with investors who had several solar PV projects within SDE+2017 or had applied for SDE+ prior to SDE+2017. Furthermore, the longer interviews were mostly the interviews conducted face-to-face.

Sampling strategy

The selection of the interviews with investors was based on the product capacity and the investment cost indication they provided to RVO. This is an excel-based overview of all SDE+2017 applications which was obtained from RVO. Only investors with an expected production capacity below 250 kWp were considered. The limit was set at 250 kWp because (i) the overall range in investment costs estimated by solar PV investors varied most for project capacities smaller than 250 kWp and (ii) the Ministry of Economic Affairs and Climate Policy wanted to know whether splitting up projects at 250 kWp with a different base rate would be sensible. The selection of interviewees was also based on the applications in the autumn round in order to avoid any disturbing factor which might exist between the autumn round and the spring round. Nevertheless, in the spring round, disparities in investment cost can be seen as well (see Appendix E). In figure 7, the distribution of the number of SDE+2017 applications for several investment cost categories can be seen. Around 22% of the applications concerned projects with investment costs between 956-1045 €/kWp, while the minimum and maximum investment cost applied for were respectively 600 €/kWp and 4249 €/kWp. To obtain an understanding of factors that make a project expensive or less expensive, the investors (after selecting the ones below 250 kWp) were divided into 3 groups. The division of the investors into these three groups was based on the distribution of the SDE+2017 applications as seen in figure 7. The data set was restricted by including only systems between 15 kWp[16] and 250 kWp, while the investment costs have been adjusted according to the group. For the interviews, investors with and without intermediaries were selected to consider the full range of views which is necessary to be able to answer the research question adequately (Young et al., 2018). The investors with intermediaries that were selected for the interviews were also investors who hired a different intermediary then the intermediaries interviewed in this research. This enabled diversity in the sample size. Taking all these aspects into account, the three investor groups formed were:

- Group 1: High investment cost

This group consisted of investors with high investment costs and with a production capacity x that is defined as 15kWp≤x<250kWp. Investors with investment costs above 1300 €/kWp were labeled as 'high cost'. For this group, 5 interviews were conducted: 2 with investors with an intermediary and 3

[15] While contacting investors for interviews, it was mentioned that they received the email as they are mentioned in a publically available list containing investors in solar PV.

[16] 15 kWp is the minimum capacity for which subsidies can be received through the SDE+.

without intermediaries. The interviewed investors within this group had costs ranging from 1302-2083 euro/kWp.

- Group 2: Low investment cost

This group consisted of investors with low investment costs and with a production capacity x that is defined as 15kWp≤x<250kWp. Investors with investment costs below 800 €/kWp were labeled as ‘low cost’. For this group, 4 interviews were conducted: 1 with an investor with an intermediary and 3 without intermediaries. Investors within this group had costs ranging from 633-808 euro/kWp.

- Group 3: Average investment cost

This group, labeled as ‘average cost’, contained investors with a production capacity x that is defined as 15kWp≤x<250kWp and investment costs for which most investors applied for (between 1000-1100 €/kWp; see Figure 6). For this group, 2 interviews were carried out, one with an intermediary and one without an intermediary.

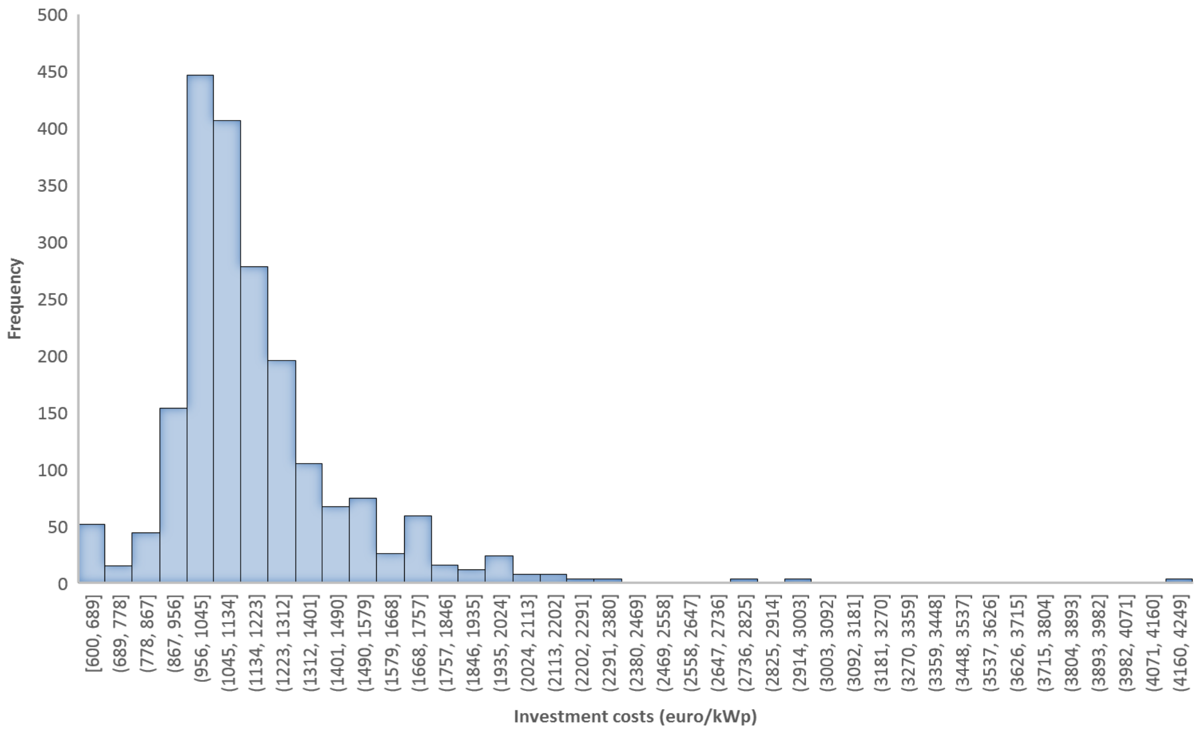

Figure 7. Histogram of the autumn application round from a total number of 2060 SDE+ applications. *Source: Created with data from RVO (2018).*

The interview guide used during the interview with the intermediaries and the investors can be seen in respectively Appendix F and Appendix G. The question regarding the included cost components in the cost estimation was conducted through a form. The reason behind this is that in the first conducted interview where this question was asked, it was noticed that the investor forgot cost components and this question was answered as “costs of the solar panels and installation”. However, this was not specific enough for this research. Therefore, after each interview, the investors were also asked to fill in a form where they were asked to check the cost components they included in their estimations (see Appendix H). This gave a better overview and gave the investor also time to think. In case the interview was done through phone, the checklist was sent after the interview via email. Furthermore, the checklist was also sent via email to the first interviewee in order to remain consistent with the data collection method among all interviewees.

3.3 Data analysis

All interviews (face-to-face and through phone), were carried out and transcribed verbatim in Dutch. After the interviews were transcribed the data was analyzed using codes. Codes are "tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study" (DeCuir-Gunby, Marshall & McCulloch, 2011, p.137). To ensure that meaningful labels were created, open codes were assigned to chunks of data, usually phrases, sentences, or paragraphs that were connected to the research questions. The coding categories were the factors for disparities identified during the literature review. Some additional coding categories were developed during the analysis. These concerned other factors which were not identified during the literature review. An example of how coding was carried out can be seen in the Appendix I. After the interview data was open coded, axial coding was applied where text fragments with similar codes were compared based on similarities and differences. The two main groups (investors with high cost and low cost) were compared and relevant statements from the investors with average costs were provided as well. The most frequent mentioned factors were seen as the main factors and factors which were only once mentioned were grouped into secondary factors.

3.4 Validity and reliability

Validity of the research implies "the degree to which an instrument measures what it is intended to measure" (Long & Johnson, 2000, p.31). Although only 11 interviews were conducted with SDE+ applicants from the total number of 1448 applicants, 3 interviews with intermediaries were also conducted to validate the results. Intermediaries have been involved in several projects till date, meaning that by conducting interviews with intermediaries the findings from the interviews with SDE+ applicants can be confirmed. The internal validity of this research might therefore be sufficient as the interviews did result in explaining what factors are leading to disparities due to data saturation. However, the external validity of this research might not be ideal which could make generalization of the results to other countries or other RETs difficult. For instance, the SDE+ is differently designed from other subsidy schemes and in other countries other factors such as permits and regulations might be more relevant than the factors which are stated in this study. Despite this limitation, the findings may provide important insights into the usefulness of information from the investors to determine subsidy tariffs.

Reliability refers to "the degree of consistency or dependability with which an instrument measures the attribute it is designed to measure" (Long & Johnson, 2000, p.30). Measures have been taken up to improve the reliability. The interviewees were selected among the applications in the autumn round in order to avoid any difference which might exist in the spring round. Furthermore, all interviewees were asked the same or similar questions. To avoid that interviews conducted though phone will have implications on the reliability of it, these interviews were recorded and transcribed as well. The methods and all steps undertaken have been described as detailed as possible. Qualitative methods have been selected over quantitative methods as motivations behind the involved SDE+ participants needed to be understood of which limited explanations would be found from quantitative research methods.

4. Results and discussion

> *"I do not know what the current situation is, but I earn more with these solar panels than with my job"* (Investor 1).
>
> *"The SDE+, I think it stands for something like stimulation renewable energy. […] these are all regulations which stimulate nothing. It is almost impossible* [to make solar PV feasible]*"* (Investor 11).

These statements represent the currently ongoing unconformity regarding solar PV investments. While one investor claimed their solar PV project to be feasible, the other said it was not. To identify the factors that lead to disparities, a total of 14 semi-structured interviews have been conducted: 11 interviews with investors and 3 interviews with intermediaries. In section 4.1, the factors that lead to high investment costs are presented, while factors that lead to low investment costs are presented in section 4.2. These results are based on interviews with the SDE+ applicants. Generally, the SDE+ applicants are the owner of a company, someone within a company or an intermediary (i.e. consultancy agency, installer or PV supplier). In this case, they were the owner of the company or someone within the company. In sections 4.3 and 4.4, secondary factors and the remaining other factors are presented. In section 4.5, the causes for disparities are presented based on the disparities found within the intermediaries' own projects. After each section, the results are discussed and compared with literature. In section 4.6, the impact of the factors is synthesized which was done based on the discussion.

4.1 Cost-increasing factors

In this section, the main factors which are leading to high investments costs are presented. These factors were stated to be the leading causes for disparities by the majority of investors. The factor "the included cost components" was also assessed based on a checklist as mentioned in section 3.1.2.

4.1.1 The included cost components

The business case of the investors differed from each other in terms of the cost components that are included in the total cost estimation. Table 3 shows for each project and for each cost component whether it was included in the cost estimation (depicted with the check mark) or whether it was excluded (depicted with x mark). The cost components which were included in the estimations by most investors, regardless of whether it concerned a low cost or high cost project, were the costs for the modules, inverters, consultancy costs (if applicable) and other costs directly related to the installation of the system, such as the mounting materials and connections to the fuse box. The costs related to the installation were reasonably simple to get an insight into which was usually done by asking for quotations from solar PV suppliers and/or installers (Investor 4; Investor 7). Investors with low cost had cases of self-installation and were less dependent on intermediaries for the preparation of their project, whereas investors with high cost hired external parties for the installation. Therefore, some investors with low costs did not have installation costs. However, all investors that hired an installation agency to install their PV panels included these costs in their estimation.

On other cost components, the low and high costs projects differed in whether the cost components were included in the cost estimations, such as replacement of the inverters, costs of the monitoring system, and maintenance costs. These cost components were more often included by investors with high cost than low cost. Although the maintenance costs were not included by investors with low costs, for instance because it was forgotten, an investors stated that they should be included because *"the panels get dirty very quickly"* (Investor 2). On the other hand, an investor with high costs that did not include the maintenance costs in the estimation stated that it was purposely chosen to exclude these costs: *"… we purposely excluded maintenance cost because we expect that if we chose the correct panels […], there will not be much maintenance needed"* (Investor 8). Additionally, investors with high project costs more often included unforeseen costs. An investor stated: *"I am used to calculating 2% to 4% unforeseen costs because it concerns existing buildings and we do not always know all the details of the building, or whether the building drawings are correct. This building is 10-12 years old, but the other buildings here are 35 years old. Adjustments* [in those buildings] *have been made so often that we are not always sure of what we may encounter. So, it may be that an extra cable has to be pulled through during the project or the fuse box has to be renewed or anything else"* (Investor 8). Contrarily, most investors with low cost did not include unforeseen costs as stated by an investor: *"… I did not take unforeseen costs into account, but you should do that because stuff can just break down"* (Investor 2). The unforeseen costs which investors with completed projects encountered were most of the times costs for the production meter[17]. Only investors without an intermediary did not include the costs for the production meter. Other unforeseen costs encountered were costs for laying extra cables to the fuse box due to a lack of space in the fuse box for the production meter, grounding of the solar panels where it was not clear whether this was mandatory, and expectations that certain cables could be cut, which was not possible afterwards (Investor 1; Investor 7; Investor 8).

Cost components such as legal costs and permits, were not applicable to several investors. In one case, legal costs were part of the cost estimations as the whole project had to be tendered. To do so, lawyers were needed for the formation of contracts. Likewise, in most cases no permits were needed to install PV on roofs. Permits were needed in some cases, such as when it concerned installing PV on monumental buildings and new constructions (Investor 8; Investor 11). Investors had an indication of the grid connection costs in advance through their DSO. However, the exact costs became known as the project went along (Intermediary 2). The initially estimated grid connection costs were included in the cost estimation in case investors did not already have a grid connection.

Some investors also mentioned other costs. For instance, an investor mentioned fall protection systems, which were needed to conduct work safely on roofs and these were also costly (Investor 11). Additionally, some investors included roof construction calculations. Investors that checked their roof construction prior to proceeding with the SDE+ application did so to make sure the roof could sustain the weight of the solar panels as stated by an investor: *"… I have to know whether the roof will collapse if I put something on it"* (Investor 8). Costs related to building inspections were also sometimes included as stated by an investor: *"… we had 35 buildings and each building was different. Inventories had to be drawn up for each of them in order to provide the best possible information about the building to the suppliers and installers. And we also included these costs"*

[17] This production meter measures the generated amount of electricity from solar PV (HIER opgewekt, 2018).

(Investor 11). Detailed building inspections were not always done as investors simply let their own installer give an estimation of the possibilities of PV on the building (Investor 7). However, for some investors, detailed inspection of the PV possibilities on the available buildings was a requirement as the project needed to be approved within the organization. This approval required more specified information on the business case of the project (Investor 11; Investor 8).

Table 3: Cost components included in the estimation (per project)

Investor	1	2	3	4	5	6	7	8	9	10	11
Cost indication	Low	Low	Low	Low	Average	Average	High	High	High	High	High
Intermediary	No	No	No	Yes	No	Yes	No	No	No	Yes	Yes
Cost components											
Modules	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Inverters	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mounting and fixing materials[18]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AC connection of the inverter to the fuse box	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Connection of solar panels on the fuse box	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Installation costs	N/A	N/A	✓	✓	X	✓	✓	✓	✓	✓	✓
Consultancy costs (for intermediary)	N/A	N/A	N/A	✓	N/A	✓	N/A	N/A	N/A	✓	✓
Replacement of inverters	X	X	X	✓	X	✓	X	✓	✓	✓	✓
Insurance	X	X	X	✓	X	✓	X	X	X	✓	X
Permits	N/A	X	N/A	✓	✓	✓	N/A	✓	N/A	N/A	✓
Maintenance costs	X	X	X	X	X	✓	X	X	✓	✓	✓
Legal costs	N/A	N/A	N/A	N/A	N/A	✓	N/A	N/A	N/A	N/A	✓
Earth leakage circuit breaker	✓	X	N/A	✓	X	✓	X	N/A	✓	✓	✓
Production meter	X	X	✓	✓	✓	✓	X	✓	X	✓	✓
Costs for grid connection for large consumers	N/A	N/A	N/A	N/A	N/A	✓	N/A	N/A	N/A	✓	✓
Monitoring system	N/A	X	N/A	✓	✓	✓	✓	N/A	X	✓	✓
Unforeseen costs	X	X	—	✓	X	✓	X	✓	✓	X	✓
Other costs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Construction	Construction	Construction checks,

[18] This includes racking and other hardware.

									checks	checks	Protection systems, project developm ent costs

✓ indicates that the cost component was included by the investor

x indicates that the cost component was not included by the investor

N/A indicates that the cost component is not applicable to the investor

- indicates that no data is available for the cost component

4.1.2 Grid connection or expansion

In order to be eligible for SDE+ subsidy, investors are required to have an existing grid connection for large scale consumers or are expected to build a new grid connection in case they do not already have one (RVO, 2018e). In this case study, some investors with high costs had an existing grid connection, while some investors had to build one. On the other hand, all the investors with low costs had a grid connection. This grid connection led to high costs according to investors without this grid connection. However, the high costs did not necessarily lie in the grid connection itself as there were still enough investors who despite lacking an existing grid connection, had low investment costs. The high costs were rather embedded in the cables necessary for the grid connection. For instance, around 3500 euros needed to be paid to the DSO for merely the grid connection. In this amount, 25 m of cable was included "free of cost". The remaining costs for the cables had to be paid by the investor. The cost of this is highly dependent on the distance of the location to the transformer station. If the station is located next to the building where the PV would be the installed, the costs for the cables are minimal (Investor 2; Investor 10). However, if the transformer station is on a distance, the costs can increase substantially as stated by an investor: *"… we had a location where we needed 275m of cables which cost 45 euros per m. When subtracting the 25 m of cable which is included in the base price of 3500 euros, we still needed 250 m cable. This means that I have to pay 11250 euros only for the grid connection and you will hardly get that back with your subsidy"* (Investor 11). Monthly fees also have to be paid for the grid connection, which can be as high as 2000 euros per month. Furthermore, with a grid connection for large scale consumers, the fuse box need to be extended as a standard 80 cm is not allowed, rather 1.20 m is a necessity. Hence, a new fuse box had to be built as well (Investor 11). To get an indication of what the costs for the grid connection would be, quotations were obtained from the grid operator. These quotations were merely an estimation as the grid operator did not make official quotations unless the operator surely knew that the investor was going through with the project (Investor 11; Investor 10)). However, investors themselves did not know the fate of their project as they can get halted if certain complications occur later on such as failing to get subsidies from RVO or difficulties in obtaining funding from the bank (Investor 2). Investors that did not have a reasonable estimate of the grid connection costs faced additional costs. An investor stated: *"… we initially got to know that the costs for the grid would be 4000-5000 euros. This was also mentioned on the website of Liander. But later on they calculated 11000 euros excluding VAT"* (Investor 10). According to an investor with average costs, it is important to always check the capacity in the fuse box and based on that capacity the available capacity for solar electricity generation should be estimated. This can avoid the disappointment of high costs for the grid connection (Investor 6).

4.1.3 PV cell technology

Various types of solar PV modules and other system components are available on the market today. For instance, investors can select solar panels based on criteria such as efficiency, color, materials, and price. Most of the investors looked at the type of panels prior to the SDE+ application. This enabled them to get a better cost estimation for the PV modules and the installation costs through quotations from the PV supplier or installer. However, investors did not desire certain PV cell technologies based on the materials used, such as C-Si or thin film[19]. Rather, the warranty on the solar panels was an important criterion. This criterion was important for the projects with low and high investment costs alike. One of the investors stated: *"…an important criteria for us is that the supplier or manufacturer is expected to be on the market for some time, has a decent warrant regulation, and preferably not a small player on the world market so that we can be pretty sure that in case a solar panel fails to work, we can get another one instead from the supplier or another manufacturer"* (Investor 8). Aside from the warranty on the solar panels, projects with higher investment cost selected high quality and solar panels with a high efficiency. The investors who preferred the more expensive panels were of the opinion that they were better compared to cheaper solar panels. An investor stated: "*…we wanted to be extremely sustainable so we chose glass-to-glass panels with high efficiency. […] we did not just want to throw cheap panels on the roofs just to earn the money back faster. We wanted to do it right"* (Investor 10). However, the investors with high cost selected the cheapest option if the quality and warranty between the available options were similar or the same. For instance, some PV investors asked for quotations from several solar panels suppliers. They provided their demands to the suppliers and then several quotations were received. From these quotations, the cheapest option was selected by the investors with high cost in case all quotations contained high quality panels with good guarantees (Investor 11). An investor stated: *"… there were 5 or 6 suppliers and we chose the financially most appealing one. But the important component was the quality of the panel and we desired a certain minimum watt-peak. They had the freedom to choose whether to suggest thin-film,* [poly]*crystalline panels or mono-crystalline panels"* (Investor 11). On the other hand, besides the warranty, investors with low costs also considered the price to be important, where the cheapest option was selected (Investor 1; Investor 2). The cheapest option was chosen due to a lack of trust in the advertisements of solar panels suppliers. An investor stated: *"…we asked 3 suppliers and all 3 claimed to have the best solar panels for the best price, as if I know that. […] ultimately I had to blindly believe that they actually had good panels. But I still chose the third supplier because they clearly gave a lower price"* (Investor 2).

4.1.4 Differences between buildings

The buildings on which the solar panels were installed were different from each other. Before the project started some investors had their the buildings including roofs examined and money was spent on conducting this research as indicated by an investor: *"… you have to invest a lot in research beforehand if you want to do it correctly and you do not even knew whether you will get the subsidy"* (Investor 11). On some locations, extra constructive measures had to be undertaken for instance on

[19] The factor "PV cell technology" was not revealed to be one of the main disparity factor as investors did not desire panels in terms of the used materials (e.g. C-Si/ Thin-film). However, it is still included in this section where the main factors are stated as the factor "PV cell technology" can be extended to include preference for certain panels based on other factors such as quality and efficiency.

a location with an ice rink. In this case, the cherry picker (used for lifting the materials) could not be brought inside on the ice unless all ice was removed from the area (Investor 11). Taking such constructive measures easily increased the cost of the investor. An investor gave another example of when taking constructive measures increase the costs: *"… on one of our locations, we had a swimming pool and to install the solar panels, the whole building had to be made completely voltage free. This meant that the whole swimming pool installation first had to be step-by-step shut down. Water from the pool had to be put in the buffer tanks, otherwise the water, which is very expensive, would go down the drain. It all happened at night in order to prepare to pump the extra water back next day and to check the water quality, temperature, and safety. There were also cash register systems connected to it. The moment the whole building was completely free of voltage, you could no longer find tickets. […] it cost us 7000 euros extra"* (Investor 11). Additionally, sometimes roof adjustments had to be made by investors in order to put more panels on the roof. Therefore, to make sure that the roof could carry the weight of the solar panels, sometimes the roof(s) were checked first. For instance, new building codes became effective in 2012 as a result of the collapse of buildings due to heavy rain falls leading to water accumulation. The new standard became stricter and made the investors' building weaker according to this standard. An investor further explained: *"… suppose that with the old standard you could put 30 kg on a roof per square meter, with the new standard you may only put 12 kg on it. And solar systems weigh 20 kg per square meter on average with ballast. What was possible with the old situation, is no longer possible with the new norm"* (Investor 11). As fewer panels could be put on the roof due to the weight, it led to a disadvantage as certain fixed cost such as the production meter and grid connection still had to be made regardless of the amount of panels that would be put on the roof, but these costs were made over a lower electricity yield which led to high costs per watt-peak (Investor 6; Investor 7). An investor stated: *"… if I have a building from 2000, then in the construction calculation, there is nothing mentioned about the reserve capacity I have on the roof. If you have the calculation done now, it will be based on the new standard based on which you will get to know the reserves you have. Based on the new standard you will have to make more facilities if you want to put more panels on the roofs and only then can the project be made feasible"* (Investor 11). Investors with low and average investment costs were of the opinion that it is better to avoid having to make adjustments construction wise. If these adjustments are made, the costs will increase which means that the investor will be better off with fewer panels on their roofs (Investor 4). Another investor even said to halt the project in case adjustments had to be made: *"… if the construction is not suitable, we do not go ahead with the project because then the adjustments are expensive and you can end up with extreme high costs"* (Investor 5). Therefore, it is better to wait until the building actually needs constructive adjustments, so that these adjustments can be made and PV can be installed as well at the same time. Having to make the adjustments just for the sake of installing PV can lead to high project costs (Investor 5). However, on some location such as the examples given of an ice rink and swimming pool, adjustments are inevitable. Not only because of adjustments that have to be made to buildings, but solely the type of location where the PV would be installed can increase costs. An investor gave an example of the need of permission for PV on new buildings and stated: *"…we wanted to put carports with solar panels for part of our parking areas. But the municipality said that because it is a new construction, I need permission first. […] the costs for the carports were 300000 euros, the solar panels were 300000 euros, and additionally I had to pay 15000 euros legal dues over the whole amount. It is understandable that I have to pay legal dues for the carports, but for the solar panels as well makes no sense. […] I ended up talking with civil servants who were not confronted with* *anything like this before and had no solution. […] after pushing through, I finally had to pay the legal dues only for the carports"* (Investor 8). The investor further stated that there is a lack of national wide guidelines on this as some cases are exceptional.

4.1.5 Willingness to pay

Despite that some investors had high project cost and high payback periods, the majority of the investors did not state to have high investment cost. The ones who stated that their project is not feasible even with the SDE+, had for instance cheap electricity purchasing agreements which resulted in no or negative returns (Investor 11; Investor 10). The remaining investors either claimed to have good returns on their investment or acceptable ones and these investors did not seem to be bothered with their high payback periods. The projects with payback periods below 10 years were all either low investment PV projects or projects with average costs which had payback periods, ranging from 6 to 9 years. These two groups (i.e. low project costs and average project costs) seemed to be willing to invest only in case payback periods and returns on the projects were good. An investor stated: *"[…] if the payback period exceeds 6,5 years, we do not even look further and halt everything. That is why we will never get into such a situation* [where we will have high investment costs]*"* (Investor 5). Additionally, the PV panels are not always necessarily installed because of the subsidy. For instance, an investor stated: *"[…] we did not install the solar panels because of the subsidy, but just because it is economically interesting to have these solar panels. […] the previous sets of panels which I installed on this building are without subsidy as I had not come across the subsidy before. But the subsidy was not the decisive factor for installing the second sets of solar panels"* (Investor 1). On the other hand, the investors with high costs had payback periods between 14 and 15 years. Despite this, not all investors with high costs stated to find their payback period and estimated investment costs to be high. These investors who did not state to have high investment costs and were not displeased with the SDE+ subsidies would install solar PV regardless of the subsidy. The subsidy just catalyzed this process so that the proposal for the project could get faster through the company and eventually faster approved (Intermediary 2). For instance, some investors with high project costs found the 15 years payback period to be acceptable as their company had either environmental goals or they thought investing in solar panels would be good for the image of their company. Therefore, their main aim with the SDE+ subsidy is to have a project which can partly substitute their fossil based electricity and for this they do not necessarily have to make large amounts of profits (Investor 11; Investor 8). This is also confirmed by an intermediary: *"… we have some big companies and for them it does not matter whether the payback period is 8 or 12 years. They install PV just to show that they are sustainable"* (Intermediary 2). The willingness to pay for solar PV can lead to less efforts in searching for cheaper options as some of the investors with low costs seemed to do. This will be further explained in section 4.3.2. Nonetheless, even these investors who were willing to pay for their project and were not that concerned about the payback periods, were cautious as they also would not consider projects where the return goes below 0% as this could lead to issues regarding funding (Investor 11). Thus, many projects still go through despite the high investment costs and payback periods. According to intermediaries, projects did not get realized when the business case of the investors was not working out after the subsidy from RVO was known. For instance, projects did not get realized when the actual costs for the grid connection were higher than expected, when the checks were done construction wise and adjustments had to made, problems with the AC connection or in case the bank did not want to continue funding the project (Intermediary 1; Intermediary 3).

4.1.6 Discussion

Regarding the included cost components, the findings indicate that investors with high costs included more cost components into their business case. In the literature review, it was mentioned that currently, the modules consist of 47% of the total investment costs (Wirth, 2018). Based on a cost division in the Netherlands, the modules and inverter combined comprise between 35% and 50% of the total investment costs (Lensink & Cleijne, 2018). The module and inverter costs were included by investors with high cost and low costs alike. The investors also included the following costs: permits, mounting and fixing materials, consultancy costs, earth leakage circuit breaker, AC connections, and grid connection. The only costs which were additionally included by investors with high costs were: replacement of the inverters, monitoring system, unforeseen costs, and additional costs. This means that the included cost components might not play a big role in this case as the majority as well as the most important cost components were included by both groups. This indicates that instead of whether a certain cost component is included or not, the price assumed for these various cost components could be where the differences lie. Additionally, in the literature review, the factor 'PV cell technology' was stated to possibly lead to disparities due to a preference for a particular technology. Contrarily, the PV cell technology was not the determining factor for the selection of panels for investors with high costs. Rather, the investors had a higher preference for European panels or high efficiency panels as the results indicated. Research shows that Chinese crystalline silicon modules are 9-17% cheaper than their equivalents manufactured in other places such as Europe, the U.S. and Japan (Davidson & Steinberg, 2013). Given that modules make up a significant portion of the investment costs, higher priced panels such as non-Chinese modules will therefore lead to higher investment costs.

Other findings comply with the literature. In section 2.2 it was mentioned that the construction of a grid connection for large-scale consumers can lead to high costs. This was also found to be the case in this study. However, the impact of this was shown to increase when there was a large distance of the location where the PV would have been installed to the location of the transformer due to the involved price of the cables. This meant that despite that some investors had to construct a grid connection, the costs of these were not necessary high. In an ideal situation where the transformer would be present in the surroundings of the location where the PV system is to be installed, the costs would be typically 3500 euros. In case, the grid connection only has to be expanded, the extra costs due to this are not that high as the findings indicated. Alternatively, in some cases, the transformer can also be built on the location itself, but this also leads to high costs (Investor 2).

The results also show that the investments costs can vary depending on the building type. This can be attributed to the fact that certain types of buildings required additional measures to be undertaken in which extra costs were involved. Gillingham et al. (2016) points out that governments, schools and non-profit customers are associated with higher priced PV systems which might be the result of more complicated and less standardized installations. Other studies have identified differences between buildings as a factor of cost disparities, however this was more inclined towards roof types and the fact that on some locations, the costs per Wp can be lower due to the possible system size which can be installed. For instance, multi-story buildings such as hotels have limited roof availability compared with supermarkets (Ong, Campbell & Clark, 2012). Additionally, strengthening of the roof and the involved roof checks led to additional costs as indicated in the results. However, the cost of this depends on the amount of work that needs to be done (the ECO experts, 2018). According to the investors that did roof checks prior to the installation, the costs of these checks are acceptable, however it is typically avoided to strengthen the roof. Instead, fewer panels are placed on the roof, which makes the price higher compared with when more panels could be installed on the roof. This is also confirmed by Honeker et al., (2016) who further stated that using light weight solar panels could reduce costs as more panels can be put on the roof.

The findings also suggest that there might exist a certain willingness to pay for solar PV among some investors. These findings comply with research conducted by Blom et al. (2016). The study indicated that within the SDE+ there are free riders in certain categories which exists besides in the category thermal conversion (bio-heat) and bio-cogeneration, also in the category solar PV. For these investors, generating solar energy is not seen as the core activity, but as an activity which can offer marketing value such as corporate social responsibility (Blom et al., 2016). This has also been noticed within this research where some investors with high costs did not state to have high costs and did not express any disappointments neither regarding the SDE+ subsidies nor their high payback periods. Rather, they revealed traits of a certain willingness to pay for their project such as the investor who stated to have installed PV without any subsidy before. Most of these investors installed PV for the sake of being seen and portrayed as sustainable, or to reach environmental targets within the company. The results also indicate that these investors found the 15-year payback period acceptable. It is important to keep in mind that if the money is not earned back in these 15 years even some of these investors would re-consider installing PV due to possible funding issues and would look at other options which would still give them the sustainability image they desire. Previous research indicated that the investors' willingness to pay for PV might not be high. For instance, Blom et al. (2016) concluded that the amount of investors willing to pay (which he refers to as free riders) are limited and lie between 5-15% based on the respondents of a sample in their research.

4.2 Cost-reducing factors

In this section, the main factors which are leading to low cost solar PV projects are presented. As mentioned in section 4.2.1, investors with low cost projects either did not include all cost components into their total cost estimations or they did not have to make those cost. As the factor "included cost components" was already presented in section 4.2.1, it will not be repeated. Rather three other factors are explained in this section: do-it-yourself approach, searching for cheaper options and experience. These factors are drivers for cost decreases according to the majority of investors.

4.2.1 Do-it-yourself approach

Investors with low costs and without intermediaries mentioned that self-management of your own project is key. These investors believed that by holding the projects in their own hands, money was saved. Regarding this an investor stated: *"…I did not have to pay people to do things I could do myself, meaning I did not have installation costs. It is only because of this that it* [the return on the project] *became interesting"* (Investor 1). Self-installation of PV systems is possible if the investor has the time and knowledge for it. An investor stated: *"… my work related to calendars is mostly seasonal work. In spring, we are not busy here. I can go on the internet doing nothing, but I can also install PV on the roofs. […] But you have to be able to and willing"* (Investor 1). The importance of time to do so was also mentioned by another investor: *"[…] you are now talking with someone who took the time and put in a lot of effort to figure out everything and to make the cheapest out of the cheapest from this project"* (Investor 2).

4.2.2 Searching for cheaper options

As investors are looking at prices of components, such as solar panels and inverters, it can be beneficial to continue searching for better priced products due to the cost reductions it brings. However, only few investors continued searching for better priced products. These investors did not only search for cheaper products in the initial stage of their project, but also after the subsidy amount they would receive from RVO was known. Searching for better priced options was not always done as there might be a lack of motivation among people to reduce costs. An investor gave an example of this and stated: "… *an acquaintance of mine bought 9 solar panels for 3900 euro and everyone was extremely enthusiastic. If he had called me, I could have done that for half the price. But apparently people are not motivated to look further for prices"* (Investor 1). Investors also stated that it is important to know on which components of the PV system money should not be spent and on which components a higher amount could be paid for better quality (Investor 1; Investor 6). An investor stated: *"All those people in the solar panel business advertise that they have the best materials for PV racking and that their materials will not be blown away by the wind, but then they are 10 euros more expensive. In fact, they all sell almost the same stuff, but the important things to keep an eye on are the electronics, inverters and solar panels"* (Investor 1). Investors with high costs on the other hand also made efforts to reduce costs by searching for cheaper options, but this was not always easy. For instance, the production meter has to be read by a measuring company and nowadays investors are allowed to select their own measuring company. However, the measuring company that is selected is actually the measuring company which belongs to the DSO of the investor and the investor is indirectly bounded to this measuring company. An investor stated: *"… if I tell my measuring company that I find them expensive and I found a cheaper alternative, then the problem is that the main meter of the building belongs to my measuring company. If I choose another measuring company, this means that I have to change this main meter as well because you cannot have two measuring companies on one location. And the biggest problem is that those contracts are for 5 years. So usually you cannot suddenly change your main connection unless you pay extra for it"* (Investor 11). These aspects are not always considered or known beforehand, so making the most favorable or financially attractive choice is not always possible.

4.2.3 Experience

Investors with low project costs and without an intermediary stated that their past PV installations contributed to reducing the total project costs even further. Past experience with SDE+ or PV installations also meant that the investors knew where to start and search for prices as well as what costs would be needed to realize the whole project. This was also important for investors with high costs who managed the project on their own. An investor stated: *"For the first [SDE+] application, I hired an intermediary because I had no idea about what things had to be done and no one else knew* *that within the organization. But once I knew what it was about, I thought by myself that it is something we can do ourselves. Thus, for the second time, I did it myself and we managed to reduce our total costs by two tons as the intermediary just filled in a high amount for the first application"* (Investor 7).

4.2.4 Discussion

The results indicate that the do-it-yourself approach was an influential factor for reducing costs. This is in accordance with Gillingham et al. (2016). In that study it was found that self-installation was the most important cost-reducing factor which could reduce costs up to 38%. Based on this, it could be argued that the impact of this is quite substantial, especially, if the PV system is self-installed and for the preparation of the whole project no external party is hired. Furthermore, all investor also stated that the installation costs are increasing due to a lack of technical labor in the market. This notion is also supported by Lensink and Cleijne (2017b). Self-installation in this scenario will therefore lead to lower costs compared with the costs made in case an installation agency would be hired. Additionally, the results showed that searching for cheaper options may reduce costs. Contrarily, according to O'Shaughnessy and Margolis (2018), investors face search costs which occur in markets with price disparities. PV prices are not readily available as installers do not tend to advertise generic prices that are not a reflection of the site-specific costs. Instead, investors must actively search for quotations to inform themselves of potential installation prices. These search costs are costly as investors have to invest time to identify and contact potential installers. Other costs such as the time spent to host the site inspections before quotations are obtained, are incurred as well. Therefore, some investors accept the lowest available price after conducting a limited search, while other investors have higher search costs (O'Shaughnessy & Margolis, 2018). Searching for cheaper options in this study reduced costs which might be because the benefit of the search (i.e. the reduction in costs), exceeded the costs of the search for the investors. Additionally, the difference between these findings may also be explained by the fact that some of the lower priced projects were projects where the investor had prior experience in PV or SDE+. As a result of this experience (and the available time) they were able to manage their project on their own and also had the benefit of knowing installers and PV suppliers. Janssen and Moraga-González (2004) referred to such investors as "fully-informed" investors as they are able to search for prices at no if not limited costs. Therefore, it can be said that experience can lead to lower investment costs. Comparing these results with the literature review, the impact of experience was stated to be two-fold: it could either lead to low costs due to knowledge, or it could lead to the identification of more cost components in the business case. However, as mentioned, the former was found to be dominant in this study.

4.3 Secondary factors

In this section, the secondary factors are presented. They are referred to as "secondary factors", considering that these factors are only mentioned by a minority of the investors for leading to disparities.

4.3.1 PV mounting system

Some investors installed PV on several locations and with both flat and sloped roofs. The majority of the investors stated that the PV installation on the flat roof was more expensive compared with the sloped roof. Flat rooftops require ballast to avoid that the panels get blown away from the roof (Intermediary 1). However there are some cases where a sloped roof can be more expensive as additional measures have to be undertaken. An investor stated: *"… whenever the location has a sloped roof, it becomes troublesome because you have to rent a big crane and you have to make arrangements so that people can work safely. Thus, scaffolding has to be built. […] On a flat roof on the other hand, the process is faster. If you can install 100-120 solar panels on a flat roof, a sloped roof can install maybe only 40. For instance, if the installation takes place in the city center, permission has to be arranged first to be able to bring in the crane. And then you are told, that you are allowed to bring in the crane, but only between 6 P.M. and 7 P.M. This means that the crane does not have to be brought only once, but maybe even 2 to 3 times. And if it concerns a big crane, you have to pay for it per half day. This only increases the costs further"* (Investor 11).

4.3.2 East-west orientation

According to an investor, the project costs are acceptable with south oriented PV systems. However, if the aim is to generate as much as electricity possible, an east-west orientation is more suitable. By installing the panels in an east-west orientation, more panels can be installed, thus a higher yield can be achieved. This can be achieved as in the morning hours, the electricity generation can be provided by the eastern side, while later in the day, the electricity can be generated by western side. As more panels would be used in the east-west orientation, the cost for the modules increased as well (Investor 8). An investor stated that an east-west orientation made his project less interesting to invest in: *"[…] it becomes critical to install solar panels east-west, as for my project I need double the amount of solar panels but I cannot earn that in 15 years"* (Investor 8).

4.3.3 Discussion

The findings reveal that the mounting systems of the PV installations were considerably similar. There were no ground-mounted systems, no BIPV and no tracking systems. The only aspect which differed was whether the PV was to be installed on a flat or sloped roof. This is shown to have an impact on the price. In general, PV installed on a sloped roof was found to be cheaper compared to a flat roof due to the reasonably limited items needed for installation. However, the investors stated that the difference was not large enough to cause significant deviation in the investment costs. In some cases, sloped roofs can be even more expensive than flat roofs as the findings indicated. This is in line with previous studies where it has been demonstrated that for instance, a multi-story building with a steep roof, required additional labor, safety protocols, and potentially non-traditional mounting hardware all of which lead to an increase in the price (Davidson & Steinberg, 2013). This was also seen in the example given by an investor where cranes were brought in and safety measures had to be undertaken. The findings also indicated that east-west oriented PV can be more expensive. This is also asserted by Chattopadhyay et al. (2017). While the east-west orientation are most suitable for balancing the power demand and generation and in fact have a higher yield[20], the price increase due to this can be substantial (Chattopadhyay et al., 2017). This suggests that the maximum amount of panels which can be installed with an east-west orientation does not out weight the extra costs needed for these panels and might therefore not be advantageous.

[20] A higher yield of the east-west orientation is achieved in summer (Chattopadhyay et al., 2017).

4.4 Other factors

In this section "other factors" are presented. They are referred to as such because these factors were not indicated to lead to disparities by the investors themselves. However, these factors are the remaining factors from the literature review. The role these factors played in this case study will be described in this section.

4.4.1 Varying methods

The investors (both with and without intermediaries) first developed a business case for their PV project before they applied for SDE+. This business case was prepared by the firm owner, an installer, or an intermediary. The starting point of this business case was to have an indication of the available roof area. Based on the roof availability, the amount of solar panels and the corresponding electricity this could generate was estimated[21]. The information needed for the cost estimation was obtained from similar sources. The majority of investors made the cost estimation based on quotations which were obtained from the PV supplier or installer. The remaining minority stated that the PV suppliers did not make quotations. Rather, these suppliers only gave a price indication (Investor 1; Investor 11). Another investor recently bought solar panels for his previous SDE+ project which was around the same time when he was applying for SDE+2017. Hence, the investor was aware of the current prices and used that to estimate the investment costs (Investor 2). However, the detail to which the business cases are made differs between investors. Some investors made a detailed business case analysis, while others indicated that the investment cost are merely a first estimation. An investor stated that before applying for SDE+ only first estimations are calculated and the details are left for later: *"… we start with making a first estimation of what the technical possibilities are. Once the subsidies from RVO are known, we look at the final actions needed such as the construction calculations. […] we want to keep the costs that we make prior limited, until we get the subsidy. Because you can put a lot of time into a fantastically prepared project, but if you do not receive the subsidy, then you do not have a business case"* (Investor 8). On the other hand, some investors stated to consider as much of aspects before applying for SDE+. For instance, these investors checked the roof construction and the possible load before applying for SDE+ in order to avoid that, it is known that the construction is not suitable only after the SDE+ is applied (Investor 11).

4.4.2 Role of the intermediary

Some PV investors hired intermediaries to assist with part or the whole process. Sometimes the intermediaries only filled in the application form (which was free of cost), while the investment costs were estimated by the investor or in cooperation with the intermediary. Among the 11 interviews conducted with investors, 5 interviews were conducted with investors who hired intermediaries. Of these 5 interviews, only 2 were projects where the intermediaries managed the whole project: from SDE+ application until project realization. The investors who hired intermediaries for the whole process are of the opinion that they presented a very clear and real picture of the possibilities (Investor 11). Another intermediary stated: *"… I hired an external adviser and they managed literally*

[21] It should be noted that some investors could generate more electricity with these panels (based on the roof availability) than they actually consumed. However, as they only wanted to self-consume the generated electricity they installed less panels on the roofs.

everything. They selected the correct products matching our needs, [identified] *how it should be done construction wise and submitted the SDE+ application. Our only condition was that we would pay in case the project went through. So there was no risk on my side"* (Investor 10). These investors who let an intermediary estimate their costs are of the opinion that investors who make the estimations themselves leave out several cost components from the business case (Investor 11). For the remaining 3 investors, the SDE+ application was either only filled in by the intermediary or a cost estimation was given as well. In the latter cases, the intermediary was the installer or PV supplier who filled in the application forms free of cost. Six interviews were conducted with investors without intermediaries. In these cases the SDE+ application was done by someone within the company or the company owner, while the costs were estimated by the company owner, someone within the company or a PV installer. These investors applied for SDE+ themselves because they had previous experience and the knowledge, or the investors did not entirely thrust the opinions of intermediaries. For instance, an investor stated: *"… the assignments are very quickly pushed towards a befriended supplier, so you do not always get the best advice"* (Investor 1).

4.4.3 Reliability of information

Out of the interviews with the investors, most projects (7) were realized, a smaller part (3) were not realized at the time of the interview, but would be in a few months and 1 project had been halted. Except for investor with the halted project, the remaining investors had projects realized where the estimated costs hardly differed (or is not expected to differ) from the actual cost after project realization. This is true for the low, average and high cost projects. Regarding this, an investor stated: *"… we had to make more costs, had to arrange more facilities, and it took more time to realize the project, which are additional costs. But we also saved costs along the way. So we had increases, but also decreases in cost components. On average, the costs are the same"* (Investor 11). Other investors stated that it is almost impossible for the estimated costs to differ much from the actual cost (Investor 3; Investor 5; Investor 8). For instance, an investor mentioned*: "… in most cases we have agreements with the suppliers that they have to deliver and install everything for a fixed price in the tender and that only in special cases they may settle more or less work. But then there really needs to be a very clear reason for it. So they cannot say halfway through the project that they have 25% cost overrun. […] and there are plenty of parties here that have so much experience in the installation world that they should not come to face any big surprises"* (Investor 8). To obtain precise agreements, having the roof examined beforehand can also help in making a fixed deal: *"… we had it* [the roof] *carefully examined in advance, made contracts and paid exactly what was in the tender"* (Investor 6). If costs for certain components increase (e.g. due to forgotten cost components in the financial model), then costs for other components can be saved along the line. An investor who already estimated low costs in the SDE+ application form continued looking at prices after the subsidy he would get from RVO was known and said the following: *"… to have the solar panels ballasted I needed basalt blocks and I looked at the price and they were 2.30 euros each. We looked at "marktplaats", people were renovating there gardens and those could be picked up free of cost. It saved me 10 euros per panel. […] we also looked at inverter prices and they were not available at a price lower than 1200 euro excluding VAT which we did not find interesting. Thus we called installers and explained what we were looking for and also because we knew that sometimes the inverters are wrongly dimensioned. Thus, sometimes a wrong inverter gets delivered or the inverter is too large. So one of those installers called us and said they had an inverter lying around which could not be sent* *back to the importer. We got it from him for 500 euros including warranty"* (Investor 1). In short, according to the investors, there is little possibility for the actual costs to differ largely from the estimated costs and in case some components are more expensive than anticipated, costs for other components can be reduced along the line.

4.4.4 Discussion

It was mentioned in the literature review that the intermediaries could indicate higher investment costs in the application forms to increase their payment. However, if the investors' perspective is considered, all investors in this case were satisfied with the intermediary and stated that the intermediary had a positive influence on the process. Investors without intermediaries were also satisfied by doing the project on their own as they had perceived negative opinions about intermediaries or they stated that the SDE+ application is not that difficult to hire an external party. However, the impact intermediaries have on the cost estimation, may be somewhat different. This will be described in the next section where the perspectives of intermediaries on intermediaries are considered. Furthermore, the results indicate that according to investors, the expected investment costs did not differ much from the actual costs. Contrarily, according to RVO, the actual costs always differ from the expected costs as mentioned in section 2.2.2. The difference between these findings may be explained by the fact that the significance and reliability of the self-reported investments costs by the investors were not well understood. For instance, it was not known whether general indications were given or actual business cases were developed by the investors for projects smaller than 250 kWp, although the former was expected. The findings also show that all investors in this case made a business case for their project whether the investors was a farmer, a small company owner, or big company owners. In short, according to investors, intermediaries had a positive role, the investment costs were estimated based on similar sources, and although the business case of investors with high costs were more extensive, in section 4.1.6 it was already discussed that the most important components were included in the business case of projects with low costs as well. Additionally, the information on investment costs provided by the investors is reliable as per the investors' perspective.

4.5 Intermediaries' take on disparities

Three intermediaries were interviewed to investigate whether there are also disparities seen in the projects they manage. The results from these interviews are presented below.

4.5.1 Causes for disparities

The intermediaries indicated that only sufficient insight into the costs of the solar panels and the installation can be obtained. The deviation in costs arises on the cost surrounding this as a result of which cost components are included in the cost estimations (Intermediary 3). Regarding this, an intermediary stated: *"... the question is which costs should be included. The one says only solar panels, whereas the other includes all cost components, such as permit costs and warranties"* (Intermediary 3). The intermediary further gave an example of how investors have different opinions on whether certain cost should be included or not: *"...in the countryside there are a lot of asbestos roofs. Nowadays, a combination is made with slogans like remove asbestos, install solar panels. If you are going to remove asbestos, are you going to include those costs? For instance, I think that you* *should not attribute such costs to the SDE+. If necessary, consider a structural improvement or reinforcement to be able to carry those solar panels because that is really necessary for your solar panels. But if certain consultants or investors believe that roof renovation should also be included, then you will of course get a very distorted picture. So where do you draw the line?"* (Intermediary 3).

Additionally, intermediaries stated to use a standard value per kWp for projects below 500 kWp. This standard value is based on quotations from PV installers who they are connected with. In this standard value, the PV panels, inverters and costs related to the installation are included. Other costs, such as the grid connection costs and roof strengthening are not included in this standard value. Additionally, this standard value is generic and is based on average panels. In case the client got a quotation from his PV supplier than that value is used. Again, this value only contained the PV panels, inverters and all costs directly related to the installation. The costs surrounding this are not included (Intermediary 3). Another intermediary who stated to use the standard value as well included additional cost components, such as grid connection and unforeseen costs (Intermediary 1). Intermediaries warned using the investment costs as indication of the costs of PV projects as they do not always reflect reality and are therefore not reliable (Intermediary 1; Intermediary 2; Intermediary 3). According to the intermediaries, the estimated investment costs which are indicated on the SDE+ application forms are meaningless and non-consequential for the decision on the subsidy as there is no incentive to seriously estimate the investment costs (Intermediary 2). For instance, an intermediary stated: *"… the problem is that you can fill in anything for the investment costs. Whether you put a million as costs or two tons, it does not matter because you will still get the subsidy as there are no criteria or judgment on that. I would say let everyone hand over their construction drawings and quotations from their supplier"* (Intermediary 2). This gets confirmed by another intermediary: *"… as soon as I use rough estimates on the basis of past realized projects, you get high values for the investment costs compared to when I use the customized quotation I receive from the installer"* (Intermediary 1). As the investment costs indicated on the SDE+ application forms do not reflect the actual costs of investors, the intermediaries indicated that the costs after project realization does differ from the costs estimated before project realization (Intermediary 1; Intermediary 2; Intermediary 3). They stated that actual costs are usually lower than the estimated costs because in the estimation, conservative numbers are used. Additionally, the investors had 3 years for realizing their project. Therefore, by the time the solar panels and inverters are bought, the prices were lower compared to the prices estimated before (Intermediary 1).

Apart from the cost components that are included in the cost estimations, intermediaries also stated that the disparities lie in the "included cost components", "grid connection", and "how accurate the investor or intermediary estimated the costs". The accuracy of the investment costs estimation also had to do with the knowledge investors have as stated by an intermediary: *"… I think the disparities lie in how much knowledge people have on the business case of solar panels and in case they do not have enough knowledge they should do their homework well. Larger projects are forced to do their homework well because they have to conduct the feasibility study from RVO"* (Intermediary 1). Other factors such as the roof type do affect the needed investment costs, however the impact of this on the costs is not large enough to lead to the disparities that are seen within the SDE+ (Intermediary 1).

4.5.2 Discussion

Some findings from the interviews with intermediaries corresponded with the investors. The stated reasons for high costs were costs for the grid-connection. However, the causes for low costs were stated to be that the investors did not include all costs or that the investors did not prepare the business case accurately due to a lack of knowledge. This differs from the results from the investors. Self-installation, experience, and searching for cheaper options were stated to be the most cost-reducing factors. Additionally, although investors with low costs did not include all costs or did not have to make all costs, the most important cost components were included as the results indicated.

Intermediaries also stated to use a generic cost estimation for various projects. By using one value for the investment costs for different projects, the actual costs for these projects are not truly reflected. These generic estimations might not necessarily deviate from the costs in case they would have been assessed on a per-project-basis. However, this might be the case if for instance, some investors desired European panels, high quality panels, or had different buildings aspects, which would have increased the costs from the "standard value". An intermediary stated that the total costs could increase 43% by replacing the standard panels used for estimating the "standard value" by high quality panels (Intermediary 2; Intermediary 3). In this case, the indicated investment costs for a certain project were not necessarily the specific costs for that project. Whether the "standard value" differed from the specific costs and how large the difference would be is unknown. Given that the impact of this is unknown, the role of the intermediary is unknown as well. Furthermore, intermediaries had diverse roles. Sometimes they were merely the installer who filled in the application form or the person who actually estimated the costs. Therefore, intermediaries and their role cannot be generalized. Intermediaries that only filled in the application free of cost would have almost no impact on the investment costs, but intermediaries that are involved in the whole process including the estimation of the costs might have a higher impact due to the standard values which are used by some intermediaries. Again, this cannot be confirmed.

Regarding the reliability of the information, intermediaries presented a totally different picture compared with the investors. Intermediaries stated that the reliability of the information is low as the actual costs are not presented. The actual costs are lower compared with the costs estimated before, while investors stated that their costs did not differ much from the estimated costs. The contrast between these findings might be explained by the method the intermediary used compared with the investors. The investors made cost specific estimations mostly based on quotations, while the intermediaries often used generic values and conservative numbers which can lead to lower actual costs.

4.6 Synthesis

In Table 3, a synthesis of the results and discussion can be seen. The plus-sign indicates that the factor can be considered to be influential in leading to disparities, while the minus-sign indicates that the influence of the factor might be low. "Undetermined" is assigned to a factor in case conflicting results on the topic were found. The factors "varying methods", "role of the intermediary" and "reliability of the information" can be linked to each other. While based on the results from the investors, the role of the intermediary is positive, similar sources and methods are used for estimating the investment costs, and the information provided by the investors are reliable, the intermediaries stated otherwise. Due to these conflicting results, the significance of these three factors is undetermined. Grid connection or expansion, PV cell technology and differences between buildings can be seen as the most important factors that can cause disparities. These factors were both stated by the majority of investors as well as the literature. On the other hand, the most significant cost-reducing factors were the do-it-yourself approach, the search for cheaper options and experience. Although some factors are labeled as "most significant", this does not mean that the other factors are not relevant or are not contributing to disparities. For instance, several cost-increasing factors together can have the same impact as one highly influential factor. Therefore, it might be that several factors simultaneously led to high or low project costs as well.

Table 4. Synthesis of the impact of factors on disparities

Factor	**Impact on the costs**	**Overall impact on disparities**
The included cost components (More cost components)	Cost-increasing factor	-*
Grid connection or expansion ****	Cost-increasing factor	+**
PV cell technology (High quality and non-Chinese)	Cost-increasing factor	+
Difference between buildings (More adjustments)	Cost-increasing factor	+
Willingness to pay	Cost-increasing factor	-
Do-it-yourself approach	Cost-reducing factor	+
Searching for cheaper options	Cost-reducing factor	+
Experience	Cost-reducing factor	+
PV mounting system (Flat roofs)	Cost-increasing factor	-
Roofs with shading	Cost-reducing factor	-
East-west orientation	Cost-increasing factor	-
Varying methods	Undetermined	Undetermined***
Role of the intermediary	Undetermined	Undetermined
Reliability of the information	Undetermined	Undetermined

* Indicates that the factor cannot be considered to be influential in leading to disparities

** Indicates that the factor can be considered highly influential

*** Indicates that conflicting results are found on the specific factor

**** The costs involved for the grid connection or expansion varies. Still a plus-sign is given to it as the needed costs for the grid connection can be very high.

5. Limitations and recommendations

In this chapter, first the methodological limitations will be discussed including the implications these have on the results. Based on the limitations, recommendations for further research will be given. Finally, based on the findings of this research, policy recommendations are given.

5.1 Methodological limitations

The main methodological limitation of this research is the sample size. The ambitious goal was set to interview 20 investors in total. However, due to delays during data collection this was not possible to achieve. Additionally, due to the arrival of the summer vacations, many investors were out of office or outside the country making it difficult to collect data. Therefore, only 11 interviews with investors were conducted: 5 with high costs, 4 with low costs and 2 with average costs. Five interviews for investors with high costs and four interviews with investors with low costs might not represent all investors within each of these groups. The same is true for the interviews conducted with the 3 intermediaries. As a result, this made it difficult to generalize findings.

The methodological limitations can impact the findings and the conclusions drawn from the research. For instance, it was decided to select investors with and without an intermediary for the selection of the interviewees in order to increase the representativeness of the results. Additionally, this was done as the initial aim was also to identify whether differences existed between investors with intermediaries and without intermediaries. However, during the interviews it was discovered that hiring an intermediary did not necessarily mean that the investment cost was estimated by the intermediary. The way in which the intermediaries exactly impact the investment costs can therefore not be generalized and in this case no conclusions could be drawn. For instance, the role of the intermediaries was positive according to the investors, but then again many of the investors hired an intermediary who only filled in the application form.

5.2 Recommendations for further research

There are several research gaps present which can be explored in further research. Firstly, the results indicate that it might be more relevant to get insights into the breakdown of the total costs from the investors instead of only having an understanding of the cost components that are included in the cost estimation. In this research, a firsthand estimation was given regarding the cost components that were included, however the costs associated with each component is unknown. In further research, surveys can be conducted with investors including a much larger sample size in order to get a breakdown of the cost estimation. This will also help in identifying whether the factors which were stated to lead to disparities according to this study, also apply to the larger SDE+ population. For instance, the research suggested that the factor “PV cell technology” might play an important role as sometimes non-Chinese panels are desired as well as high efficiency panels. If insights into the module costs among the SDE+ applicants are obtained, the actual role of this factor can be better understood. This will enable making more accurate statements and make a generalization of the findings possible. It might be important to consider doing these surveys anonymously as some investors might be reluctant to share their business case. This was also seen during the interviews, where even though investors were asked to only mention the cost components they included in their estimation, some investors immediately stated that they can only mention the cost components and would not provide a breakdown of the total costs. On the other hand, some investors were willing to indicate their cost break-down.

Secondly, the results reveal that some intermediaries used one standard value for the estimation of the investment costs for various projects. Investigating how this "standard value" differs from the "specific value" (i.e. the costs in case project specific cost estimation would be conducted) might shed more light on the factors "varying methods", "reliability of the information" and "role of the intermediary". For instance, if the standard value does not differ much from specific value, then it could be assumed that the role intermediaries have on cost dispersion is minimal. Furthermore, this will mean that although intermediaries and investors use varying methods for estimating the costs (i.e. generic estimations and project-specific estimation respectively), these impacts are minimal as well. This in turn could lead to the conclusion that the information provided by both investors and intermediaries are reliable to use. This research could not find uniform evidence which could explain the impact of these factors, so they remain undetermined. Therefore, this can be looked into in further research.

5.3 Policy implications

Investors with low costs seemed to benefit from experience and limited search and information costs.[22] The search and information costs can be limited by putting a specific list containing the various possible costs involved in a PV project online. This might be advantageous in numerous ways: Firstly, this might help investors to familiarize themselves with the business case. This might also lead to more consistent cost estimations in terms of the cost components that are included between various investors as it will become straightforward where the boundary lies in terms of the costs that can be allocated to the SDE+. Secondly, publicizing a specific list containing the various possible costs involved in a PV project might help investors to identify whether cost components are forgotten. This might minimize circumstances such as the investors mentioning that they forgot to include certain costs such as the production meter. The costs involved in a PV installation can also be known from a search on the internet or through other measures, but not all investors are willing to put time and money into this research. Furthermore, the fact that investors have to indicate the expected investment costs in the application forms are seen as "probably not really important". Emphasizing in advance on the importance of this might lead to investors either knowing that the cost estimations might be important and therefore putting a better estimation in there or it can also lead to investors knowing the relevancy of it and therefore indicating higher costs in the hope to increase the base rates. Ensuring that all cost components are included might not seem to be the most relevant task right now as the most important cost components were included. However, it can still help to ensure lower information and search costs which have the potential to bring costs down (Gillingham et al., 2016).

Making it obligatory for the investors to provide more information on the build-up of the total investment costs may prove to be advantageous in three-ways: firstly, significant amount of pressure will be put on investors to research and investigate on the costs beforehand by asking

[22] It should be noted that investors with low costs did search for cheaper system components, but were able to do so on their own.

quotations from their PV investor or supplier. Secondly, this could lead to fewer projects getting halted as investors will have a better overview of expected costs of their project. Thirdly, a build-up of the costs can be useful in knowing on which components the cost disparities actually exists. If unaddressed, this might inhibit understanding of costs developments going on in the practical world. Making a breakdown of the total costs mandatory may lead to the assumption that it might not be effective as there is a possibility of fewer SDE+ applications due to the perceived increased work. On the other hand, the benefit of this might be a reduction in non-realized projects as investors would be more aware of the total costs. Additionally, it could lead to more serious SDE+ applications. The downside side is that it will require more administrative work from RVO and more work for the investors. The results show that investors have relatively good insights into costs of the modules, inverters, and costs directly related to the installation of the system as several investors do ask quotations from their PV supplier or installer. If investors already ask for quotations while making the cost estimation, submitting it to RVO might not be a problem. Furthermore, as the project realization term for projects smaller than 250 kWp is shortened to 1,5 years, investors are compelled to do part of the preparation of the project prior to applying for SDE+. This could mean that even more investors will ask quotations from their PV supplier or installer.

According to the results, the estimated investment costs hardly differ from the costs after project realization as the investors stated that it is easy to get an indication of the costs. This indicates that these costs could possibly be used by policy makers to get an indication of the investment costs needed by investors. However, the cost estimation which some investors with intermediaries submit might not be reliable and reflective of the 'actual' costs as some intermediaries seemed to use a standard cost estimation per Wp for different projects as mentioned before. This might be the case if the intermediary is an advisory institution and the costs are estimated by intermediaries. Therefore, before the actual impact of using these values is known, the information provided by such intermediaries needs careful interpretation.

The findings of the study reveal how the construction of a grid connection for large scale consumers can be the reason for projects with high costs. To avoid cost increases due to this, the current minimum capacity of 15 kWp[23] for which SDE+ can be requested, can be increased. Investors who request subsidy for a capacity of 15 kWp are usually small companies or investors who do not have a grid connection for large scale consumers. Another option could be to make the SDE+ only for investors with a large scale grid connection as currently investors are still applying for SDE+ despite that it is made known by RVO beforehand that a grid connection for large scale consumers is mandatory and might involve high costs. This can 'filter out' projects for whom the SDE+ is actually not intended in the first place. However, the down side of this will be that even investors who are willing to pay for these costs would be exempted from the SDE+ in case a line would be officially drawn between whether the investor has an existing grid connection for large scale consumers or not.

[23] This applies to the SDE+ category "solar PV".

6. Conclusion

Despite the reduction in mean costs over the years, renewable energy technologies have to cope with disparities in investment cost. To analyze what the causes for these disparities are, a case study of the disparities encountered in investment cost within the Netherlands was conducted. The investment costs were derived from the costs solar PV investors indicated when applying for SDE+, the Dutch subsidy incentive for renewable energy technologies. The main research question this research aimed to answer was: *"What causes disparities in investment costs of renewable energy technologies and what does this mean for renewable energy support systems?"* Interviews were conducted with intermediaries, who were advisors to solar PV investors for part or the whole project, and the investors themselves. The findings in this research support the notion that there is fact not one price which represents the investment costs of solar PV systems. Projects differed due to legitimate reasons and not necessarily because investors indicated the investment cost without a grounded basis. Many factors were found to act as price shifters of PV systems. However, the importance of these factors differs. The most influential cost-increasing factors were the grid connection for large scale consumers, differences between buildings and the choice of PV technology. The most influential cost-decreasing factors were the do-it-yourself approach, the search for cheaper options and experience from previous projects. While these factors were the most influential ones, other factors could also lead to disparities in combination with several factors such as the willingness to pay, PV mounting system, roofs with shading, orientation of the panels, and the included cost components in the estimation. These results are based on a limited number of SDE+ projects and can therefore not be generalized. Additionally, for some factors, the impact could not be determined such as the reliability of the information, the role of the intermediary and the varying methods used for estimating the costs. Given that the impact of these factors are yet to be determined, self-reported information does require careful interpretation and usage for renewable energy support schemes and other purposes.

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8. Appendix

A: Applications per category

Autumn application round (2016)	
Category (kWp)	Number of applications
15-30	146
30-50	187
50-100	453
100-250	662
250-500	428
500-1000	71
1000-2000	56
2000-5000	38
5000-100000	19

B: Application form

The application form contains the following details:

- Firm name and other personal details of the applicant
- Name and contact information of the intermediary in case one is involved
- Amount for which subsidy is applied for (€/kWh)
- Phase for which the SDE+ is applied
- Location of the production installation
- Total production capacity for which the subsidy is applied for (kWp)
- Whether the firm applied for multiple SDE+ applications for that round and whether they exceed 500kWp
- Whether the production installation will be a ground-mounted system
- Whether the production is an extension of an existing installation
- Whether the production installation will be a replacement of an existing installation or renovation will take place of existing system
- Whether or not permits will be needed which have to submitted as well (this applies for ground mounted systems)
- Project planning
- Expected total investment costs (in €)
- Percentage own capital which will be used
- Whether the applicant applied for SDE+ before
- Whether MEP has been used before.

C: List of intermediaries

Table 5. Participants (intermediaries). Interviews are listed in order of the date of the interview.

Reference number	Description of the company	Date interview	Type of interview
1	Provides advice regarding renewable energy generation, energy saving options, sustainable mobility. Within solar energy 2 types of projects are done: SDE+ and postal code subsidy (Postcoderoos) where clients can choose to lease their roofs to the consultancy firm.	18-06-2018	Personal
2	Provides advice for organizations in the Netherlands and other European countries regarding all possible European subsidy measures	05-07-2018	Personal
3	Specializes in providing information on subsidy opportunities and acquiring grants regarding real estate, industry, housing association, agriculture and ICT	20-07-2018	Personal

D: List of investors

Table 6. Participants (SDE+ applicants). Interviews are listed in order of the investments level from low to high and the presence of an intermediary

Reference number	Type of company	Interviewee	Investment costs	Intermediary	Date interview	Type of interview
1	Bindery	Company owner; involved in whole project	Low	No	22-06-2018	Personal
2	Organic milk producing farm	Farm owner; involved in whole project	Low	No	16-07-2018	Personal
3	Real estate company	Owner/director	Low	No	21-08-2018	By phone
4	Car retail company	Project leader	Low	Yes	20-07-2018	By phone
5	Supermarket	Project leader	Average	No	23-07-2018	Personal
6	Damaged car repair company	Project leader	Average	Yes	26-07-2018	By phone
7	Health care institution	Facility and sustainability coordinator; involved in SDE+ application	High	No	04-07-2018	By phone
8	Technological company	Involved in project development and realization	High	No	10-07-2018	Personal
9	Sport club	Treasurer of the club; involved in application of SDE+ and realization of the project	High	No	24-07-2018	Personal
10	Health center	Organizes facility, housing and ICT affairs; not directly involved in the SDE+ application	High	Yes	29-06-2018	Personal
11	Municipality	Involved in project development	High	Yes	03-07-2018	Personal

E: Histogram (spring round SDE+2017)

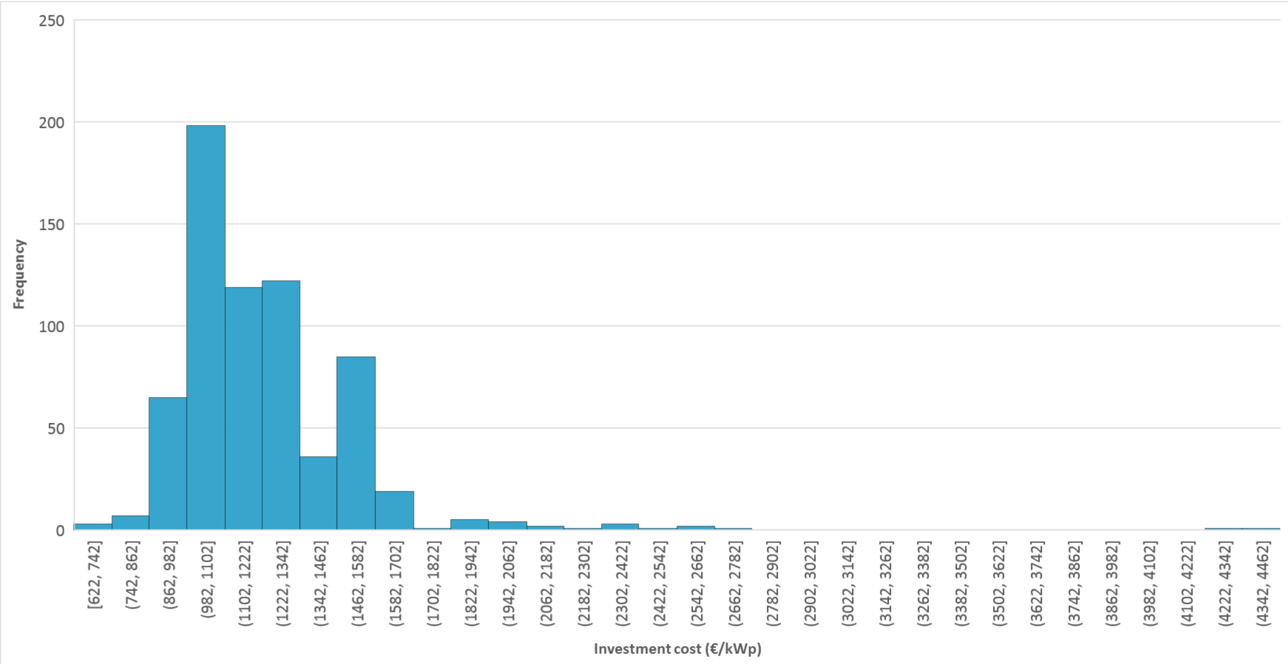

Figure 8: Distribution of the number of applications per investment cost category (Spring round SDE+2017). *Source: Created with data from RVO (2018).*

F: Interview questions for intermediaries

Introduction

1. Can you tell me a bit about this company and your position in this company?
2. Do you often have cases where firms ask advice for SDE+ applications?
3. Can you tell me how this process for SDE+ application comes together (e.g. how firms usually approach you) and what your main tasks are within this?

Cost estimations

4. Can you describe how the investment costs are estimated?
5. Are the investment costs which are estimated by intermediaries used by firms? Or do they in the end fill in their own costs in the application forms?

Role of the intermediary

6. Some investors do not hire an intermediary. What do you think are the reasons for this? Do you think that this will affect the investment costs that are estimated?

Disparities in costs

7. Did you notice differences in costs estimations for small PV projects? What do you think are the reasons for this?

Project realization

8. After approval of the SDE+ application do many projects get realized or are many projects halted? If (some) projects are not continued, what are the reasons for that?
9. To what extent are the total investment cost estimated prior to the project realization accurate and where does overestimation or underestimation of costs occurs?

G: Interview questions for investors

Introduction

1. Can you tell me how this process for SDE+ application came together and what your tasks were in this process?
2. Was this the first SDE+ application or PV project?

Cost estimations

3. Who was responsible for estimating the investment costs? Was the result of this used for the SDE+ application form?
4. Can you describe how the investment costs were estimated? Which costs were included in the estimation? Were certain criteria used to select system components such as solar panels?
5. Was a feasibility study conducted?

Role of the intermediary

6. Was an intermediary involved in the SDE+ application process? What were the tasks of the intermediary in this process?
7. What were the reasons for (not) hiring an intermediary?

Disparities in costs

8. The average costs within the SDE+ 2017 were around 1 euro/Wp. What do you think are the reasons that you estimated higher, lower or the same project costs?

Project realization

9. Is the project already realized?
   a. Yes: To what extent do the estimated costs differ from the actual costs? For which cost components were the costs overestimated or underestimated?
   b. No: What are the reasons that the project is not (yet) realized?

H: List of cost components

Which cost components are included in the estimation of the investment costs for your solar PV project? Please note that this value is what has to be filled in the application form of RVO. If a certain cost component is included, it can be indicated with ‘yes’ after the mentioned cost component and if a certain cost component is not included it can be indicated with ‘no’ including the reason for not including this cost component such as ‘forgotten’, ‘did not know’ or ‘not needed’.

- ☐ Modules
- ☐ Inverters and transformers
- ☐ Replacement of inverters
- ☐ Insurance
- ☐ Permits
- ☐ Installation costs
- ☐ Mounting and fixing materials
- ☐ Consultancy costs (for intermediary)
- ☐ Maintenance costs
- ☐ Legal costs
- ☐ Production meter
- ☐ Earth leakage circuit breaker
- ☐ AC connection of the inverter to the fuse box
- ☐ Connection of solar panels on the fuse box
- ☐ Costs for constructing a new grid connection for large-scale consumers
- ☐ Costs for expanding the current grid connection for large-scale consumers
- ☐ Monitoring system
- ☐ Unforeseen costs
- ☐ Other costs, namely………..

I: Coding framework

To illustrate the coding process, an example of a fragment of the transcript is presented. In table 7, the approach of assigning themes to sections of the transcripts can be seen. Some codes or themes were developed during the literature review. Open coding was used to label text sections with the main topics of the coding such as PV mounting system, grid-connection or expansion, PV cell technology and so forth. Other codes were developed while assigning codes to the transcripts. These codes were initially grouped as “others”. This coding group contained statements through which new codes could be developed. For instance, from the code “others” as seen in table 6 the codes “payback period” and “reason for PV” were developed both of which were grouped into one singular code “willingness to pay”.

Table 7. Initial coding of the transcripts

Transcripts	Initial codes
Interviewer: Did you also need a grid-connection for large scale consumers?	
Investor: The connection had to be expanded. We already had a grid connection, but the capacity was not enough. We discovered that with existing locations we always have to check whether the capacity is sufficient if we want to install solar panels. Sometimes, you also need to put a transformer on the location if you have to expand your fuse box. And that would be totally our own costs. Therefore, we have the choice then to put fewer panels for the sake of having a decent business case. Because if you have to put a transformer is place, it becomes less interesting. Anyway, we had a payback period of 8 years.	Grid connection or expansion Other: Payback period; reason for solar PV
Interviewer: And did you find this payback period acceptable?	
Investor: Yes definitely. We get SDE+ subsidy for 15 years, thus if you earn it back in 8 years it is feasible and it also sustainable. We are a commercial firm, thus it is also good for our image.	Other: Payback period; reason for solar PV

After open coding, axial coding was conducted. The coded fragments were transmitted to an Excel spreadsheet. The data of this was organized by linking each code with each investor. This made it possible to have an overview of what each investor stated on each code/factor. In the table 8, an example of axial coding can be seen. This is conducted for the factor “varying methods”. It can be read as investors 1 estimated the investment costs based on input from the PV supplier and no quotations were used, investor 2 based the investment costs on recently bought panels, while investor 3 used quotations.

Table 8: Example of axial coding

Codes	Investor 1	Investor 2	Investor 3	…
Varying methods	PV supplier, no quotations	Recently bought panels	Quotations	…
…	…	…	…	…