The Role of Power Purchase Agreements in the Financing of Solar Parks

Insights from the Dutch Case

MSc Thesis Construction Management & Engineering

Tom Hoogstede

Delft University of Technology

TU Delft

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by

Tom Hoogstede

Chair Committee TUD:	Prof. dr. ir. J.W.F. Wamelink
First Supervisor TUD:	Dr. Z.J. Taylor
Second Supervisor TUD:	A.A. Ralcheva
First Company Supervisor:	W. de Graaf
Second Company Supervisor	ir. M. ten Cate

Preface

As someone interested in energy, finance, and the built environment, choosing a thesis topic at the intersection of these domains was an exciting but challenging decision. I sought to explore a subject that would allow me to work at this intersection, but I quickly discovered that choosing a subject based on interest rather than existing knowledge came with its own set of difficulties. The learning curve was steep at times, yet it offered me the opportunity to dive deeper and stretch my understanding. Initially, I anticipated a more quantitative approach, but as the research developed, I found myself diving into a qualitative methodology, pleasantly surprised by how engaging and insightful interviews can be. They provided perspectives that enriched my understanding of the field and even helped me with orientating potential career paths.

Following this, I would like to extend my gratitude to the persons who made the aforementioned possible, starting with my TU Delft supervisors. First and foremost, my thanks go to my primary supervisor, Zac Taylor. Your expertise, flexibility, and kindness, along with conveying your message that struggle is an integral part of the research process, made this journey not only manageable but enjoyable. I also want to thank my second supervisor, Aleksandrina Ralcheva, for her direct approach, critical insights, and availability. It has been a pleasure working with both of you, as we have already discussed how our dynamic as a 'team' brought out the best during this thesis process. Finally, I would like to thank Hans Wamelink, my committee chair, for steady guidance throughout the process and official meetings.

I am equally grateful to my PwC supervisors, Willem de Graaf and Max ten Cate, for your support in helping me refine the direction of my research and for letting me take up so much of your time. Your pragmatic advice, realistic perspectives, and typical consultancy insights provided a grounding that was incredibly valuable. I would like to thank the entire Capital Projects & Infrastructure team for their interest in my work and for creating an inspiring and supportive environment. Special thanks to my fellow intern, Merel van 't Hoen, for the "gezelligheid" that made my days at office all the more enjoyable.

To everyone I interviewed, thank you for sharing your time, experiences, and perspectives. The conversations were not only enlightening but also thoroughly enjoyable, making the research journey even more rewarding.

Finally, I extend my thanks to my family, roommates, and friends. Your support, encouragement, and reality checks have been invaluable in guiding me through this process.

I hope you enjoy the result!

Tom Hoogstede
Amsterdam, November 2024

Executive Summary

The Netherlands faces the task of increasing renewable energy production to meet its climate goals, as outlined in the Paris Agreements and the national Climate Agreement. Solar PV electricity plays a central role in achieving the targets of reducing CO2 emissions by 55% by 2030 and reaching climate neutrality by 2050. However, despite the initial momentum, recent reports indicate that the country's long-term solar PV growth is stagnating. Key barriers include regulatory challenges, grid capacity limitations, and financial uncertainty following the scheduled termination of the SDE++ subsidy scheme. The SDE++ has provided financial stability for renewable energy projects by covering the unprofitable component of their business models. With its phase-out, the future financing of large-scale solar PV projects faces risk, potentially threatening the realization of national energy goals.

In light of this challenge, this thesis investigates whether Power Purchase Agreements can serve as an alternative to mitigate the uncertainty left by the SDE++ scheme's planned termination. PPAs are long-term contracts between energy producers and offtakers that offer predictable revenue streams, which is important for securing project financing. The Dutch offshore wind sector has demonstrated success in transitioning to subsidy-free projects through the use of PPAs, forming the basis for this thesis to explore whether similar success can be achieved in solar PV. By examining the role of PPAs to provide financial stability and replace government subsidies, the research aims to fill a significant knowledge gap in the renewable energy context in the Netherlands, addressing the main research question:

"What is the role of Power Purchase Agreements in mitigating financial uncertainty in large-scale solar PV projects in the Netherlands?"

Methodology

Scoping it down to project finance and corporate PPAs, the research strategy for this thesis adopts an exploratory approach to address the relatively new topic. It uses a qualitative research approach, combining desk research and semi-structured interviews with industry professionals. This mixed-method approach allows for triangulation to ensure a comprehensive understanding of the research problem. The primary goal of the desk research phase is to develop a theoretical framework based on the research subquestions, which in turn forms the foundation for the research's propositions.

These propositions are central to the research strategy as they help digest the theoretical framework. The propositions are built off one another and shape the interview questions, which are then translated into an interview protocol. The interviews are designed to validate or challenge the propositions while allowing for new insights to be included into the thesis. The validation phase of the research incorporates a total of 14 semi-structured interviews with professionals involved in the financing of solar PV projects in the Netherlands, ranging from policymakers to lenders.

Theoretical framework

The framework begins by addressing the reliance of solar PV projects on debt financing. Given the capital-intensive nature of these projects, securing funding through debt is essential, and this process depends on the project's ability to meet specific bankability criteria set by lenders. To enhance bankability, mitigating price risk becomes crucial, as reducing exposure to market price volatility can make

projects more attractive to lenders and thus influence the availability of debt.

The framework further explores the roles of support schemes and PPAs in de-risking solar PV investments by stabilizing revenue streams and ensuring predictable returns. While feed-in schemes like the SDE++ reduce price risks, corporate PPAs offer similar long-term revenue stability. However, PPAs allocate this price risk to private private offtakers, requiring additional risk mitigation. Specific PPA structures, such as those with Pay-as-Produced volume paired with fixed pricing, can enhance bankability but emphasize the importance of the creditworthiness of the offtaker. The framework also highlights broader systemic challenges, including market cannibalization, uneven playing fields created by PPAs, and the financialization of renewable energy, which may hinder solar PV development in the Netherlands.

These insights result in the following list of propositions, each building upon the previous:

- P1: Dutch solar PV projects are reliant on debt financing.
- P2: Mitigating price risk enhances solar PV project bankability.
- P3: A Feed-in-Tariff premium mitigates price risk for a solar PV project.
- P4: A corporate PPA mitigates price risk for a solar PV project.
- P5: Since a private offtaker is involved, a corporate PPA requires mitigating additional risks to achieve the same level of bankability as a Feed-in-Tariff premium.
- P6: A Pay-as-Produced volume structure combined with a fixed price or a price floor pricing mechanism increases PPA bankability.
- P7: PPAs alone cannot lead to the desired development of solar PV projects in the Netherlands.

Results

The interview results show several challenges and trends in the financing of large-scale solar PV projects in the Netherlands. One of the most pressing issues identified is the increasing frequency of negative price hours, which threaten the business case of solar projects by reducing or eliminating revenue during periods of grid congestion and oversupply. This phenomenon is increased by the growing solar capacity, which leads to market saturation during peak generation times.

Interviewees emphasized the role that the SDE++ subsidy scheme has played in mitigating price risk and ensuring bankability. However, the SDE++ does not provide financial support during periods of negative pricing, leaving projects vulnerable when prices fall below zero. This limitation calls for market-based alternatives like PPAs. As the SDE++ is phased out, challenges in securing financing can arise, as banks have grown accustomed to the long-term revenue stability the subsidy provides and both developers and equity investors have grown accustomed to advantageous project gearings. PPAs, while viewed as a potential replacement for subsidies, face adoption barriers due to the limited creditworthiness and demand from corporate offtakers in the Netherlands. This issue is further compounded by the relatively small scale of Dutch solar PV projects, which struggle to attract large, reliable offtakers for long-term contracts.

The discussion of these results (partially) validates the propositions. The reliance on debt financing for Dutch solar PV projects was confirmed, as well as the essential role of price risk mitigation in enhancing bankability. The SDE++ continues to provide a stable foundation for financing, but its phase-out and inability to address negative price hours present new risks that PPAs are not yet fully equipped to handle on their own. Long-term PPAs with Pay-as-Produced structures and fixed price mechanisms offer comparable risk mitigation characteristics, but market challenges related to offtakers and their creditworthiness limit their ability to replace subsidies. The findings show that while PPAs currently complement the SDE++, allowing for a higher project gearing, the Dutch solar PV market is not yet ready to rely on them entirely.

Putting these findings in a broader context, they imply that other and additional strategies and measures, such as a PPA guarantee fund and a restructuring of Dutch debt models, could be necessary to ensure the financial viability of future solar PV projects. However, there are limits to these de-risking measures, as they cannot fully address systemic market issues like negative prices. The consequent shift in financing conditions could increase the overall cost of energy, burdening end-users. The findings also highlight a duality to financial innovations like corporate PPAs: while they offer a promising route to manage price risk in a subsidy-free market, they also introduce new layers of complexity and risk into renewable energy financing. As the renewable energy sector becomes more financialized, balancing risk management with cost containment remains a challenge for the transition.

The thesis has both data-centred and scope-centred limitations. The narrow range of developer perspectives and the qualitative nature and interpretive analysis of the research may limit the generalizability of the findings and may introduce bias. Additionally, confidentiality concerns restricted the depth of insight into specific PPA strategies. In terms of scope, the thesis focuses on traditional project finance mechanisms, meaning innovations were not included. Lastly, while the thesis provides a solid foundation for understanding the role of PPAs in Dutch solar PV financing, its findings may not be directly applicable to other countries and contexts.

In conclusion, the findings indicate that PPAs are currently used alongside subsidies, rather than as a standalone solution, as the Dutch market is not yet fully mature for a subsidy-free model. Issues such as the scarcity of creditworthy offtakers, the smaller scale of solar projects, and the increasing occurrence of negative price hours were identified as key challenges limiting the adaptation of PPAs. Recommendations for future research include exploring the bundling of smaller projects to attract larger offtakers, investigating the role of smaller offtakers in the PPA market, and evaluating policy interventions and their impact on the cost of energy. Furthermore, studies should continue to examine alternative financing structures, such as those used in other European markets, and hybrid solutions like battery storage, to address the challenges of intermittency and negative price hours.

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Introduction

1.1. Context

In 2016, the European Union, including the Netherlands, signed the Paris Agreements with as central goal to limit the heating of planet earth (Ministerie van Infrastructuur en Waterstaat, 2023). In pursuit of this goal, the Netherlands signed the Climate Agreement envisioning 55% CO2 reduction in 2030 as well as climate neutrality in 2050 (Ministerie van Economische Zaken, Landbouw en Innovatie, 2020). As can be seen in Figure 1.1, the share of energy produced from renewable energy sources has to increase over the coming years to realise these goals.

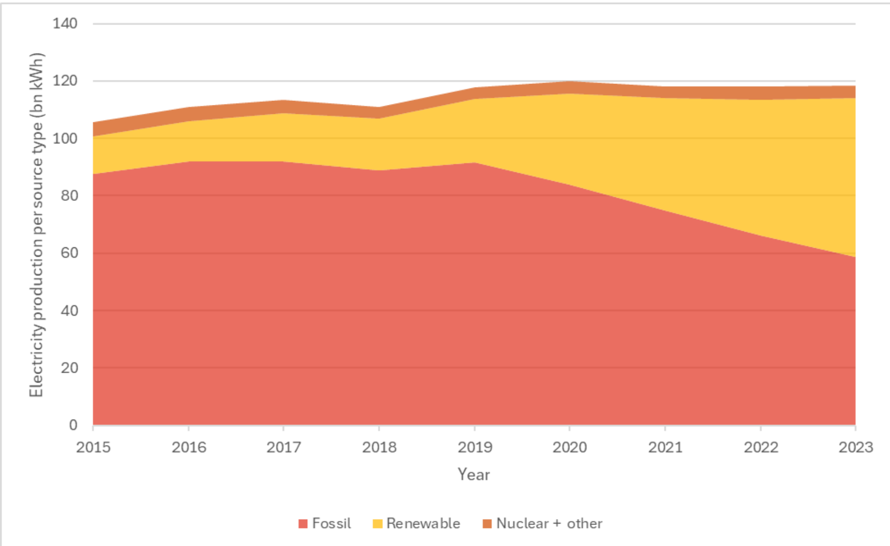

Figure 1.1: NL Electricity Production per Source Type (CBS, 2024)

The goals as set in the Climate Agreement state that the ambition for large-scale (> 15 kW) onshore electricity generation is at least 35 TWh production by 2030 (Ministerie van Economische Zaken en Klimaat, 2019), coming from both wind energy and solar PV energy. This 35 TWh generation goal has even been ‘outbid’ by the 30 RES-regions in their RES 1.0 and determined their total bid at 55 TWh (Planbureau voor de Leefomgeving, 2023), forming a brand-new ambitious goal. The combined bid for solar PV is 26 TWh, consisting of 12.6 TWh large-scale rooftop solar PV, 11.6 TWh solar on-field and 2.1 TWh unspecified. However, in the more recent Monitor RES 2023 it becomes clear that, although the original 35 TWh is still achievable, the aimed total bid of 55 TWh is not in sight as the needed long-term growth is stagnating (Planbureau Voor de Leefomgeving, 2023). The PBL identifies that one of the reasons for this stagnation is the increasing delay in the realisation of solar parks.

The reasons for this slowdown (Planbureau Voor de Leefomgeving, 2023) can be identified as:

1. **Regulatory and land-use challenges**: One of the primary hurdles has been the increasingly complex regulatory landscape. The process for obtaining permits for large-scale solar projects has become more cumbersome, with local and regional governments often having different requirements and priorities when it comes to land-use.
2. **Grid capacity limitations**: The Dutch electricity grid is facing capacity issues, particularly in areas with high potential for solar energy generation. This grid congestion has led to delays and uncertainties in connecting new solar parks to the grid, hindering their development.
3. **Financial uncertainty**: The Stimulation of Sustainable Energy Production and Climate Transition Initiative Scheme (SDE++) provides subsidies for technologies that either generate renewable energy or reduce CO2 emissions (Rijksdienst voor Ondernemend Nederland, 2023). However, this scheme is scheduled to end, paired with uncertainty if any financial backing at all will be available (Planbureau Voor de Leefomgeving, 2023).

While efforts are being made to address the regulatory and grid capacity issues, such as through the National Action Program on Grid Congestion (LAN) and new policies for land-use planning (Autoriteit Consument & Markt, 2022; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2023; Ministerie van Economische Zaken en Klimaat, 2022), these challenges primarily involve technical, legal and political considerations that are beyond the scope of this research. On the other hand, the termination of the SDE++ scheme creates financial uncertainty that can be more directly influenced through academic research focused on economic policy and market-based solutions. Regarding the financial uncertainty, the only fact that is addressed is the need for certainty after the SDE++ termination, while this is being considered as a condition for further streamlining of the policy processes (Planbureau voor de Leefomgeving, 2023). The letter to parliament speaks of a rather vague 'lighter version of support but with sufficient investment security to make sure the roll-out does not stagnate' (Ministerie van Economische Zaken en Klimaat, 2023). Given the adaptability of financial structures and mechanisms, this thesis will concentrate on addressing financial uncertainty as a key barrier to the continued development of large-scale solar PV projects in the Netherlands.

The SDE++ covers the "unprofitable component," which is the difference between the technology's cost (base rate) and the market value of the produced energy or CO2 reduction (corrective amount) (Rijksdienst voor Ondernemend Nederland, 2023). When the SDE++ scheme is terminated, it will lead the loss of the long-term certainty provided by the base rate, calling out for a replacement in the solar PV business case.

1.2. Research Problem and Objectives

With the scheduled termination of this scheme, the Netherlands faces a gap in financial support for large-scale photovoltaic projects. This poses a threat to achieving national renewable energy targets and undermines the country's commitment to international climate accords. As solar PV projects are needed for meeting these commitments, there is a need to explore alternatives that can ensure the continuous and stable funding of solar energy projects.

In early 2018, the Netherlands achieved a world first with the launch of the initial subsidy-free tender for offshore wind farms (Hollandse Kust Zuid Sites I and II), with energy company Vattenfall winning the tender to deliver energy by 2022 (RVO, 2024). In 2019, Vattenfall won another subsidy-free tender for Hollandse Kust Zuid Sites III and IV. Unlike earlier projects, which still received subsidies for the electricity produced, all revenue for these new offshore wind farms must be generated from electricity sales on the energy market. Recently, Vattenfall signed a new 15-year Power Purchase Agreement (PPA) with Air Liquide for 115 MW of installed capacity from the Hollandse Kust Zuid wind farm, starting from 2026 (Vattenfall, 2024).

PPAs are tools in the grid-based power market, offering a structured approach for wholesale energy companies to acquire exclusive rights to a portion or all of an energy provider's electricity output (Ottinger & Bowie, 2015). These agreements enable facility owners to secure necessary project financing by establishing a steady revenue stream. Given the scheduled phase-out of the SDE++ scheme for solar PV, exploring PPAs as replacement could be beneficial. If the offshore wind sector can leverage PPAs to become subsidy-free, then similar success could be possible for large-scale solar PV projects in the Netherlands, ensuring their continued development and contribution to national renewable energy targets. This thesis, therefore, focuses on investigating the applicability and impact of PPAs in mitigating financial uncertainties for Dutch solar PV projects as government support diminishes.

Earlier literature on PPAs has predominantly focussed on PPA pricing, leveraged cost of energy calculations (LCOE), optimization of generated energy forecasts, and influence of credit risk ratings. In their research on the link between PPAs and LCOE in wind energy projects, Miller et al. (2017) state the importance of PPAs in securing long-term revenue streams necessary for the financial feasibility of wind projects, as lenders often require PPAs that span the term of the loan or longer. The paper highlights the importance of understanding the detailed components of LCOE and PPAs, such as contract length, energy delivery limits, penalties, and various pricing structures like fixed-price or fixed-escalator. It argues that a deeper understanding of these elements can lead to more effectively negotiated PPAs, ensuring projects are financially viable and meet the specific objectives of all parties involved. Similar research by Bruck et al. (2018), also focussing on a new LCOE calculation within wind energy projects, including PPAs and a wind energy case study, resulted in similar conclusions.

A fictive wind park case study was used in work by Hundt et al. (2020), where the role of PPAs in financing RE projects is researched in the context of decreasing reliance on government subsidies and focusses on credit risk ratings. It shows that the pricing of PPAs is closely linked to the financing of RE projects. The creditworthiness of the off-taker (the entity purchasing the power) significantly influences the investment return rate (IRR) and the financial leverage of the project. Companies with lower credit ratings, termed as speculative grade, must pay higher PPA prices to compensate asset owners for the associated risks and lower financial leverage.

When scoping it down to PPA useage in PV projects, the majority of research focusses on energy forecasts, predictive modelling, and data optimization for bankability (Gueymard, 2014; Mesa-Jiménez et al., 2023; Vignola et al., 2012). Different PPA structures, most of the time with emphasizing flexibility, have also been quantatively explored. Both Ghiassi-Farrokhfal et al. (2021) and Jain (2022) show new, flexible PPA structures for intermittent RE, incorporating storage, for mitigating financial uncertainty. These approaches address the daily and seasonal variability of solar PV generation, which traditional yearly PPAs often fail to manage effectively.

PPAs have been well-studied within the wind energy sector and there seems to be no discussion on their role in securing long-term revenue streams. However, there remains a gap in understanding and documentation of how these agreements impact the financial stability and attractiveness of large-scale solar PV projects in the Netherlands. This gap is particularly evident in the context of:

- the adaptation of PPAs to address the challenges of Dutch solar PV projects specifically;
- the potential for PPAs to provide financial stability in an environment where government subsidies are reducing;
- how different PPA stuctures impact the financial feasibility of Dutch solar PV projects differently.

The identified knowledge gap leads to the following main research question:

MRQ: ***What is the role of Power Purchase Agreements in mitigating financial uncertainty in large-scale solar PV projects in the Netherlands?***

To fully address the main research question, several sub-questions have been developed:

SQ1: *How are large-scale solar PV projects typically financed, and what factors influence decision-making during the financing process?*

This subquestion examines the project financing structures used in large-scale solar PV projects, focusing on the importance of debt. The research explores the criteria used by investors and lenders to assess project bankability, as well as the risks that impact financing decisions.

SQ2: *What is the role of support schemes and Power Purchase Agreements in the financing of large-scale PV projects in the Netherlands?*

This subquestion investigates the de-risking capabilities of PPAs and government support schemes like the SDE++.

SQ3: *How does financial decision-making differ when using a Power Purchase Agreement compared to a support scheme, and what are the best practices and challenges associated with Power Purchase Agreements?*

This sub-question focuses on comparing the financial decision-making processes when using PPAs versus traditional support schemes. It analyses different types of PPAs and their associated risks and mitigation capacities, providing insights into their application in the Dutch solar PV sector. It also explores the broader challenges PPAs both introduce and face.

The aim of this thesis is to examine the role of PPAs in the financing of large-scale solar PV projects in the Netherlands, with a particular focus on their potential to mitigate financial uncertainty. This is especially relevant in light of the upcoming phase-out of the SDE++ subsidy scheme, which has historically provided financial stability for renewable energy projects. By focusing on the Dutch context, this research contributes to the understanding of how PPAs can be used to address the specific challenges faced by PV projects in a market characterized by increasing negative prices and demand issues.

Additionally, this thesis provides an analysis of how PPAs compare to traditional support schemes in terms of securing long-term revenue streams and enhancing the bankability of solar PV projects. While PPAs have been extensively studied in the context of wind energy, their application to solar PV projects in the Netherlands remains underexplored. This research seeks to fill that gap by exploring how PPAs can be tailored to suit the Dutch solar PV market as it transitions away from reliance on the SDE++.

1.3. Report Outline

In chapter 2 the background information for the thesis is provided by introducing the different types of PPAs, the focus on corporate PPAs, the SDE++ subsidy scheme, and project finance. It sets the foundation for understanding the financial structures and challenges that will be analysed later and it further scopes the research.

Next, chapter 3 outlines the research strategy, which uses a mixed-method approach including desk research and semi-structured interviews with 14 experts. This chapter describes the role of the propositions derived from the literature and how they will be validated through thematic analysis of the interview data. In chapter 4 the theoretical framework is developed, exploring project financing and risks in solar PV projects, particularly how price risk can be mitigated or allocated through subsidies and (different configurations of) PPAs. This chapter formulates propositions that guide the research further in terms of interview questions and are validated in subsequent chapters.

The interview results are presented in chapter 5, focusing on the practical aspects of financing Dutch PV projects, the roles of SDE++ and PPAs, and systemic challenges such as fluctuating electricity demand and policy changes. These findings are aligned with the propositions for further validation in chapter 6. There, the validation of the theoretical framework and propositions is disucssed, analysing key issues like negative price hours, the phase-out of SDE++, and the limitations of PPAs. It offers insights and implications for project financing and public de-risking. The empirical findings are linked to the theoretical framework.

Lastly, the thesis is concluded by anwswering the main research question using the findings, emphasising that while PPAs can reduce price risk, they currently mostly complement the SDE++ rather than replace it. The chapter highlights the market's readiness challenges, such as the scarcity of creditworthy offtakers, and recommends further research on bundling smaller projects, policy interventions and integrating storage solutions.

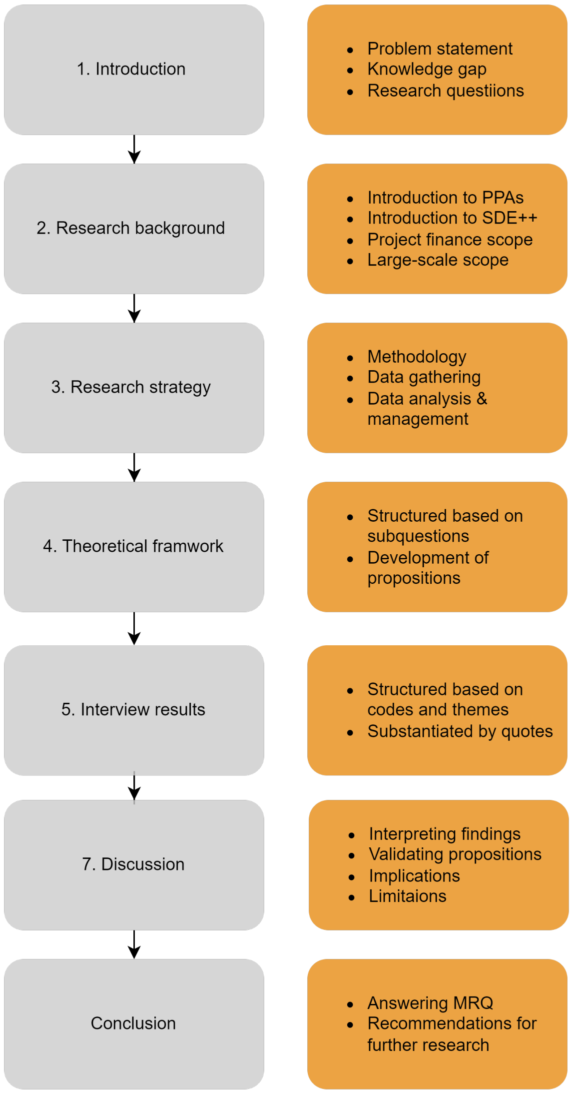

Figure 1.2: Thesis Report Outline (Autor's figure)

2
Research Background

This chapter of the thesis provides background information and sets the stage for the scope of the research. It covers Power Purchase Agreements PPAs, explaining the different types, its focus on corporate PPA and the players involved. It also introduces the SDE++ mechanism, which is important for understanding the subsidy that is to be replaced. The chapter elaborates on project finance as a method for financing renewable energy projects, which is the center focus of this thesis. It also outlines the distribution of the capacity of solar energy projects in the Netherlands, which identifies the scale of Dutch solar energy projects eligible for project finance.

2.1. Introduction to Corporate Power Purchase Agreements

A PPA is a long-term contract to buy electricity from a producer (Thumann & Woodroof, 2021). According to Hollmen et al. (2022), there are two primary categories of PPAs: corporate PPAs and utility PPAs, where in the case of corporate PPAs, the corporate offtaker enters into a direct contract with the power producer. In contrast, utility PPAs involve the offtaker working with a utility company or electricity trader. Hollmen et al. (2022) state corporate PPAs represent the majority of PPAs.

Unlike utility PPAs, which are typically tied to constant baseload energy demands and indexed to volatile spot market prices, corporate PPAs offer more predictable and secure financial arrangements (Christophers, 2022). Moreover, utility PPAs differ from cPPAs as they involve agreements between utilities and offtakers, without directly financing energy producers or specific projects. Since this thesis focuses on PPAs as an instrument for mitigating uncertainty in renewable energy projects, utility PPAs fall outside its scope.

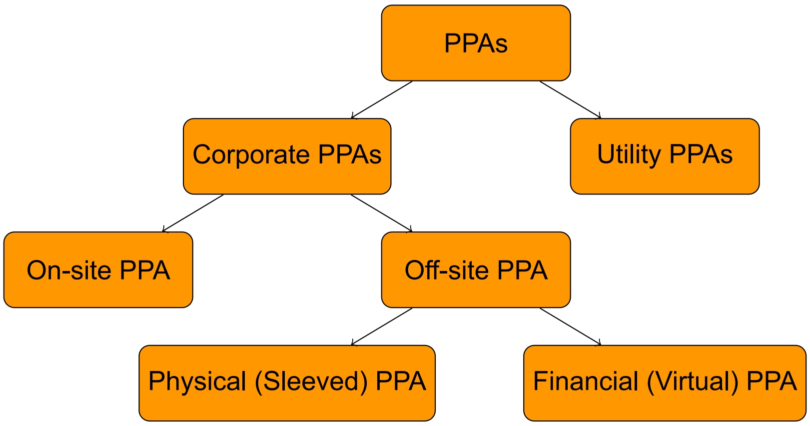

Figure 2.1: Different types of Power Purchase Agreements (Author's figure)

Hollmen et al. (2022) further categorise these corporate PPAs into on-site and off-site models. On-site PPAs (Figure 2.2) involve a third party operating and maintaining the power generation facility located close to the corporate offtaker, transferring the electricity directly (Hollmen et al., 2022).

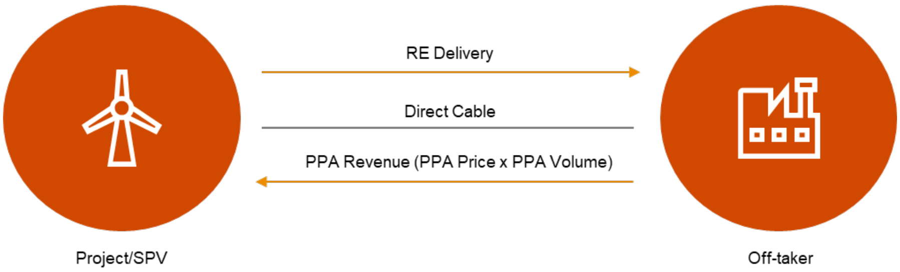

Figure 2.2: On-site Corporate PPA (Author's figure)

For off-site renewable power plants the cPPAs are typically structured as sleeved cPPAs and virtual CPPAs (Mendicino et al., 2019). In physical sleeved PPAs (Figure 2.3), electricity is transported through the grid to the offtaker (Hollmen et al., 2022). The final price for the electricity delivered is determined by the contracted PPA price plus transmission-related expenses.(Das & Malakar, 2021).

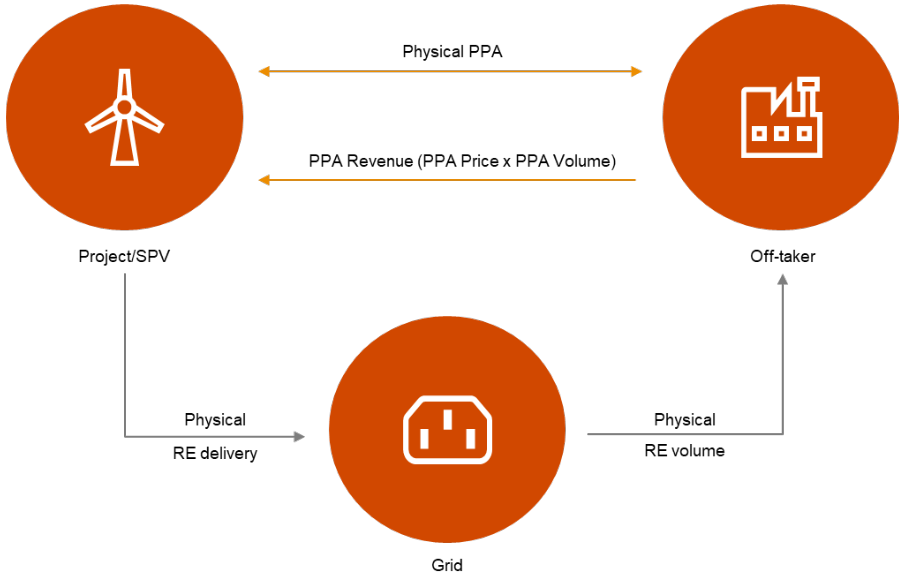

Figure 2.3: Off-site Corporate Sleeved PPA (Author's figure)

A virtual or financial PPA (Figure 2.4) acts as a Contract for Difference (Hollmen et al., 2022). This means that a strike price for electricity is set alongside a market reference price, where the offtaker compensates for the downward difference and the producer compensates the offtaker for the upward difference, as explained by Hollmen et al. (2022). Simpily put, unlike physical PPAs, virtual PPAs involve the transfer of cash rather than electricity. Additionally, virtual PPAs are generally easier to negotiate and involve lower transaction costs, making them more common than physical PPAs, particularly in the rapidly growing US market (Horsch & Hundt, 2022).

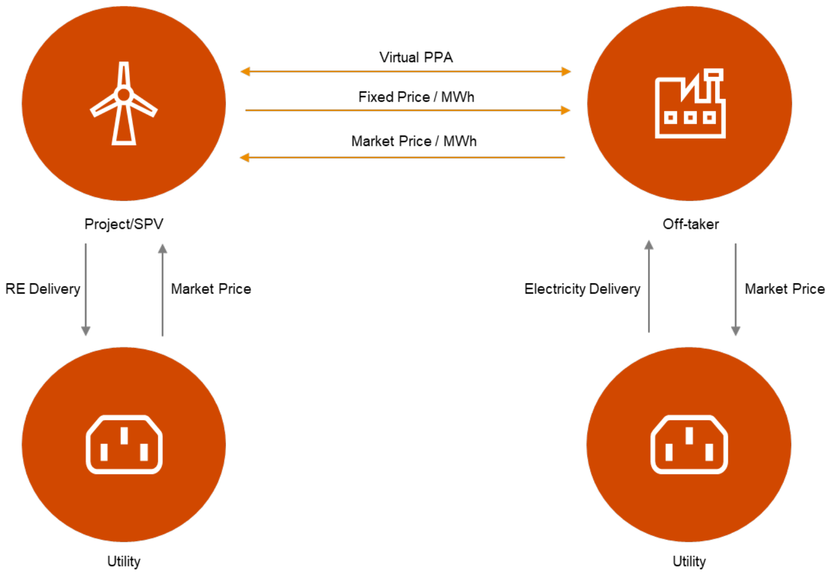

Figure 2.4: Virtual Corporate PPA (Author's figure)

The entities owning or managing renewable energy assets can be broadly categorized into four groups (Akinci & Ciszuk, 2021): independent electricity producers, larger utilities and energy companies, infrastructure investment companies, and renewable energy fund managers. For simplicity, these groups can be classified based on their primary motivations into two main categories: those focused on electricity production and those focused on investment and green value (Akinci & Ciszuk, 2021).

The first category, comprising independent electricity producers and larger utilities and energy companies, primarily aims to generate electricity and stabilize project prices through PPAs (Akinci & Ciszuk, 2021). These producers calculate marginal production costs, insurance, balancing costs, and aim for a specific rate of return.

The second category includes infrastructure investment companies and renewable energy fund managers, whose motivations extend beyond mere electricity production, aiming to add green values to their portfolios in response to growing client demand for green investments (Akinci & Ciszuk, 2021). They seek secure, long-term returns, which renewable energy projects like wind and solar can offer through PPAs (Akinci & Ciszuk, 2021).

Buyers of PPAs can be grouped into three categories: large multinationals, larger electricity and energy companies, and industrial customers (Janardhanan & Chaturvedi, 2021). Large multinationals, such as IKEA and Google, are characterized by high electricity consumption. These corporate off-takers enter into PPAs primarily for two key reasons. First, these agreements provide price stability and visibility, allowing companies to avoid the volatility of power prices, which is particularly valuable for these large electricity consumers (Christophers, 2022).

Second, PPAs with renewable energy producers enhance corporate green credentials, demonstrating a commitment to environmental sustainability (Akinci & Ciszuk, 2021) This helps meet corporate social responsibility goals and positions the companies as leaders in the transition to renewable energy, which can be a significant marketing and competitive advantage (Christophers, 2022). Buyers entering into renewable PPAs can claim that their contracted volumes come from renewable sources, even though the grid's actual electricity mix varies (Akinci & Ciszuk, 2021). This strategic adoption of PPAs has led to a substantial increase in corporate-driven renewable energy developments, notably in the U.S. and Northern Europe, and has become a major factor in the growth of the renewables market globally (Christophers, 2022).

2.2. Introduction to the SDE++ Subsidy Scheme

The SDE++ subsidy scheme in the Netherlands is designed to support renewable energy production and technologies that reduce CO2 emissions. It plays an important role in financing large-scale PV projects by mitigating the unprofitable component, which is the difference between the cost of sustainable energy production and the revenue generated (RVO, 2023).

The base rate is constant over the subsidy period, while the corrective amount is adjusted annually, based on market values. Therefore, when market values increase, the unprofitable component—and thus the subsidy—decreases. Figure 2.5 shows the mechanism for the SDE++ scheme.

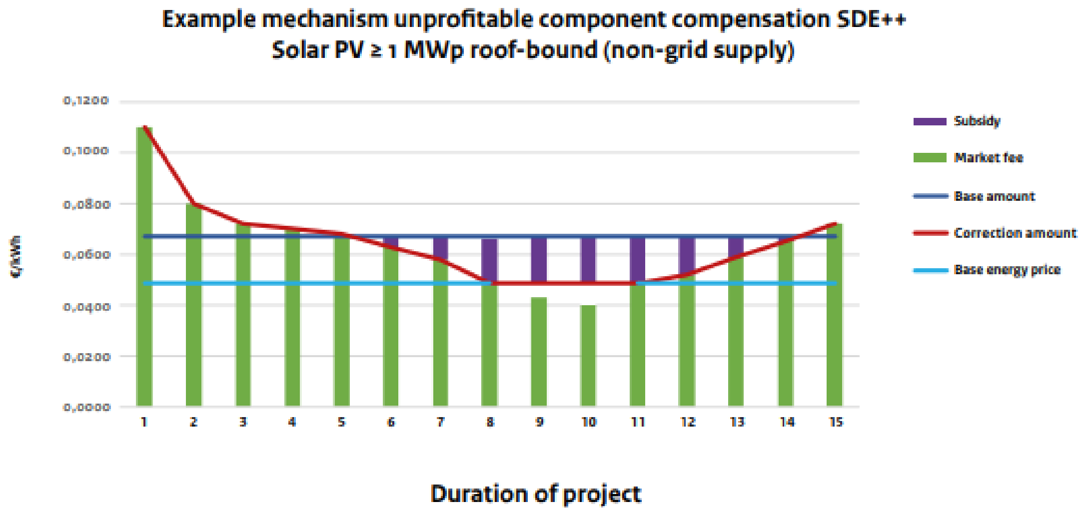

Figure 2.5: Exemplified SDE++ Mechanism (RVO, 2023)

The subsidy is provided for a period of either 12 or 15 years, depending on the specific technology used (RVO, 2023). Only the operator of a power generation facility can apply for the subsidy, and they are limited to submitting one application per category and per site. This targeted approach ensures that the subsidy supports those directly involved in renewable energy production (RVO, 2023).

The application process for the SDE++ scheme is phased and budgeted annually and applications are processed on a first-come, first-served basis within each phase, ensuring fair distribution of the available funds (RVO, 2023). Each technology under the SDE++ scheme has a specific base rate, which represents the maximum subsidy amount that can be applied for, expressed in euros per MWh. Additionally, a correction amount is determined annually to account for the revenue generated from energy production and the avoided costs of purchasing energy or emissions allowances (RVO, 2023).

2.3. Project Finance

Project finance is the most common form to finance renewable energy plants (Mohamadi, 2021). Project finance uses a special purpose vehicle (SPV) which has been set up only to realise the project (Steffen, 2018). This SPV is funded with little to no guarantees from the sponsors, meaning that the lenders rely solely on the project's future cash flows for repayment, without the ability to claim against other assets (Steffen, 2018). This type is usually used for large and complex installations like power plants (Bank for International Settlements, 2006).

Direct investments in infrastructure assets, of which RE projects are an example, involve long-term commitments due to the lengthy life spans of these assets. As illustrated in Figure 2.6 by Bitsch et al. (2010), these investments are characterized by high liquidity risk as they cannot be easily sold, significant capital requirements due to their capital-intensive nature, and high political and regulatory risks, particularly if the legal framework changes or expropriation occurs in the host country. This type of investment is typically suited for entities like insurance companies or pension funds that can handle large, long-term investments (Bitsch et al., 2010).

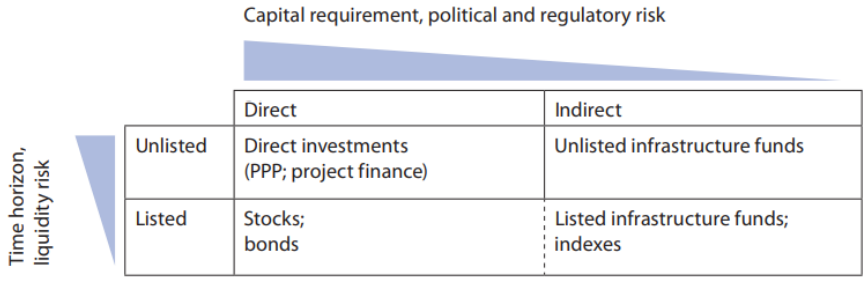

Figure 2.6: Infrastrucure Investment Classes (Bitsch et al., 2010)

In contrast, corporate finance generally deals with the broader financial management of a multi-purpose firm, utilizing a mix of debt and equity that is subject to which means that in cases where the firm cannot meet its financial obligations, creditors have the right to claim the firm's assets or equity to recover debts (Raikar & Adamson, 2019). The capital in corporate finance is permanent and has an indefinite equity horizon, allowing companies flexibility in dividend policies and capital reinvestment decisions, which are typically made by corporate management (Raikar & Adamson, 2019). The evaluation of creditworthiness in corporate finance is based largely on the overall financial health of the corporate entity or its guarantor, which supports a broader and deeper investor base and secondary markets, consequently leading to relatively lower financing costs (Raikar & Adamson, 2019).

Project finance specifically supports a single-purpose entity with no recourse, implying that the lenders have limited claims only to the project's assets and cash flows, and not to the broader assets of the firm managing the project (Raikar & Adamson, 2019). Such projects typically have a finite-time horizon that matches the life of the project, with pre-defined dividend payouts and no options for reinvestment, leading to higher leverage ratios and elevated transaction costs, also due to the complex risk assessment required (Raikar & Adamson, 2019). The investor base in project finance is narrower, consisting mostly of highly sophisticated investors familiar with such structures (Raikar & Adamson, 2019). The financing costs are also higher (Raikar & Adamson, 2019).

This thesis will concentrate on direct investments in solar PV projects using the project financing structure.

2.4. Large-scale Solar Projects in the Netherlands

According to Planbureau voor de Leefomgeving (2021), a field or roof with solar panels considered large-scale if the combined capacity of the panels exceeds 15 kW. This 15-kilowatt threshold is also the minimum capacity required to be eligible for subsidies through the SDE scheme. However, these projects are too small for project financing. In this thesis, large-scale projects are defined as those that qualify for financing through project finance mechanisms.

Given the assumption that projects smaller than 1MW are unlikely to secure project financing, it is useful to examine the distribution of projects above this threshold. According to the SDE-viewer developed by the RVO, a total of 2,074 solar energy projects with a capacity greater than 1 MW have been awarded an SDE++ subsidy. Out of these, 1,354 projects have been completed, while 720 projects are still in development and not yet operational. The largest project, both among those completed and those still under development, is Solar Park Dorhout Mees, which has a capacity of nearly 148 MW.

Table 2.1 illustrates the distribution of solar energy projects in the Netherlands, awarded an SDE++ subsidy.

Capacity Range (MW)	Number of Projects
≥ 1 <5 MW	1453
≥ 5 <20 MW	481
≥ 20 <50 MW	106
≥ 50 MW	34

Table 2.1: Distribution of Solar Energy Projects in the Netherlands (based on RVO SDE viewer)

3 Research Strategy

The phrasing of both the problem statement and the main research question calls for exploring the role of PPAs in mitigating financial uncertainty in PV projects. The topic in the context of large-scale solar PV projects in the Netherlands is relatively new. While there is existing literature on PPAs in general, limited research specifically focuses on their role and adaptation in the Dutch market. This lack of established theoretical frameworks means the research cannot rely only on traditional confirmatory methods to test predefined hypotheses. Confirmatory research focuses on improving method reliability, yet it falls short in exploring more broadly how its results fit into the real-world and what they imply (Reiter, 2017), which is of importance regarding the research goal. Instead, Reiter (2017) explains that an exploratory study seeks to introduce new concepts and explanations to provide alternative perspectives on how something functions, stressing that its findings can add insights to already existing explanations .

3.1. Methodology

Facilitating the exploratory nature of the study motivated above, a qualitative research approach was designed. A qualitative research approach is viewed as a method for investigating and understanding the perspectives of people related to a certain topic (Weyant, 2022). The approach adopted in this thesis involves a literature review, policy analysis and a round of validation interviews. By using this mixed-method research approach, triangulation is added to the methodology, reflecting an attempt to secure an in-depth understanding of the phenomenon in question (Denzin, 2012). The research approach can be broadly divided into two phases, the desk research phase and the validation phase. A visualisation of the general research flow can be found in Figure 3.1. The steps are further elaborated upon below.

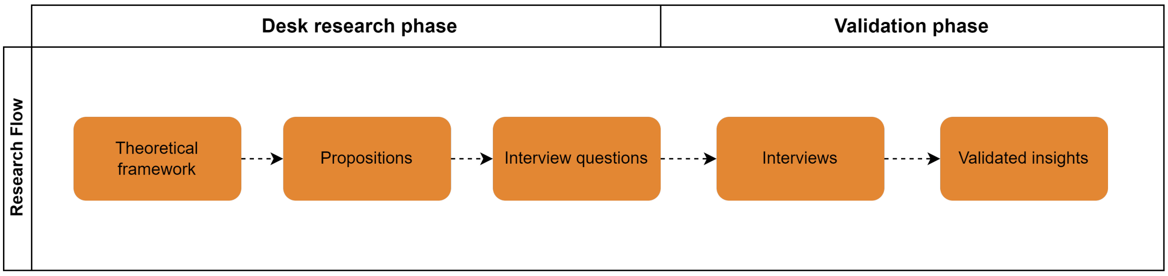

Figure 3.1: General Research Flow (Author's figure)

3.1.1. Desk Research Phase

The primary objective of the literature study and policy analysis is to develop a comprehensive theoretical framework that shows the relationships between the financing of PV projects and the roles of PPAs and subsidies. The theoretical framework aims to address the three subquestions:

SQ1: *How are large-scale PV projects typically financed, and what factors influence decision-making during the financing process?*

SQ2: *What is the role of support schemes and Power Purchase Agreements in the financing of large-scale PV projects in the Netherlands?*

SQ3: *How does financial decision-making differ when using a Power Purchase Agreement compared to a support scheme, and what are the best practices and challenges associated with Power Purchase Agreements?*

Developing propositions

Before conducting research, it is important to formulate hypotheses, necessary for both confirmatory and exploratory research. Formulating a priori theory and hypotheses is important for limiting and focusing a approach to a complex reality (Reiter, 2017). Due to their qualitative nature, hypotheses will be refered to as propositions. The development of the propositions was driven by the theoretical framework constructed through the literature review and policy analysis. Each proposition was formulated to address specific aspects of this framework..

For the first subquestion, propositions focus on the reliance of debt and the availability of debt based on bankability. For the second subquestion, propositions examine the role of support schemes and PPAs in mitigating price risk and enhancing project bankability. For the third subquestion, the propositions explore comparisons in risks and bankability when using a (specific constructed) PPA versus a support scheme for financing. The last prorpostion follows from exploring the systemic PPA limitations, as called for by the third research question.

The propositions will also serve a central role throughout the research process, forming the basis for the interview questions and acting as reference points during the analysis of data gathered through the interviews.

Developing interview questions

The interview questions are thus designed based on the propositions derived from the theoretical framework. This ensures that the interviews are focused and relevant, allowing for the collection of detailed and pertinent information that directly addresses the research questions. By aligning the questions with the propositions, the interviews not only explore the theoretical concepts but also validate and expand upon them through practical insights. This alignment helps the reliability and depth of the data collected, contributing to the robustness of the research findings. The interview design, showing the step between the propositions and the formal questions can be viewed in Appendix D. These questions eventually led to an interview protocol, which can be found in same appendix.

3.1.2. Validation Phase

To validate the theoretical framework, a total of 14 interviews were conducted with industry professionals and key stakeholders involved in the financing of PV projects. These interviews aimed to gather practical insights and confirm or deny the propositions in real-world applications. By focusing on diverse perspectives from developers, financiers and policymakers, the validation process tested the theoretical assumptions against industry realities. The interviewees provided input on how the roles and challenges concerning the SDE++ scheme and PPAs in practice. This validation step strengthened the robustness of the research by ensuring that the framework was grounded in practical evidence, and added new insights to the discussion.

3.2. Data gathering and analysis

This thesis adopts a mixed-method research approach. This means that multiple methods for gathering data are needed as well. Also here, in line with the approach, triangulation is strived for. Carter et al. (2014) state data source triangulation is achieved by collecting data from various interviewee categories. The overview in Figure 3.1 has been extended using the relations between the gathering, analysis and results of the data and support systems in Figure 3.2.

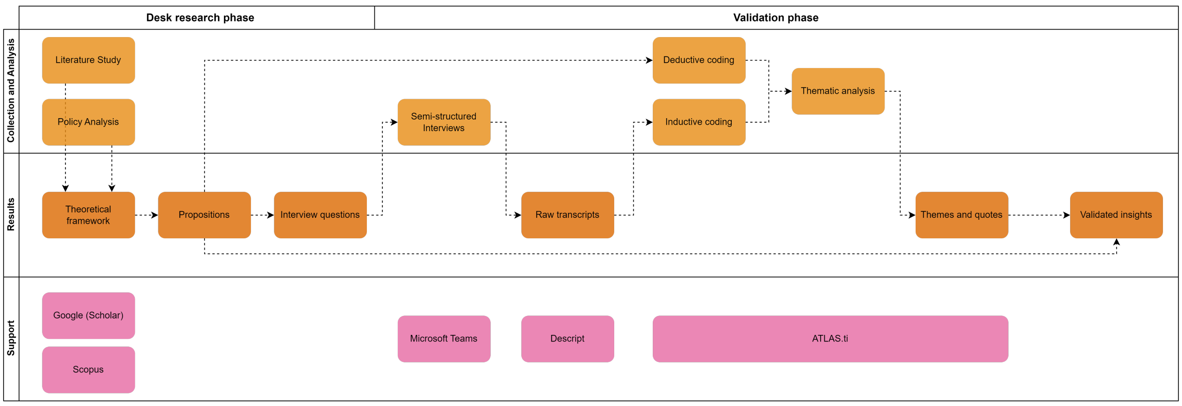

Figure 3.2: Methodology Relations Overview (Author's figure)

3.2.1. Literature study and Policy Analysis

To conduct a thorough literature study, both Google Scholar and Scopus databases were used to identify relevant sources. Publications focused on renewable energy financing, Power Purchase Agreements, project finance, support schemes, and policy stability were selected, with an emphasis on those applicable to the Netherlands. The initial batch of papers underwent multiple filtering stages to arrive at a final list of relevant literature.

The data gathering process began with keyword searches in Google Scholar and Scopus using terms such as "renewable energy financing," "Power Purchase Agreements," "project finance," "support schemes," and "policy stability." While a particular focus was placed on studies relevant to the Netherlands, publications from other regions were also considered to provide a broader perspective. There was not much literature available on the topic from research in the Netherlands. Next to this, it is important to mention that articles behind paywalls that were inaccessible were removed.

The policy analysis aimed to examine the regulatory and policy frameworks impacting the financing of renewable energy projects in the Netherlands. The policy analysis eventually contributed mostly to explaining different types of support schemes, the mechanism of the SDE++, and the knowledge on the PPA guarantee fund exploration.

3.2.2. Semi-Structured Interviews

Individual interviews are widely recognized as a effective method for collecting qualitative data, offering valuable insights and enabling in-depth exploration of specific topics, particularly in exploratory research (Carter et al., 2014; Taherdoost, 2022). The utilization of the semi-structured interview approach stems from its versatility and adaptability, as emphasized by Kallio et al. (2016). This methodology empowers interviewers to tailor and spontaneously formulate follow-up questions in response to participants' feedback, facilitating a complete investigation into the research subject.

The semi-structured interviews were based on the interview questions derived from the propositions. To make these question manageable, a interview protocol was constructed, which can be viewed in Appendix D. This interview protocol was based an interpretation of on the Long Interview Approach by McCracken (1988). This meant dividing and asking the questions in the following manner:

- Grand Tour questions: General in nature and non-directive
- Floating Prompt questions: Depend on specific interview and open the possibility to pursue a thread in more detail
- Planned Prompt questions: Issues from earlier interviews and literature will be addressed nearing the end of the interview

The interviews were conducted with a focus on maintaining the anonymity of participants, with job titles and identifying details being generalized to protect confidentiality. Each interview lasted between 30 and 75 minutes, providing sufficient time to explore the topics in depth while allowing flexibility based on the flow of the conversation. As stated above, the interviews were structured to switch focus per category of interviewees, ensuring a comprehensive coverage of all relevant themes. Except for one, all interviews were held in Dutch.

Selecting participants

The selection of participants is based on a combination of the four points by Robinson (2014) and the sample size considerations by Malterud et al. (2016).

Point one: Define a sample universe

The categories were based on basic knowledge of the renewable project finance sector in the Netherlands. This includes participants with professional experience in energy (debt and equity) financing and solar project development, as well as energy policy, active in the Nethelands. Key categories were defined as lenders, investors, policymakers and developers.

Point one: Decide on a sample size

The sample size is determined by the criteria outlined in the table below, based on the Malterud et al. (2016). Given the specificity of the research question and the theoretical foundation, a sample size of at least 10 participants was determined as adequate.

Table 3.1: Sample Size Considerations by Malterud et al. (2016) Applied

Key Item	Explanation	Application to Thesis
Study Aim: Narrow or Broad?	A narrower aim requires fewer participants, while a broader aim needs more.	The focused aim on the role of PPAs in mitigating financial uncertainty in solar PV projects suggests that a smaller sample can provide sufficient data.
Sample Specificity: Dense or Sparse?	High specificity of participants' experiences reduces the number of participants required.	The sample is specific, as it includes experts familiar with PPAs and large-scale PV projects in the Netherlands, allowing for fewer participants.
Theoretical Background: Applied or Not?	A strong theoretical background can reduce the necessary sample size.	The thesis builds on established theories of financial risk management and policy, reducing the need for a large sample size.
Quality of Dialogue: Strong or Weak?	Strong, clear communication enables fewer participants; ambiguous communication requires more.	Theoretical familiarity with the subject but limited interview experience, a moderate number of participants will suffice.
Analysis Strategy: Case or Cross-Case?	In-depth or narrative analysis needs fewer participants; cross-case analysis requires more.	As cross-case analysis is used to compare experiences across multiple projects, a slightly larger sample size is recommended.

Devise a sample strategy

A convenience sampling strategy was used to select participants who are easily accessible and have relevant expertise. This strategy was chosen to ensure the inclusion of professionals with an understanding of policy design, PPAs and financial risk mitigation in the Dutch renewable energy sector.

Source the sample

Snowball sampling was employed to reach further experts referred by initial interviewees, meaning participants were contacted via personal professional networks and through PwC supervisors. This ensured access to individuals actively involved in large-scale solar PV projects and familiar with the SDE++ and/or Power Purchase Agreements. The definite list of interviewees can be viewed in Table 3.2, which provides the role of each participant.

Table 3.2: List of Interviewees

Interviewee abbreviation	Function	Category
Interviewee A1	Advisor Renewable Energy	Policymaker
Interviewee A2	Advisor Renewable Energy	Policymaker
Interviewee A3	Policy Officer	Policymaker
Interviewee A4	Researcher	Policymaker
Interviewee A5	Business Developer	Policymaker
Interviewee B1	Project Finance Manager	Lender
Interviewee B2	Project Finance Manager	Lender
Interviewee B3	Project Finance Manager	Lender
Interviewee B4	Project Finance Manager	Lender
Interviewee C1	Contract Manager	Solar PV Developer
Interviewee C2	Asset Manager	Equity Investor
Interviewee C3	Contract Manager	Wind Developer
Interviewee C4	Asset Manager	Equity Investor
Interviewee C5	Specialist	Solar Sector Association

Transcribing

The next step in the qualitative research process is the transcription of the recorded interviews. Matheson (2007) emphasizes that transcription quality is especially important when computer-aided qualitative data analysis software is used, such as ATLAS.ti, as transcription errors can affect the coding and analysis process.

To achieve the quality wanted, this thesis used a local automatic transcription workflow, using software that transcribes the interviews without transferring the audio files outside the research environment (Wollin-Giering et al., 2024). The software used was Descript. However, Wollin-Giering et al. (2024) mention that any automated transcription result should not be used in the original form it is produced in and stress that manual review is always necessary. Following this, the transcripts were walked through thoroughly afterwards, along with listening to original recording.

Coding Process

Consistent with the qualitative approach adopted in this research, thematic analysis method was chosen to identify recurring patterns or ”themes” within the data collected from the interviews. As per Braun and Clarke (2006), thematic analysis is a method that is easy to access and does not demand in-depth theoretical knowledge, which makes it useful for researchers new to qualitative methods.

Thematic analysis of the data can be done through coding in ATLAS.ti data analysis software (Atlas.ti, 2023). ATLAS.ti facilitates the creation of a coding framework that reflects the key themes, concepts, and categories derived from the theoretical framework and the research questions. Codes can be applied to specific segments of text where interviewees discuss related concepts, making it possible to retrieve all instances of a particular theme across different interviews. Coding, as a process of data reduction, is an aspect of data organization in most qualitative approaches (Vaismoradi et al., 2016).

This study uses an interpretation of the six-phase thematic analysis process as outlined by Braun and Clarke (2006), which provides a structured yet flexible approach to qualitative data analysis. The phases are not meant to be followed in a strict linear sequence but rather in an iterative manner, where movements back and forth between phases are possible if needed. This process allows for an in-depth engagement with the data and a refined development of themes. The six phases have been used in this thesis as follows:

Phase 1: Familiarisation with the Data: In this initial phase, the data and textual content was re-read multiple times. If relevant or needed, the audio recordings were also re-listened.

Phase 2: Coding: Coding involved generating concise labels for significant features of the data that are relevant to the research questions. This phase is not merely a method of data reduction but an interpretative process. These codes were found both inductively and deductively.

Phase 3: Searching for Themes: In this phase, themes were constructed by analyzing the relationships between codes. Themes are coherent patterns that emerge from the data.

Phase 4: Reviewing Themes: During this phase, the themes were evaluated based on their relation to both the coded extracts and the entire data set. The themes should present a narrative about the data.

Phase 5: Defining and Naming Themes: This phase involves identifying the main stories and how they contribute to the overall understanding of the data. Names for each theme were constucted. The results of this step can be viewed in chapter 5

Phase 6: Writing Up: Lastly, an analytic narrative presents a coherent account of the findings.

This phase also involved situating the findings in relation to the literature framework, thereby clarifying the study's contribution to the field. The results of this step can be viewed in chapter 6.

As stated in step two, the thematic analysis conducted for this research was a combination of deductive and inductive coding strategies. Deductive coding involves applying a predefined set of codes derived from theoretical constructs or research propositions established prior to data collection. In this thesis, the deductive codes were based on the propositions outlined in the theoretical framework. Inductive coding is a more exploratory and flexible approach in which codes are developed directly from the raw data without preconceived categories. In this thesis, the inductive coding process involved identifying new patterns and themes that emerged from the interview transcripts. This approach allowed for the identification of unexpected themes and nuances in the data, ensuring that the analysis was grounded in the participants' own words and perspectives rather than being based only on the initial theoretical framework. By using both deductive and inductive coding strategies, this thesis was able to maintain a balance between testing pre-existing propositions and remaining open to new insights, leading to rigor in thematic analysis (Fereday & Muir-Cochrane, 2006).

Since 13 out of the 14 interviews were conducted in Dutch, the codes and corresponding quotes were translated manually into English. However, as Dutch expressions and idiomatic phrases may not have direct equivalents in English, this could have led to potential shifts in meaning during translation. Furthermore, manual translation involves a layer of interpretation, where the understanding of the context may influence the way specific words or phrases are rendered. Therefore, while care was taken to maintain fidelity to the interviewees' intended meaning, the translation process could have had a subtle impact on the overall analysis.

3.2.3. Data Management

The research process has a detailed data management plan, which is available in Appendix A. This plan outlines the procedures for data analysis and ensures that they align with the research questions and objectives. The data management plan follows the FAIR data principles, focusing on Findability, Accessibility, Interoperability, and Reusability. By adhering to these principles, the research aims to improve the quality and accessibility of the collected data for future use and verification.

Due to the sensitive nature of the data from the interviews, great care is taken to protect the privacy and confidentiality of the participants. All individuals involved in the research have been given abbreviations to safeguard their personal identities while still allowing insights to be drawn from the data.

Additionally, the data management plan has been thoroughly reviewed and approved by the TU Delft Human Research Ethics Committee, which emphasizes the commitment to ethical standards and responsible data handling practices, ensuring that the research complies with the highest ethical guidelines.

After the research is finished, the results will be shared through the TU Delft Repository at www.repository.tudelft.nl. This open access method will increase the visibility of the thesis and assist the larger scientific community by offering findings that can contribute to future studies and policy decisions.

4
Theoretical Framework

In this chapter, a theoretical framework is developed to understand the financing mechanisms and risk factors affecting the bankability of large-scale solar PV projects. The framework will guide the formulation of key propositions that serve as tools for digesting and conceptualizing the theory, making it more accessible and actionable. These propositions are not only theoretical constructs but also practical elements that shape the validation research design, as explained in chapter 3. Each proposition is designed to link specific aspects of the framework to the development of interview questions, ensuring that the theoretical insights are effectively translated into concrete data points. This chapter thus serves as a bridge between the theoretical foundations and the practical validation.

4.1. Financing Large-scale PV Projects

This section addresses SQ1: *How are large-scale solar PV projects typically financed, and what factors influence decision-making during the financing process?*

This section delves into the theoretical foundations of renewable energy financing, focusing on the role of debt, the criteria that determine project bankability, and the various risks that influence the financing decisions. By exploring these elements, the section builds an understanding of how financing decisions are made and lays the groundwork for proposition 1 that highlight key aspects of solar PV project finance. This proposition lays the basis for propositions in subsequent sections.

4.1.1. Debt Dependency

Financing renewable energy projects presents challenges due to their capital-intensive nature, with 80% to 90% of overall investment costs typically concentrated in upfront capital expenditure (CAPEX), unlike fossil-fuel power plants (Hirth & Steckel, 2016). These high upfront costs mean that securing adequate financing is important to ensure the viability of the project. Investors and developers often rely on a combination of debt and equity financing, allowing the project to spread out the high initial costs over time, while the long-term revenue from energy sales provides returns to the investors (Hirth & Steckel, 2016).

The difference between lenders and and investors is in the way they analyse projects (Wiser & Pickle, 1998). Since Equity investors have the potential for unlimited returns from project success they often take higher risks while lenders are generally more risk-averse (Wiser & Pickle, 1998). A debt contract is a fixed obligation, and, as described above, lenders do not profit beyond a certain point from a project's success. Lenders adjust interest rates and terms based on default but they also practice credit rationing, meaning they will not finance projects with a high likelihood of default (Wiser & Pickle, 1998).

The investor's own equity may not be enough to cover the entire cost of renewable energy projects, so they will need support from lenders (Ozorhon et al., 2018). Even if the investor has enough equity, it's not practical to develop a renewable energy project using 100% equity, as this would limit the investor's ability to fund other projects. Therefore, investments must be bankable, and investors need to meet the lending criteria of the lenders (Ozorhon et al., 2018).

This forms the basis for the choice of investor - lender relationship considered in this thesis. A simplified visualisation of the considered relationship is viewed in figure 4.1.

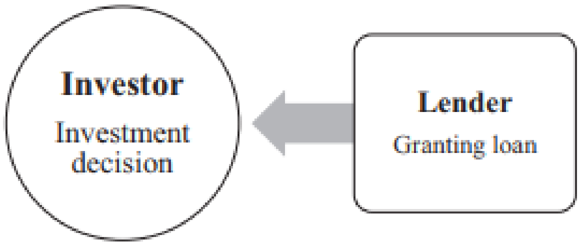

Figure 4.1: Lender Dependency based on Ozorhon et al. (2018)

The theory above highlights the role that debt plays in the feasibility of large-scale solar PV projects. Given that these projects are highly capital-intensive, with most costs concentrated in the upfront investment, securing adequate funding is paramount. Investors typically cannot finance these projects using their own equity alone, as doing so would not only require substantial capital but also limit their ability to invest in other opportunities. As a result, investors must turn to lenders for debt financing to cover the majority of the costs. However, this reliance on debt means that lenders' risk assessments and criteria become central in determining whether a project can proceed. Therefore, the theory indicates that, also for Dutch solar PV projects, the dependence on debt financing is inherent due to the need to meet the capital requirements for development.

4.1.2. Proposition 1

P1: Dutch solar PV projects are reliant on debt financing.

Project finance heavily relies on debt financing, with lenders playing a crucial role in determining the feasibility of projects based on their risk assessment criteria. Investors must align their projects with the lending criteria to secure necessary funding.

To secure funding for a construction project like a solar PV projct, it is essential to convince potential lenders of the project's viability, looking at both technical and economic features (Finnerty, 2013). This relates to the concept of bankability.

4.1.3. Project Bankability

'A project is bankable, whether from public or private sources, when its risk-return profile meets investors' criteria and can secure financing to implement the project' (Cities Climate Finance Leadership Alliance, 2022). This means that improved bankability can directly translate to an increase in available

debt, thus reducing the need for equity from investors. As stated before, the providers of debt determine whether they consider a project to be bankable (Weber et al., 2016).

Bankbability has been connected earlier to the ”C’s of Lending” in the book by (Thumann & Woodroof, 2021). The 5 C’s, as identified by Thomas (2000), can be seen as the perspective from which lenders originally evaluated a possible loan (Trönnberg & Hemlin, 2012). The 5 C’s, based on Thumann and Woodroof (2021), have been summarized in Table 4.1

C’s of Lending	Description
Capital	Is there capital at risk from the borrower?
Credit/Cash flow	What are the revenues and expenses of the borrower?
Collateral	What security is available for the loan?
Conditions	What are the desired terms of the loan?
Character	What is the management team’s experience and reputation?

Table 4.1: Summary of 5 C’s of Lending ((Thumann & Woodroof, 2021)

These ”C’s” seem to form the basis for the concept of bankability. D. Yang and Liu (2020) explain the process of declaring solar PV projects bankable.

1. **Know-Your-Customer process:** Lenders start with a Know-Your-Customer (KYC) process for the SPV, parent company, and equity investors. This involves reviewing financial statements, tax forms, and corporate documents to ensure trustworthiness and minimize risks (D. Yang & Liu, 2020).
2. **Project structure and transparency:** A transparent shareholding structure, outlining how equity and loan injections affect the debt ratio is important according to D. Yang and Liu (2020). This clarity increases lender and investor confidence by presenting a clear financial and managerial setup.
3. **Collateral and creditworthiness:** For non-recourse project financing, valuable collaterals such as land ownership, surface rights, or project IDs and PPAs (with state-owned company in Feed-in Tariff schemes) are used. The creditworthiness of corporate offtakers or state-owned utility companies is mentioned as a key factor by D. Yang and Liu (2020).
4. **Financing scheme:** The project’s structure and collateral quality influence whether non-recourse, partial recourse, or full recourse financing is used. Market conditions and the creditworthiness of involved entities are considered in this decision.
5. **Contractor and technology evaluation:** The track record of EPC and O&M contractors is assessed to ensure regulatory compliance and operational efficiency. Proven technologies and experienced contractors reduce project risks (D. Yang & Liu, 2020).
6. **Financial Metrics:** The Debt Service Coverage Ratio , ranging between 1.2× and 1.6×, is a key metric (D. Yang & Liu, 2020). It reflects the SPV’s ability to meet debt obligations. Lenders will be most interested in the debt service coverage analysis (Thumann & Woodroof, 2021). A stable revenue stream is necessary to maintain a healthy DSCR.

Through a evaluation of these factors, lenders can assess the bankability of PV projects and their potential for delivering expected returns. These factors impact the risk profile and the financing terms of a solar PV project (D. Yang & Liu, 2020).

4.1.4. RE Investment Risks

The statement of bankability as an elaborate analysis of a risk-return profile calls for investigating these risks. Effectively assessing these risks can be seen as the main task in project finance, according to Böttcher (2020). Lenders are willing to accept limited risks if adequately compensated through the interest rates on their loans (Finnerty, 2013).

According to Yescombe (2002), the risks within project finance structures can be grouped into three categories:

1. Commercial risks, or project risks, are those directly tied to the project or its market;
2. Macro-economic risks, or financial risks, involve broader economic factors like inflation and currency fluctuation;
3. Political risks, or country risks, arise from govenment actions or political instability.

Zooming into these categories, earlier research into the different risks associated with RE projects has been carried out significantly. Based on the literature review by Egli (2020), where more than 20 papers on RE risks were analysed of which the most common risk types mentioned in the literature were identified and validated by expert interviews. The identified risks and their definitions can be found in Table 4.2.

Risk type	**Definition**
Curtailment risk	The risk of lower revenues due to unexpected curtailment.
Policy (reversal) risk	The risk of lower revenues due to a retroactive change in a cornerstone RET policy, taxation or other policy measures.
Price risk	The risk of price volatility within a stable policy regime. Price risk has increased significantly in relative importance from 2009 to 2017.
Resource risk	The risk of lower revenues due to inaccurate resource potential estimation.
Technology risk	The risk of lower revenues or higher maintenance costs due to the technology's novelty and unpredictability.

Table 4.2: RE Risk Types and Their Definitions (Egli, 2020)

Price Risk in Solar PV Projects

Independent project developers of solar PV projects choose how they sell their electricity, either by using a PPA or selling their electricity directly on wholesale markets (Bartlett, 2019). Since electricity price is notoriously volatile (Christophers, 2022) this selling of electricity is paired with risk, defined as price risk or merchant risk.

This risk differs from fossil-based power plants, as Christophers (2022) explains, because those projects, banks are less concerned about future electricity price volatility because if electricity prices fall, gas prices, and thus the plant's primary ongoing costs, are also likely to fall. However, this symmetry does not exist for renewable energy projects, since they have no fuel costs and the primary cost for running a solar or wind farm after construction is the debt service on the initial financing (Christophers, 2022). The lack of this hedge makes their business models highly sensitive to fluctuations in the spot market (Christophers, 2022). Unsurprisingly, this risk has seen a significant increase in importance (Egli, 2020).

The discussion on bankability highlights that lenders' willingness to finance renewable energy projects is contingent upon managing and reducing key risks, including price risk. Unlike traditional energy projects, solar PV projects are particularly sensitive to fluctuations in electricity prices because they have no fuel costs to offset these changes. As such, their business model is more vulnerable to revenue volatility, which in turn affects their ability to secure debt financing. By implementing mechanisms to stabilize revenues makes the project more attractive to lenders, increasing bankability. Thus, the theory underscores that mitigating price risk directly enhances project bankability.

4.1.5. Proposition 2

P2: Mitigating price risk enhances solar PV project bankability.

Price risk is, next to being unique for renewable energy projects, becoming increasingly important. By mitigating this risk, overall project bankability is enhanced making debt for the project available.

4.2. Mitigating Price Risk to Increase Bankability

This section addresses RQ2: *What is the role of support schemes and Power Purchase Agreements in the financing of large-scale PV projects in the Netherlands?*

Here, it is explored how price risk can be mitigated. The two explored mechanisms, support schemes and PPAs, play key roles in de-risking renewable energy investments by stabilizing revenue streams, leading into proposition 3 and 4.

4.2.1. The Role Support Schemes in Mitigating Price Risk

Couture et al. (2010) outlines two main types of Feed-in Tariff (FiT) models for promoting renewable energy: the Fixed-Price FiT and the Premium-Price FiT. The Fixed-Price FiT offers a stable payment for electricity over a set period, independent of market fluctuations, and is widely used in countries like Germany, France, and Canada (Couture et al., 2010). This model can include adjustments for inflation and specific technology bonuses. In contrast, the Premium-Price FiT adds a variable premium to the market price, adapting payments to reflect market conditions. Variations include the Constant Premium, Sliding Premium (with caps and floors), Spot Market Gap Model (covering gaps between market prices and a guaranteed level), and the Percentage-Based Model (adjusting premiums as a percentage of market prices). The Spot Market Gap Model is similar to the Dutch SDE++ scheme, where payments adjust to ensure target profitability based on market dynamics.

Importance of Robust Subsidies

Wiser and Pickle (1998) emphasize that stable and predictable support policies are critical for renewable energy project financing. Their study shows that uncertain policy environments can raise financing costs and reduce the effectiveness of renewable energy programs. They identified issues such as uncertainty in project eligibility, policy stability, and long-term revenue predictability as key challenges. Similarly, Barradale (2010) found that policy uncertainty, such as delays in the Production Tax Credit (PTC) renewal in the U.S., leads to stalled PPA negotiations and investment volatility. Such findings underline that stable and consistent support mechanisms are essential for encouraging long-term investments.

More recent studies, such as Sendstad et al. (2022), found that retroactive subsidy changes can lead to a significant reduction in investment rates, whereas consistent government support boosts renewable energy investments (X. Yang et al., 2019). This suggests that reliable support schemes are fundamental to attracting investments and mitigating financing risks in the renewable sector.

De-Risking and Bankability

Research indicates that subsidies play an important role in enhancing the bankability of renewable energy projects by reducing external capital costs and signaling project quality to market-based financiers (Meuleman & De Maeseneire, 2012; Takalo & Tanayama, 2010). The Spot Market Gap Model in particular, providing financial support by offering a premium above market prices, thus stabilizing revenue streams and mitigating the adverse effects of market price volatility. By providing a predictable income stream even during periods of low market prices, FiPs like the SDE++ reduce the overall financial risk associated with project revenues. This stability enables projects to cover operational costs, generate consistent returns, and become more attractive to lenders and investors. Christophers (2022) also highlights that FiPs effectively cushion projects from low market prices, strengthening their financial viability.

Further supporting this claim, Matekenya (2011) argue that subsidies such as FiPs and government guarantees provide financial certainty, which lowers perceived risk and increases investor confidence. This reliable revenue stream reduces lenders' concerns over project profitability and the likelihood of default, thereby facilitating access to debt financing. In this way, FiPs contribute to increasing the bankability of renewable energy projects by ensuring cash flow stability and reducing the Weighted Average Cost of Capital (WACC).

However, FiPs do not entirely eliminate price risk; rather, they transfer this risk to a counterparty, usually a policymaker or a regulatory entity (Devine et al., 2017). When market prices fall below the guaranteed FiP level, policymakers or consumers absorb the financial burden, often through surcharges on electricity consumption (Devine et al., 2017). Thus, while FiPs mitigate direct market price risks for project developers, they redistribute the risk rather than removing it entirely.

The ability of FiPs to de-risk renewable energy investments is closely linked to the broader concept of de-risking, which involves strategies to reduce both perceived and actual risks. De-risking can be divided into two main categories: policy de-risking and financial de-risking (Steckel & Jakob, 2018). The authors explain how policy de-risking addresses the root causes of investment risks, such as regulatory uncertainty and market instability, by creating a stable and transparent policy environment. Financial de-risking, on the other hand, involves transferring investment risks to public institutions through mechanisms like loan guarantees, concessional finance, or the use of public finance institutions (Steckel & Jakob, 2018).

For instance, financial de-risking mechanisms can reduce the cost of support payments and stabilize revenue streams by providing predictable cash flows, such as those offered by the SDE++ scheme in the Netherlands (Đukan & Kitzing, 2023). Such mechanisms lower the WACC, making the project more financially viable.

By providing a fixed or sliding premium above market prices, FiPs like the SDE++ scheme effectively shield developers from the volatility of market prices, thereby reducing financial uncertainty. This stability not only mitigates price risk but also enhances the bankability of solar PV projects by making them more attractive to lenders. As these mechanisms ensure predictable cash flows, they lower the WACC and improve access to financing. Consequently, these factors lead directly to Proposition 3, asserting that a Feed-in-Tariff premium significantly enhances the bankability of solar PV projects by mitigating price risk.

4.2.2. Proposition 3

P3: A Feed-in-Tariff premium mitigates price risk for a solar PV project.

Stable FiP schemes, such as the SDE++ in the Netherlands, provide a fixed or sliding premium above the market price, offering a stable revenue stream that reduces exposure to market price volatility, de-risking investment and enhancing project bankability.

4.2.3. Role of PPAs in Mitigating Price Risk

PPAs can serve as an effective tool to mitigate risk for developers and financiers, significantly contributing to the expansion of renewable energy projects (Mendicino et al., 2019). Project finance typically involves long-term offtake agreements like PPAs that secure stable cash flows, thus reducing price and buyer risk (Dvorak, 2016). This certainty becomes even more important as policy shifts consider reintroducing merchant risks to mature renewable energies, necessitating carefully designed policies to maintain the viability of projects for project finance (Steffen, 2018).

Similar to FiPs, which de-risk investments by transferring price risks from the producer to the policymaker, PPAs achieve this by reallocating price risks to the offtaker. However, as Bartlett (2019) explains, by mitigating a particular risk for the producer and thus the project, the counterparty, in this case the offtaker, will have to assume that risk. This transfer of risk enables project developers to secure stable cash flows and enhances their ability to attract financing. In the context of financial de-risking, as discussed in chapter 3, PPAs provide a similar function to support schemes by offering long-term revenue predictability.

The theory underscores how PPAs play a comparable role to support schemes in mitigating financial risks for renewable energy projects.Therefore, Proposition 4 follows logically: corporate PPAs, by offering long-term contracts and stabilizing revenue streams, serve as a financial de-risking tool that mitigates merchant price risks and enhances the bankability of solar PV projects.

4.2.4. Proposition 4

P4: A corporate PPA mitigates price risk for a solar PV project.

Corporate PPAs offer long-term contracts providing predictable revenue streams that can attract financing by mitigating the risk associated with merchant prices, allocating it to a private offtaker.

4.3. Comparing PPAs and Support Schemes

This section addresses SQ3: *How does financial decision-making differ when using a Power Purchase Agreement compared to a support scheme, and what are the best practices and challenges associated with Power Purchase Agreements?*

Building on proposition 4, the differences between the two mechanisms have to be explored. This section compares risks associated with PPAs and support schemes influence financial decision-making by looking at the risk allocation and their effects on bankability, leading into proposition 5 and 6.

4.3.1. PPA risks within Research Scope

While both PPAs and support schemes are designed to mitigate price risk, PPAs introduce several new risks, mainly due to their reliance on private offtakers rather than government-backed schemes. In the context of support schemes the government or regulatory body assumes a significant portion of the

Table 4.3: Solar PV Project PPA Risks based on Kapral et al. (2024)

Risk	Description
PPA Price Risk	The risk that the offtaker may end up paying more for electricity under the PPA compared to purchasing from the grid.
Shape/Profile Risk	Risk from the variability in solar energy production, as generation may not match the offtaker's consumption pattern.
Volume Risk	Uncertainty in whether the solar PV plant will meet its expected generation targets due to factors like weather conditions or equipment performance.
Cannibalization Risk	Risk that excessive solar power generation during peak sunlight periods could lower market prices and reduce profits.
Operational Risk	The risk of system failures or maintenance issues preventing the solar PV project from reaching expected efficiency.
Balancing Risk	Grid costs associated with differences between forecasted and actual solar energy production.
Basis Risk	The potential price difference between the location of the solar energy generation and the location of its consumption, particularly relevant in VPPAs.
Credit and Counterparty Risk	Uncertainty regarding whether the offtaker will fulfill their payment obligations and will meet their contractual commitments.
Non-market Risks	External risks such as regulatory changes or adjustments to government incentives that could affect the project's viability.

financial risks. This de-risking increases project bankability by ensuring stable revenue streams. In contrast, PPAs, especially those with corporate offtakers, shift many of these risks to the private sector, which introduces new challenges that require careful management.

Kapral et al. (2024) propose a detailed framework for risk assessment and mitigation within PPAs. The risks they identify, along with their definitions, are taken from this framework and are summarized and applied on solar PV projects in Table 4.3.

However, not all risks identified in Table 4.3 fall within the scope of this thesis. Since this research compares PPAs to support schemes, it primarily focuses on risks that are unique to PPAs or more pronounced within PPA agreements with private offtakers. Any risks also present in the context of support schemes are excluded from this analysis. The rationale behind excluding and focusing on specific risks is elaborated below:

Cannibalization Risk: According to Kapral et al. (2024) cannibalization risk occurs when an overabundance of renewable energy production drives down market prices. This risk is not unique to PPAs but is a broader challenge in electricity markets. Therefore, cannibalization risk is not considered further within this comparison but will be considered in the next section as broader challenge.

Non-market Risk: These risks pertain to external events such as regulatory changes that can affect both PPAs and support schemes. Since support schemes are government-backed, they are equally exposed to such non-market risks. Therefore, these risks do not differentiate between PPAs and support schemes and will not be a primary focus of this analysis.

Operational Risk: The risk of systems failing to meet predefined operational performance is inherent to all energy projects, whether they rely on a PPA or a support scheme. This risk does not depend on the financing mechanism but rather on the technical performance of the project itself. Thus, operational risk is excluded from further analysis as it applies equally in both scenarios.

Balancing Risk: Balancing risk arises from differences between forecasted and actual production. This risk is relevant to both PPAs and support schemes that operate within competitive electricity markets. Therefore, balancing risk will not be considered as a differentiator between the two.

Basis Risk: Basis risk is specific to virtual PPAs according to Kapral et al. (2024). Since it is assumed that established indices are used in the Netherlands, which Kapral et al. (2024) identify as mitigation measure, this risk is not considered.

The remaining risks are considered within the scope of this thesis because they are either unique to PPAs or have a greater impact on projects financed through PPAs compared to those under support schemes. These are:

- **PPA Price Risk**
- **Shape/Profile Risk**
- **Volume Risk**
- **Credit and Counterparty Risk**

While PPAs can also provide long-term revenue certainty, the price risk is transferred from the government to the private offtaker. This shift introduces additional risks, such as the creditworthiness of the offtaker, which becomes an important factor in determining the project's financial viability. Furthermore, PPAs are exposed to volume and shape/profile risks, which arise from the unpredictable nature of renewable energy production and the potential mismatch with the buyer's energy consumption needs. To achieve the same level of bankability as FiPs, corporate PPAs require additional risk mitigation strategies. This leads to Proposition 5.

4.3.2. Proposition 5

P5: Since a private offtaker is involved, a corporate PPA requires mitigating additional risks to achieve the same level of bankability as a Feed-in-Tariff premium.

Corporate PPAs necessitate additional risk management to address the risks associated with counterparties. Since a FiP does not share these disadvantages, these need mitigating to achieve the same level of bankability.

4.3.3. Allocating the Risks

To manage the considered risks effectively, different PPA contract structures allocate the risks between buyers and sellers in varying ways. Hollmen et al. (2022) underscore this, providing an overview (Table 4.4) of how different contract structure lead to different risk assumptions. Fair allocation of these risks is one of the key factors in increasing the *bankability for funding* category in the framework created by Acharya (2021), looking to understand PPA success.

Table 4.4: PPA Contract Structure and Risk Allocation (Hollmen et al., 2022)

Contract Structure	Price Risk	Profile Risk	Volume Risk
Pay-as-produced PPA	Borne by the buyer	Borne by the buyer	Theoretically by the buyer, but seller liable for under-/over-performance
Pre-defined profile	Borne by the buyer	Partly by seller, mostly by buyer	Borne by the seller
All day peak load	Borne by the buyer	Split 50-50%	Split 50-50%
Annual baseload	Borne by the buyer	Borne by the seller	Borne by the seller
Monthly baseload	Borne by the buyer	Borne by the seller	Borne by the seller

Volume Structures for Allocating Profile and Volume Risk

PPAs offer various volume structures to accommodate different needs of renewable energy producers and buyers. Understanding these structures is important for selecting the right type of PPA that ensures financial stability for the project. However, it has to be noted that needs of the parties involved are examined case-by-case (Stanitsas & Kirytopoulos, 2023).

According to Kapral et al. (2024), the most common structure in PPAs is the Pay-as-produced (PaP) model, where a fixed rate is paid for the amount of energy generated, irrespective of market price changes. This contract can cover either all or a specified percentage of the total energy produced. Most importantly, the offtaker assumes all the risks of mismatch between consumption and production (Kapral et al., 2024), transferring these risks away from the project.

The Baseload PPA, in contrast, offers a fixed energy delivery schedule, which can be defined either annually or monthly (Kapral et al., 2024). On the other hand, a Pay-as-consumed volume structure within a PPA matches the production of energy to the actual consumption patterns of the offtaker (Kapral et al., 2024).

Stanitsas and Kirytopoulos (2023) state that PAP PPAs are among the most popular volume structures across Europe. The structure of PAP PPAs resembles that of the SDE++ scheme, ensuring revenue for all generated electricity and transferring profile and volume risk to the counterparty.

Pricing Mechanisms for Allocating Price Risk

Stanitsas and Kirytopoulos (2023) present the most common types of PPAs and in turn the most used pricing structures, with emphasis on European markets. These are:

- Fixed, escalation & indexation
- Floating price, discount to market with caps and floors
- Collar and reverse collar
- Hybrid structures (% of output)
- Clawback Mainly due to its complexity resulting in less popularity across Europe (Stanitsas & Kirytopoulos, 2023), clawback will not be considered in this thesis.

Stanitsas and Kirytopoulos (2023) explain that a fixed price combined with escalation and indexation structure means the offtaker secures an initial power price that either remains constant or adjusts over the PPA duration. These adjustments can be specified by incorporating inflation or by applying a predetermined percentage increase or decrease each year (Stanitsas & Kirytopoulos, 2023). However, the most common type of agreement is a fixed price PPA (Miller et al., 2017). An fixed priced (with agreed escalation or indexation) is seen as a mitigation strategy for PPA price risk, making sure it does not go 'out of money' (Acharya, 2021; Kapral et al., 2024).

The next price mechanism is a *floating price, discount to market with caps and floors*. This is a pricing model where the offtaker receives a market discount throughout the PPA term for which the offtaker guarantees the producer a minimum (floor) or maximum (cap) price (Stanitsas & Kirytopoulos, 2023). The authors conclude which stating the significance and the placement of the aforementioned floors in these structures for income security and thus bankability.Böttcher (2020) confirms this by stating how a price floor is important for declaring PPA bankable. Also this seems a tool for mitigting price risks in the same way the SDE++ scheme does.

Collar and reverse collar structures do not entail a market discount and involve setting a minimum and maximum price for wholesale energy (Stanitsas & Kirytopoulos, 2023). The producer assumes risk when the market price falls below the floor price, but benefits from upside potential when prices exceed the cap (Stanitsas & Kirytopoulos, 2023). While collars help manage price volatility, high floor prices may lead to a higher overall PPA strike price (Stanitsas & Kirytopoulos, 2023).

Lastly, hybrid structures sell a fixed percentage of renewable energy production using fixed prices and the rest of output using floating prices with a market discount (Stanitsas & Kirytopoulos, 2023). These PPAs typically involve large electricity consumers who are sensitive to power price fluctuations (Stanitsas & Kirytopoulos, 2023).

The transition from support schemes to corporate PPAs changes how risks are allocated in renewable energy projects. Under support schemes, the government assumes most of the price risk by guaranteeing fixed or premium prices for the electricity produced. This model provides predictable cash flows, thereby improving the bankability of the project. PPAs, however, shift this responsibility from the government to private offtakers, introducing new challenges but also creating opportunities for risk-sharing through contract structures.

Proposition 6 stems from the understanding that using a Pay-as-Produced (PaP) volume structure ensures that the seller is paid for the energy they generate, mitigating volume and profile risks. This is particularly effective when combined with a fixed price or price floor mechanism, which guarantees a price for the energy produced. This mechanism mimics the security offered by FiP schemes reducing exposure to market fluctuations. By ensuring that the offtaker bears the price risk while safeguarding the project against price volatility and production uncertainties, these PPA structures serve to de-risk the project in a manner similar to traditional support schemes. Thus, a PaP volume structure paired with a fixed price or price floor greatly enhances bankability by reallocating risks to the offtaker, aligning the PPA's risk profile with that of a FiP-based project.

4.3.4. Proposition 6

P6: A Pay-as-Produced volume structure combined with a fixed price or a price floor pricing mechanism increases PPA bankability.

Different PPA volume structures allocate risks between the producer and the offtaker in varying ways. A fixed price (floor) mechanism and PaP volume structure resembles a FiP subsidy scheme by allocating the risks from the producer to the offtaker, enhancing project bankability.

Interventions for Allocating Credit and Counterparty Risks

This only leaves credit and counterparty risk of the offtaker to be mitigated. There is a nuanced difference in credit risk and counterparty risk. According to Kapral et al. (2024), credit risk refers to the uncertainty regarding whether the offtaker will (timely) fulfill their payments, whereas counterparty risk refers more broadly to the offtaker not meeting contractual commitments. In the literature, these definitions often overlap, which is why in this thesis, it is assumed that the creditworthiness of the offtaker influences both credit risk and counterparty risk.

The importance of a creditworthiness offtaker was already stressed in the solar PV bankability section of this chapter. Consistent with earlier, the creditworthiness of buyers is another key factor in increasing the *bankability for funding* category in the framework by Acharya (2021).

In their research, Hundt et al. (2020) found that corporate offtakers, when compared to utilities, can be seen as more attractive offtaker since they may introduce a lower credit risk. However, data also points out that many companies have a low-grade credit rating, not a rating at all. They stress the importance of additional credit enhancements to provide less creditworthy offtakers to access PPAs (Hundt et al., 2020). The framework by Kapral et al. (2024) provides credit support as mitigation strategy for credit and counterparty risk, including credit insurance.

In the Dutch context, the development of a corporate PPA guarantee fund is being explored to address credit and counterparty risks. This fund would help mitigate these risks by offering financial coverage in cases where an offtaker defaults, such as due to bankruptcy (Rebel, 2023). For example, if electricity market prices are lower than the agreed price in the PPA at the time of default, the fund would cover a portion of the difference, ensuring stability for developers. This approach aligns with the strategies suggested by Kapral et al. (2024).

Due to EU regulations, the fund must be cost-neutral, with risks primarily covered by the premiums paid by developers and the fund can only offer coverage for up to 80% of the contract value (Rebel, 2023). This initiative is expected to not only improve the financing of solar and wind projects but also contribute to the maturity of the corporate PPA market, moving towards a future less reliant on subsidies (Rebel, 2023). By providing this safety net, the government assumes part of the financial risk associated with defaulting offtakers. However, this illustrates the ongoing reliance on government intervention.

While interventions such as credit enhancements and guarantee funds can mitigate credit and counterparty risks, they also underscore the dependence on government support. These interventions highlight the ongoing complexity of financing renewable energy projects through corporate PPAs in theory. However, when applied in practice, these PPAs reveal broader systemic issues exposing the limitations of market-driven approaches in achieving sustainable and equitable renewable energy development. This transition from theoretical risk mitigation strategies to real-world market dynamics raises questions about the broader implications of corporate PPAs.

4.4. Systemic Challenges to PPA-Driven Financing

This section further adresses the second part of SQ3: *How does financial decision-making differ when using a Power Purchase Agreement compared to a support scheme, and what are the best practices and challenges associated with Power Purchase Agreements?*

In previous chapters, it is argued that on paper, PPAs could form an alternative in terms of bankability to subsidy schemes, when structured to allocate risks to a creditworthy offtaker. However, they also introduce broader limitations and challenges. These limitations are not necessarily related to the immediate financial structure of the project but affect the larger landscape of renewable energy development, market fairness, and energy prices. To fully understand the role of PPAs in solar PV project financing, it is essential to consider these broader implications.

4.4.1. Cannibalization Effect

Kapral et al. (2024) already mentioned cannibalization risk in the context of PPA risks. The cannibalization effect refers to how increasing renewable energy production drives down market prices, reducing profitability for energy producers. Solar energy, with its concentrated generation around noon, increases this effect due to the merit-order effect, where low-cost renewable electricity displaces higher-cost generation sources, sharply lowering prices during these times (Prol et al., 2020). As penetration levels rise, the effect becomes more severe, leading to significant reductions in revenues for solar PV projects (Reichenberg et al., 2023).

This oversupply issue is more pronounced for solar energy than for wind, which generates power more consistently throughout the day. Mitigating the cannibalization effect requires increased system flexibility through energy storage, demand-side management, and geographic diversification (Kozlovas et al., 2024). However, despite these solutions, the cannibalization effect remains a significant challenge to the long-term profitability of solar PV projects, particularly in markets with high renewable energy penetration.

4.4.2. Unfair Playing Field

PPAs also expose a fundamental critique of electricity markets: the myth of free and equal participation (Christophers, 2022). Unlike smaller entities, only large corporations can afford the complex, resource-intensive process of negotiating multi-year PPAs, creating an uneven playing field, where large tech companies dominate the market, securing low, stable prices and favorable terms, while smaller businesses and developers struggle (Christophers, 2022)

These giant corporate companies leverage their substantial market power to dictate terms, often resulting in low PPA prices that developers must accept to ensure revenue stability, leading to diminished returns for investors (Christophers, 2022). This dynamic can deter investment in new renewable projects, threatening the growth of the renewable energy sector. This ultimately contradicts the problem statement of this thesis.

Moreover, the reliance on corporate PPAs raises broader questions about the adequacy of this market-driven approach to sustain large-scale renewable energy development. Without sufficient state support or fundamental reforms in liberalized electricity markets, the current model may fall short of meeting the ambitious renewable energy investment targets necessary for achieving net-zero emissions by 2050 (Christophers, 2022).

4.4.3. Financialization and the Cost of Energy

The debate on finance companies using their financial expertise to create new revenue streams from clean energy infrastructure fits with the development of PPAs. The rise of financial innovations, or ”fintech,” in the clean energy sector is paradoxically addressing issues that stem from financialization itself (Knuth, 2018). These ventures offer innovative financing for renewable project, achieved through complex ownership structures and tailored financial benefits for investors.

In the paper by Knuth (2018), the use of project finance and the role of PPAs is exemplified as one of the more matured versions of these specialized financing arrangements. The complexity of each deal results in expensive capital, which is why project finance has traditionally been reserved for very large infrastructure projects and these high costs are now reflected in the prices paid for U.S. renewable energy systems (Knuth, 2018). In response, new financial innovations have been proposed to further financialize clean energy infrastructure.

The continued dominance of the financial sector is reflected by the fact that many advocate for a solution to financing renewable energy that deepens the involvement of the financial sector. This approach further financializes cleantech and renewable energy infrastructure by relying on financial expertise, innovation, asset creation and the development of new financial markets (Knuth, 2018). Recent research also indicates that the excess comovement of commodity prices cannot be fully explained by macroeconomic fundamentals, suggesting that the rapid financialization of commodity markets contributes to this phenomenon (Ji et al., 2020).

While PPAs provide a mechanism to finance renewable energy projects, they expose issues such as the unequal playing field that benefits large corporations at the expense of smaller entities, and the increasing financialization of the energy market, which can drive up costs for consumers and investors alike. Moreover, the cannibalization effect, wherein the growing penetration of solar energy drives down electricity prices, further complicates the financial viability of solar PV projects under the current PPA model. These systemic challenges indicate that relying solely on PPAs is insufficient to support the scale of renewable energy development necessary, as they fail to address key market dynamics and long-term sustainability concerns. This analysis leads directly to Proposition 7, asserting that PPAs alone cannot deliver the desired development of solar PV projects in the Netherlands.

4.4.4. Proposition 7

P8: PPAs alone cannot lead to the desired development of solar PV projects in the Netherlands.

Relying solely on PPAs may not be sufficient to achieve the scale of renewable energy development required. PPAs create an unfair playing field and the financialization of renewables can lead to an increate in energy costs.

4.5. Conclusion of Chapter 4

This theoretical framework has examined the factors influencing the financing and bankability of large-scale solar PV projects. Beginning with the importance of debt financing, it was proposed that Dutch solar PV projects heavily rely on securing debt, with lenders assessing the risk profiles of these projects through a structured evaluation process. Propositions were introduced, with the first emphasising the reliance on debt financing (P1), and the second highlighting the importance of mitigating price risk to enhance project bankability (P2). Support schemes play a de-risking role in reducing price volatility, ensuring predictable revenue streams and thereby increasing the attractiveness of projects to lenders (P3).

Furthermore, the role PPAs in mitigating price and market risks was explored, with the analysis revealing that corporate PPAs can provide revenue stability but require additional risk management strategies compared to FiPs due to the involvement of a private offtaker. (P4, P5). Specific PPA structures, such as Pay-as-Produced contracts with fixed pricing or price floors, were identified as key to improving the bankability of these agreements (P6). This, however, does not remove counterparty risk from the equation.

Lastly, the chapter addressed the limitations of relying solely on PPAs for driving solar PV development. The cannibalization and financialization of renewable energy and the uneven playing field created by corporate PPAs raise concerns about their sufficiency in achieving the desired growth in the Dutch solar market (P7). An visual overview of the propositions can be found in Figure 4.2.

The propositions presented in this theoretical framework serve will be used in the validation part of this research. Each proposition is translated into specific interview questions and further into an interview protocol, as outlined in Appendix D, to ensure that theoretical concepts are thoroughly explored during the validation phase. These interview questions will allow for an in-depth discussion with experts, helping to validate or refine the theoretical assumptions.

Additionally, as pointed out in chapter 3, the propositions will inform the deductive coding scheme used during the thematic analysis. By aligning the coding process with the propositions, the analysis will capture insights and patterns related to the theoretical framework. This structured approach enables a clear linkage between theory and empirical findings, ensuring that the conclusions drawn are grounded in both the theoretical framework and the empirical evidence.

4.5.1. Proposition Overview

P1: Dutch solar PV projects are reliant on debt financing.

P2: Mitigating price risk enhances solar PV project bankability.

P3: A Feed-in-Tariff premium mitigates price risk for a solar PV project.

P4: A corporate PPA mitigates price risk for a solar PV project.

P5: Since a private offtaker is involved, a corporate PPA requires mitigating additional risks to achieve the same level of bankability as a Feed-in-Tariff premium.

P6: A Pay-as-Produced volume structure combined with a fixed price or a price floor pricing mechanism increases PPA bankability.

P7: PPAs alone cannot lead to the desired development of solar PV projects in the Netherlands.

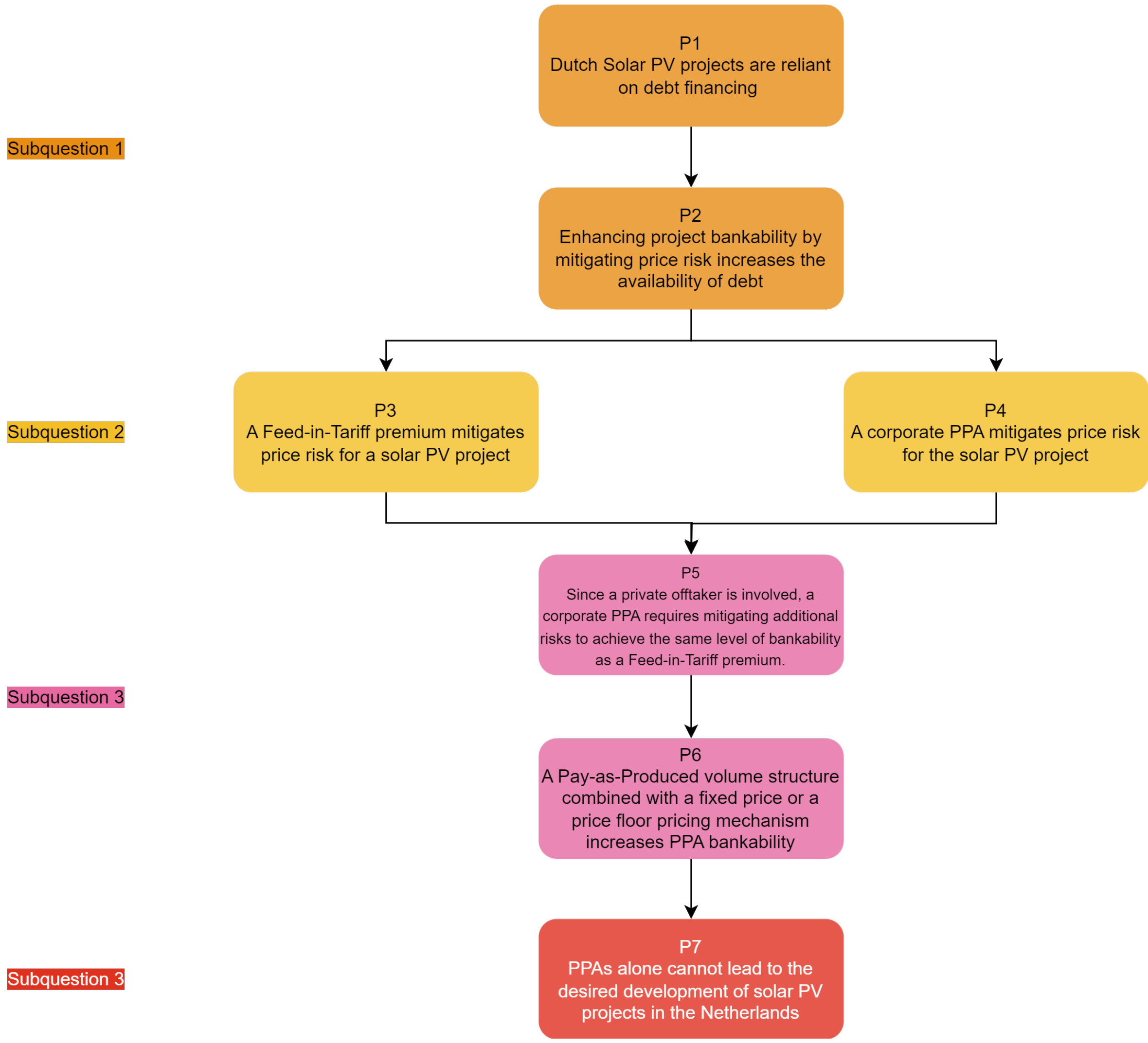

Figure 4.2: Propositions linked to Research Questions (Author's figure)

5

Interview Results

This chapter presents the findings from the semi-structured interviews conducted with the industry experts, as explained in chapter 3. It is important to note that while this chapter focuses on presenting the results as per the identified codes and themes, the validation of propositions and the interpretation of these findings will be addressed in chapter 6. There, the results will be integrated with the theoretical framework and broader literature to validate the propositions and provide an interpretation of the research outcomes.

This chapter is structured around the research questions guiding this thesis, combined with the codes and themes identified during the coding process. Below, a small reader guide for this chapter can be found. A visual representation of the codebook can be found in Appendix E.

- Financing Dutch PV Projects (RQ1): This section explores the typical financing structures used in the Dutch PV industry, focusing on the role of project finance, the factors affecting a project's bankability, and the challenges associated with merchant financing.
- Roles of SDE++ and PPAs (RQ2 & RQ3): The second section analyses the roles of the SDE++ scheme and PPAs in financing large-scale PV projects. It covers best practices and the evolving landscape as subsidies phase out and PPAs take a more prominent role.
- Systemic Challenges (SQ3): The final section delves into broader systemic challenges facing the Dutch PV sector, including the impact of fluctuating electricity demand, policy changes, and issues such as overcapacity and local ownership. Comparisons with international practices and external factors are also addressed.

5.1. RQ1: Financing Dutch PV Projects

This section outlines the financing of large-scale PV projects in the Netherlands and identifies the factors that influence these decisions. A reliance on project finance structures is evident, with financing decisions being shaped by considerations such as bankability and the predictability of cash flows. While developers often seek to optimise returns through high levels of debt financing, lenders place greater emphasis on managing risks and ensuring stable revenue streams. The challenges associated with merchant financing, where projects depend on market prices without subsidies, are also explored which illustrates cautiousness towards financing under uncertain cash flow conditions.

5.1.1. Project Finance Structures

Investors and developers underscore the heavy reliance on financing for getting projects off the ground. Investor C2 noted, *"Most of the energy projects are heavily financed,"* emphasizing that access to financing is essential for project development. Developer C3 echoed this sentiment, stating that project financing is *"a way to get projects off the ground that otherwise wouldn't happen,"* and a tool for making projects feasible that would otherwise remain unrealised.

Lenders, however, focus more on the certainty of cash flows and offtake agreements. Lender B3 stated, *"Whatever it is, we always look at how certain the offtake is, and the more certain that is, the more debt you can get."* Lender B2 reinforced this view, adding that *"The more certain the cash flows, the easier it is for us to finance."* This confirms the importance of the predictability for lenders.

5.1.2. Bankability

The question of bankability, whether a project is attractive enough to secure financing, is viewed differently by lenders and investors. Developers tend to prioritize high debt levels, seeking to maximize returns by minimizing equity investments. As lender B3 pointed out, *"An investor simply looks at it like: as much debt as possible, with as little equity as possible."* This reflects focus of developers and equity investors on maximizing their financial leverage.

Lenders, on the other hand, approach projects more cautiously. The same lender noted, *"A developer looks at the upside, and we as a bank look at what can go wrong,"* illustrating the risk-focused perspective of lenders. They emphasize predictable revenue streams with solar projects, as highlighted by lender B1, who stated, *"Your volumes are also very predictable. If you look closely at the sizing of such a project and the design, then you can really predict your revenue over the long term."*.

Focusing on the business case of a renewable energy project, policymaker A3 pointed out that rising interest rates can significantly impact project costs, saying, *"Financing costs make up the largest part of the costs for solar and wind. And if you're dealing with an interest rate that's one percentage point higher, it simply means that every project becomes a lot more expensive."*

5.1.3. Merchant Financing

The topic of merchant financing, where projects rely on market prices without subsidies, brings out consensus in lender perspectives. Lender B2 remarked, *"Fully merchant for now. I don't see that happening just yet. I don't see that happening anytime soon."* reflecting doubts about the feasibility of fully merchant projects in the current market. Lender B2 emphasized that without subsidies, projects would need much more equity investment *"But right now, we could finance up to 90% of the CAPEX, and that's going to stop. Then you'll maybe go down to 50 or 40%, so more equity will be needed."*

Another lender, B1, mentioned their limited experiments with merchant financing, noting that *"we have experimented a bit with a small merchant tail. But fully 15 years, 10 years—no, we haven't done that yet, and as far as I know, no other bank has either."* The lender added that the unpredictability of cash flows in merchant models made project financing unsuitable, stating, *"You lose the predictability of your cash flows. And then project financing isn't really suitable for that anymore."*

5.2. RQ2 & RQ3: Roles of SDE++ and PPAs and Best Practices

This section examines the roles played by the SDE++ subsidy scheme and PPAs in the financing of large-scale PV projects in the Netherlands. Lenders and policymakers emphasise the importance of the SDE++ in providing stability and predictability for project financing, while PPAs are increasingly seen as a substitute as subsidies begin to phase out. The analysis also covers the challenges of relying on PPAs, including issues related to contract duration and creditworthiness of offtakers. This results into insights in the potential for PPAs to fully replace the SDE++ scheme. Best practices for combining both mechanisms to ensure financial stability are discussed as well.

5.2.1. SDE++

Role SDE++ in Financing

Lenders view the SDE++ as a must for project financing Dutch renewables, providing stability and predictability. As lender B1 noted, *”the SDE is very important for financing. And it’s very safe. It’s also definitely one of the main reasons why the solar market in the Netherlands has developed so quickly.”* The removal of price risk is a key feature, with another lender B1 stating, *”the SDE is a very nice and safe way of financing because it essentially removes the price risk.”* The long-term nature of the SDE++ subsidy is also crucial for banks, allowing them to predict cash flows and structure long-term financing deals.

Policymaker A4 emphasizes the certainty the SDE++ provides as a government-backed mechanism. As he explained, *”if you have a decision, a subsidy decision, then you essentially have a contract with the government.”*

For lenders, the ”unprofitable top” covered by the SDE++ plays a central role. Lender B4 highlighted that the SDE++ ensures a minimum cash flow, stating, *”that’s really the role of the SDE, that you know you will at least get a minimum cash flow, on which you can structure the deal, so in practice, you actually have an investment-grade loan.”* This allows projects to achieve high levels of debt financing, *”sometimes up to 90% of the CAPX goes into it”* according to both lender B2 and B4.

Policymakers also acknowledge the societal value of the SDE++, as it enables more favorable financing for renewable energy projects. One policymaker A5 noted, *”the LCOE (Levelized Cost of Energy) really goes down because you are able to attract better financing, favorable financing. So reducing risk has societal value. So yes, the SDE system costs money. But because of it, we also have renewable energy for a bargain.””* They argue that, although the SDE++ system costs money, it brings significant benefits in terms of lower costs for renewable energy in the long run.

Details of Mechanism

Policymakers explain how the SDE++ operates by closing the financial gap between traditional and renewable energy costs. Again describing it as an ”unprofitable top” instrument, with policymaker A1 saying, *”then came the solar panels and the wind, and there was also still a gap, a financial gap, between what electricity from one source costs and what electricity from sustainable sources costs. And what the SDE does is essentially close that gap.”* Over time, as the cost of solar panels has decreased, the subsidy amounts have also been reduced.

However, policymakers stress that there are limits to the subsidy, especially in cases where electricity prices are negative. Policymaker A4 clarified, *”if the product price is negative, you are not allowed to subsidize. And I actually find that quite logical because if a price is negative, that’s already an absurd market situation. Then you have a surplus. And to subsidize a surplus—I mean, it’s the equivalent of a milk lake. You can’t subsidize that.”*

From the perspective of lenders, the SDE++ provides a buffer against market volatility. Lender B3 explained, *”the SDE gives us certainty, so a buffer... no matter what the electricity price does, the certainty will be there.”* Lenders are also aware of the changes in the scheme over time, such as the inclusion of negative price blocks in the new SDE++ design, like Lender B3 stating: *In the very old scheme, there were no negative price blocks. Then there was an SDE with six-hour negative price blocks. And now, in the new SDE, every (negative) hour is subtracted."*

Parties are also mindful of the risks that arise when electricity prices fall too low. Investor C2 pointed out, *"if the power prices are very low, then there will be a gap in the subsidy level which you will receive."*

Confidence in Government

The importance of trust in the government's commitment to the SDE++ scheme is highlighted by policymakers and developers. Policymaker A4 emphasized that a subsidy decision essentially creates a contract with the government, adding, *"the market sees that indeed, it is being handled responsibly."* This trust seems essential for ensuring long-term investment in renewable energy projects.

However, concerns are expressed about the risks associated with fluctuating energy prices. Developer C1 remarked, *"I think the energy prices this year are already such that they fall below the base energy price. If you take a bad scenario for the coming years, then you're just going to be below that every year. And then we're talking about 8 euros per megawatt-hour. That's a lot for a business case."* The same interviewee believes that the government has downplayed these risks, categorizing them as "entrepreneurial risk."

Banks reliant on SDE++

Policymakers argue that the Dutch market has grown accustomed to the security provided by the SDE++. Policymaker A3 stated, *"the Dutch market has been spoiled by the SDE. So the financiers are also used to having 15 years of security guaranteed by the government. You can't find that kind of certainty anywhere else."*

Investor C2 agreed and said, *"the subsidies probably made the world too comfortable for the banks."* The interviewee noted that, in other sectors without state support, such as other infrastructure classes, banks still finance projects without guaranteed revenue, suggesting that banks could handle more risk: *"for example, if you invest in something like a fiber optic cable or a highway, in most cases, there is no guaranteed revenue from that. Yet, the banks still finance those investments."*

Lender B1, however, pushed back on this characterization, stating, *"I think you should say that developers and the market have been spoiled by the SDE, not so much the banks."* They argued that banks have adapted to different financing models in other countries, where projects require substantially more equity from the developers or investors and carry more risk.

On the other hand, lender B4 was more understanding: *"I think that plays a role because now we often say, we don't take market risk, so it's easy to reject that because you think it's not necessary. So, in a sense, I think that's somewhat true. At the same time, I also think that if you do it differently, meaning you have market risk, no matter how you look at it, there's simply more risk in such a project, and that will always have an effect on the price. And then that price, because financing is one of the largest components of the whole project, if that pricing becomes higher, then the project becomes more expensive."*

Lender B3 echoed this statement by saying *"I think it will be difficult to change our view on that. It would mean that we'd have to take on a different risk profile. And that would increase the interest margin, which of course doesn't work for the clients, so that's tricky."* Lender B2 confirms the general lender view on changing risk perception with, "*we do have the responsibility to get those savings back, and we are also simply bound by ECB regulations to not take excessive risks."*

Failed SDE++ Design

Interviewees point out flaws in the current SDE++ design, particularly regarding its ability to address market challenges. Specialist C5 remarked, *"it's actually now a bit of a victim of its own success... it has ensured that you have a very large stream of solar production, and that is partly causing the negative prices we are seeing now."*

Also, the "rigid calculation rules" used by the government were criticized, which are believed make the scheme inflexible. Developer C1 noted, *"the intention of this subsidy was to provide support during lower energy prices... I think the scheme for 2023 has simply become a very unfavorable arrangement."* Further explaining, *"part of it is in the advance payment calculations. How was it last year? That will happen again next year. It doesn't matter if there was a war, so we're not giving an advance, because you don't need it. A lot of parties are really in a tight spot now."*

Lenders are also concerned about the impact of declining subsidy amounts on the bankability of projects. Lender B1 explained, *"the subsidy you get per megawatt hour has been decreasing... to the point where, at a certain level, some projects no longer worked out."* They added that Dutch projects are used to high levels of debt financing, but with the SDE++ amounts decreasing, more equity is now required, as lender B1 states *"you don't do 90% with the bank anymore because the SDE amounts are too low for that. Now it's more 20%, 25%, 30%, sometimes even more.*

Future/Termination of SDE++

Policymakers recognize that the market may not yet be ready to operate without subsidies. The planned termination of the SDE++ scheme was cancelled, like policymaker A3 stated, *"But later, we concluded that if we were indeed to stop after 2025, the market is still not at the point where it can solve things on its own. So we had hoped for that, but it just didn't happen. So then we said, there has to be a follow-up scheme. And that follow-up scheme is going to be the CfD (Contract for Difference). And until that's in place, the SDE will continue."*. The need for stability was still acknowledged: *"So if the SDE ends soon, then something needs to come that provides sufficient investment certainty."*

Market parties, however, are preparing for a future without subsidies. Investor C2 noted, *"the market realized that the age of subsidies is gone, effectively."*

Developer C1 suggested, *"The past shows, at least, that energy companies need some time to adjust to a new situation. So if you're creating a new scheme, you better hope it's clear two years in advance what it's going to be, so that market players can start preparing, so to speak."* Policymaker A4 soothed this by saying *"I think for market players, it will end up looking a lot like the SDE. So I expect that there won't be much change, maybe just a year of waiting and seeing."*

Subsidy-Free Market

While policymakers and developers agree on the need to move toward a subsidy-free market, there is recognition that this transition will take time. Policymaker A3 pointed out, *"of course, we want to move toward a subsidy-free market... because then you don't have conditions to meet, and you're not reliant on a subsidy infusion."* Even stated more boldly by policymaker A4: *"Well, it seems to me that's where you want to go, yes. I'm more inclined to ask, if it's not possible,then what are we doing? But I would say, ultimately, yes, either your product just gets cheaper because production costs go down, or your reference becomes more expensive through norms and obligations. But to keep putting an SDE on something for many years doesn't seem very healthy to me."*

However, lenders doubt whether the market can fully function without subsidies in the near term. Lender B1 argued, *"don't expect the market to be able to handle everything on its own. You will have to continue* *combining it with some form of subsidy. And if you don't, you can see if the market can solve it. But then you'll simply see far fewer initiatives, and you definitely won't meet your goals."*

5.2.2. PPAs

PPA Current Role

The role of PPAs has become increasingly important as subsidies like the SDE++ have started to phase out. Investor C2 noted, *"as the market effectively grew up and everyone was starting to, and the CAPEX decreased significantly on the wind and solar side —predominantly on solar— then the golden age of subsidies slowly came to an end, especially in the Nordic markets. In Sweden, Norway, and Finland, large players started to offer commercial PPAs."* This demonstrates how, with the decline of subsidies, PPAs emerged as an alternative for securing long-term financial stability for projects.

Developer C3 highlighted the motivation behind pushing PPAs, explaining, *"the declining SDE was actually the main reason to push through the PPA and set a fixed price to bring stability to the budget."* He pointed out that the newer unpredictability of the SDE due to decreasing base prices led him to seek out a PPA for financial stability.

Lender B3 distinguished between two types of PPAs, explaining, *"there are two types of PPAs. I always call it a corporate PPA. That means a fixed off-taker for a fixed price."* He also noted a market shift, stating, *"there haven't been many corporate PPAs recently. In the past half year, three-quarters of a year, we still see them with wind, but almost none with solar."* The other type of PPA is complementary to the SDE++, as explained below.

Lender B1 added that fully PPA-based projects without subsidies are still rare, explaining, *"right now, a project that only has a PPA, so fully without SDE, no subsidy at all, there aren't that many of them—you'd have to search with a flashlight to find them."* However, he acknowledged that projects do combine the SDE with a PPA: *"there are many projects that do have SDE, and then that PPA, that fixed price, as an extra, above the SDE, otherwise, you wouldn't sign it."* Lender B2 also confirms this, emphasizing the fact that they *"always make sure that the PPA follows the same system, looks at the same electricity price, day-ahead, etc., so that it matches how the SDE works".*

Lender B3 further explains how this PPA, being complementary to the SDE++, influences the debt structure: *"Well, when does it get interesting? Imagine you have an SDE of 50 euros, and someone says to you, yes, I'll pay your fixed price of 60 euros, no matter what happens. That means you have 10 euros on top of your SDE. It also means that in your revenue structure, which the debt is based on, it's 10 euros higher than the SDE. That automatically means you can attract more debt. When does that have value for us? When it's a strong offtaker."*

Duration of Contracts, Creditworthiness and Volume/Price Structure

One of the key challenges with PPAs is the duration of contracts and the creditworthiness of off-takers. Lender B4 emphasized, *"it's about the price in the contract, the duration of the contract, and the counterparty risk. I think those are the three most important components."* Lender B3 adds to his aforementioned explanation concerning a corporate PPA, *in that case, it's important that the volume is fixed. So they say, I will take everything, pay as produced, and at a fixed price."* This clarifies the importance of having a fixed price and Pay-As-Produced volume structure, which makes financing easier for lenders.

For a project to be bankable, the PPA off-taker must have a strong credit rating. However, as lender B4 noted, *"a small party often doesn't have that because it's expensive to request such a rating,"* which increases funding costs.

Lender B1 expressed skepticism about securing long-term PPAs, explaining, *"the SDE runs for 15 years. That's a very long time. That's, of course, great... Getting a 15-year PPA now—that's really not going to happen."* Lender B3 echoed this concern, noting that smaller off-takers are often not reliable enough for long-term financing. He stated, *"we can't include it in the business case because it's not investment grade, or we don't think it's strong enough to finance over the long term."*

Lender B2 added that even with large, creditworthy off-takers like Google, *"you still need to do an analysis... what's the risk that the company collapses or that the offtaker suddenly disappears?"* This shows that even with a strong off-taker, PPAs require careful risk assessment to be considered a viable financing option.

Offtaker Problems

Policymakers and lenders both highlighted challenges related to the demand for PPAs and the creditworthiness of potential off-takers. Policymaker A3 observed, *"what we mainly see is a lack of demand and also a lack of creditworthiness from many parties to enter into such long-term contracts."* Lender B3 shared a similar perspective, stating, *"if you have a small solar park or a small wind park, it's just difficult to find a strong offtaker because they want large volumes."*

Lender B1 further explained the difficulty in securing creditworthy PPA off-takers, stating, *"the good parties, the creditworthy ones, are not lining up to provide a PPA for a (relatively small) project of 4 to 5 million... and you're stuck with the fact that there are very few creditworthy parties that a bank will finance for 15 years."*

Investor C2 also highlighted that demand for PPAs from large energy-demanding companies may be nearing saturation, explaining, *"the market of these huge energy-demanding companies is, meanwhile, maybe not saturated yet, but most of them have already signed PPAs."* He suggested that the future demand for PPAs may come from smaller companies, but *"they will act very opportunistically on this."* Policymaker A5 shared this view: *"Facebook and Microsoft can do this, and they have already done it. But also regular companies in the Netherlands would like to do this ... but they buy and sell a large part of their products on spot markets, which are volatile as well, and they don't get super long-term agreements from energy companies. And yes, in that case, a significant bank guarantee is also required for market-to-market risk."*

PPA Guarantee Fund

A potential solution to the issues surrounding off-taker creditworthiness is the creation of a PPA guarantee fund. Policymaker A3 mentioned this as a way to encourage smaller parties to participate in PPAs, stating, *"such a guarantee fund could help support smaller parties in securing a PPA. Otherwise, you end up with a few giants that can do it, and the rest can't, and then that market will never really take off."*

Lender B4 supported this idea, noting, *"the concept of having another party guarantee, at least for the creditworthiness of the off-takers, is certainly very valuable."* However, Lender B1 expressed caution, stating that while it could be useful, *"there is a cost associated with that guarantee fund. It has to be paid for."*

Policymaker A4 was skeptical about the idea of government intervention, stating, *"if you're talking about a government guarantee fund for PPAs—hello, there are two private parties, and the government should guarantee it? I don't think so."* Specialist C5 echoed this sentiment, pointing out the current political difficulties in securing such a fund in the current environment, stating, *"well, we're currently in a political situation where there's some cynicism and skepticism toward solar, wind, and sustainable projects.*

And given the current circumstances, we also expect there will be cuts and reductions in various areas. To then say, we need a billion-euro guarantee fund—that's not going to happen."

PPA as SDE Substitute

Finally, the potential for PPAs to replace the SDE was discussed. Policymaker A4 expressed cautious optimism, stating, *"in the end, it should be just as certain for me."* Investor C4 believed that *"corporate PPAs with a fixed price could definitely be an alternative to SDE."*

However, there was a general sense of uncertainty about whether PPAs could fully replace SDE. Lender B2 said, *"in theory, it can be a replacement,"* but investor C2 added, *"PPAs will definitely play a role in replacing those schemes. However, I'm not sure if they can replace it one-to-one."*

Policymaker A3 expressed doubt about the Dutch market's ability to fully embrace PPAs, stating, *"I think it would be great, but I wonder if it will ever truly become a thriving market."* Lender B1 also shared this skepticism, saying, *"are PPAs a replacement for that? Well, no, certainly not for the onshore market in the Netherlands."*

Finally, developer C1 summed up the general sentiment by stating, *"No, I don't think you can leave this to the free market."*

5.3. SQ3: Systemic Challenges

This section addresses the practilities of the use in the context of the Dutch policy landscape. The discussion highlights how the role of PPAs has evolved alongside changing energy policies and market conditions, with emphasis on the need for balanced approaches that combine subsidies with market mechanisms. Attention is also given to the challenges of local ownership, fluctuating electricity demand, and the surprisingly huge impact of negative price hours on project feasibility.

5.3.1. Dutch PV Context and Policies

Energy Policy

The Dutch energy policy was initially focused on maximizing electricity production, but this approach now needs to evolve, as Lender B2 explains, *"Initially, it was set up to produce as much electricity as possible, and we really need to move away from that. That made perfect sense when it was introduced."* Lender B1 further elaborates that the market cannot handle the transition independently, stating, *"and that's the message we have given earlier as well. Don't think in terms of a zero or a one. Either you have to have subsidies or the market has to do it. The best approach is to have a combination of both. And that is really necessary. And act quickly, because it really needs to become clear now. Otherwise, you'll end up with a vacuum in your development pipeline."*

Policymakers are also considering the inefficiencies of current policies, as Policymaker A3 notes, *"And then you have to spend a lot of money on electricity that's essentially being wasted, when you might prefer to invest that money in stimulating demand so that more electricity is used."* She also hints at potential policy changes, such as a cap on solar energy.

Bringing another perspective, developer C1 reflects on the overcapacity in the current system, saying, *"Well, from another perspective, our entire society is built on overcapacity. Down to its very fibers, you know."* Lender B3 connects this to the future vision of the Dutch government, where the rapid electrification of society could eventually raise electricity prices and better balance supply and demand. As he puts it, *"If it goes really fast, and let's say there are a lot of charging stations, a lot of electric* *cars... then the electricity price will rise. Suddenly, in the middle of the day, the produced electricity will be worth something."*

Electricity Demand

Developer C1 highlights the government's dual focus on stimulating both electric generation and consumption, but expresses doubt about its effectiveness: *"I think the government says, okay, we stimulate electric generation, we also stimulate electric consumption. But in my opinion, nothing is really going to come of the latter."* He emphasizes the mismatch between production and consumption, warning that, *"If there's no corresponding electric consumption, we're just going to end up with more and more negative hours."*

Policymaker A3 recognizes that this lack of demand is a significant issue, noting, *"I think the business case is certainly challenging at this moment because of the lack of demand, which is leading to more and more low and negative hours."* Investor C4 remains optimistic, believing that as demand for green energy grows, the system will eventually stabilize: *"There needs to be demand from the market for green energy, and if there's enough demand for green energy, then it will match up."*

Cost of Energy Transition

The energy transition comes with financial challenges, and the question of who bears the cost is a recurring theme. Policymaker A4 comments, *"Yes, but if it doesn't come from the government, it has to come from the consumer. The question is, how much can you get from the consumer?"*

Policymaker A3 argues that keeping financing costs low is key to controlling the overall costs of the energy transition: *"By limiting that risk and keeping financing costs very low, we also ensure that we keep the costs of the energy transition low."* Lender B4, however, points out that taking on market risk inevitably makes projects more expensive, *"If you take on market risk... there's simply more risk in such a project, and that will always affect the price."*

Policymaker A5 notes that corporate PPAs could offer a way to manage market risk directly between the solar park and the offtaker, potentially lowering costs for the state: *"A corporate PPA... essentially manages that market risk between them. And then it becomes much cheaper for the state, for Dutch society."*

Contract for Difference

Policymaker A3 outlines the necessity of a follow-up to the SDE scheme, explaining that the Contract for Difference (CfD) is seen as the next step, *"We decided there needs to be a follow-up scheme, and that follow-up scheme will be the CfD... And until that is in place, the SDE will continue."* She highlights how CfDs will provide market stability, as they *"automatically skim off profits as soon as they are made, creating completely different incentives."* Also, she highlights the limited space for a follow-up due to European intervention: *Europe has also said that if you want to continue offering an operating support system for renewable electricity, it must be through a CfD.*

Lender B1 views CfDs as a positive development that could give more flexibility to developers, saying, *"I think that the Contract for Differences is the way forward... Then you can combine it with market mechanisms."* Lender B3 is similarly optimistic about adapting to this new system, stating, *"It's just a different mechanism, but we'll quickly adapt to it."*

However, Developer C1 expresses concern about the entrepreneurial aspect being removed from the equation, *"If we have one price, and everything above that is skimmed off, and everything below is supplemented, then the entrepreneurial aspect is taken out of it."* Also, the CfD's inability to address negative prices is mentioned, for example by Policymaker A4: *”and also in the contract for difference, that’s all fine and well, but of course, there’s also no solution for the negative hours in there.”*

Local Ownership

The push for local ownership through the RES (Regional Energy Strategies) introduces additional complexity. Developer C3 finds the requirement for 50% participation to be a major challenge, stating, *”What I see with those RES... is that they require 50% participation... that’s something I find quite complicated to arrange.”*

Bundeling projects together to increase volume, thus offtaker appetite was also discussed. Howver, lender B1 explains that local ownership structures form a barrier: *”That push, that desire for local ownership, often means that... bundling those two projects together is, of course, very difficult because they are (partially owned by) different parties.”*

Developer C3 is also concerned about the financial aspects of local ownership, *”Local ownership and financing—I find that worthless. Then you have to finance one of the cooperatives... What’s your guarantee that you’ll get your money back?”*

5.3.2. Comparisons and Externalities

Low Prices & Negative Hours

Investor C2 warns of the risks associated with capture rates, stating, *”The major risk associated with those assets is predominantly the capture rate risk.”* Developer C5 highlights that grid congestion and negative price hours are already causing issues for large-scale projects, noting, *”Due to grid congestion and negative hours, new projects are becoming fewer.”*

Policymaker A3 acknowledges the surprise at how negative hours have developed, saying, *”No one could have predicted this to this extent.”* Developer C1 agrees, adding that the pace of development has outstripped expectations, *”It has surprised me... The development has been so huge.”*. He also mentions that this poses a serious risk, and banks are not yet aware of it, but *”when the banks start thinking about it, it could become very difficult to get financing.”*

Lender B1 stresses the need for curtailment to be factored into production forecasts, *”Curtailment must be included in your production forecasts. It’s an additional uncertainty in such a project.”* And points out again: *”the more uncertainties there are, the more negative the impact on your borrowing capacity.”*

Characteristics of Solar PV

The success of solar PV has brought additional challenges. Investor C2 notes, *”The technologies are very cheap. But due to their success, they are facing other risks.”* Developer C3 highlights solar’s unfavorable profile, *”Everyone delivers at the same time... That’s why you see day-ahead prices going negative.”*

Comparing solar with wind, Developer C3 suggests wind energy is more favorable due to its spread-out generation profile, *”Wind is much more favorable. If you spread wind energy across the land, you would solve many congestion problems.”* He adds that *”Solar has a very unfavorable profile... unless you start looking at things like storage.”*

Comparison with Wind Energy

Lender B2 points out that solar projects are more affected by negative price hours than wind projects, *”You’re most affected by those negative hours, because in the winter, the wind still blows in the evening and at night, so it has a different profile.”*

Policymaker A3 adds to, stating for wind at sea, *"Larger parties, larger projects—they simply have more capacity to get involved and do this. They can offer a huge chunk of electricity as well. And they have to, because they're not receiving any subsidies. So I think it's a combination."* Lender B1 also notes that these projects tend to attract larger developers, who can offer diversified electricity profiles to larger buyers. Also, *"the creditworthiness of the buyers is much less of an issue. It's perfectly normal to have an external rating there, and if they fall below it, extra support is offered to cover that. That's the main reason it works there."*

Unfair Playing Field

Policymaker A3 acknowledges the different financial realities between large and small players, noting, *"The market is just really different, and that can lead to having different financial realities and needs."* She suggests that a PPA guarantee fund could level the playing field for smaller players, *"A guarantee fund could help support smaller parties in securing such a PPA."*

However, Lender B1 expresses concerns over the difficulties faced by smaller cooperatives negotiating with large corporates, *"If you have an energy cooperative negotiating a PPA with a large corporate, that could be difficult."*

Investor C2 adds that most small investors find it hard to finance projects nowadays, *"For smaller investors relying completely on financing, most of the projects are not doable."* He also called the "less sophisticated" potential offtakers purely opportunistic: *"If I were working for a company with significant energy demand, I would always submit bids at a very low level."*

Market in Foreign Countries

Policymaker A3 observes that financing models based on PPAs are more common in other countries, *"In other countries, you do see that financing happens, for example, based on PPAs."* Lender B1 agrees, noting that in Spain, deals tend to involve much shorter terms and substantially more equity, *"The deals you see there are really quite different. They involve much shorter terms, and substantially more equity."*

Lender B3 further confirms this,*"In other countries, the gearing often doesn't go beyond 75%, even if you have subsidies. So in the Netherlands, the market is quite aggressive. In other countries, it's much more conservative."*

Role of Batteries

Developer C2 notes that battery storage is becoming a standard part of projects, *"Actually, a solution without a battery is unique nowadays... Every project, every developer is planning battery projects as part of the overall project. "* Developer C1 adds that while battery integration is progressing, it still lags behind in terms of permitting and development, *"We're working on setting up batteries... but the permitting procedures and such, they are lagging behind compared to solar."*

Lender B4 emphasizes that the financing focus is shifting to large battery storage projects, while Lender B3 points out that *"since there is no SDE (subsidy) for that, you go to a very different gearing—something like a maximum of 60% debt, for example."*

6 Discussion

This chapter analyses interview results presented in the previous chapter. The structure of this chapter has been designed to reflect the key themes from the interviews and to build a logical flow from problem identification to validation and finally to broader implications.

The discussion begins by addressing negative price hours, a central and pressing issue identified by multiple interviewees. The prevalence of negative price hours was repeatedly highlighted as one of the most significant challenges facing solar PV projects in the Netherlands. This section is placed at the forefront of the discussion because it represents a foundational barrier to securing financing and because the severity of the identified problem was not found in the theoretical framework. By elaborating on this topic first, the discussion sets the stage for illustrating the need for market-based alternatives.

Next, the chapter moves to the role of the SDE++. This section explores how the SDE++ has played a important role in de-risking projects but is now being phased out as the market matures. The transition away from subsidies necessitates examination of the role of PPAs, which are increasingly being seen as a complement or potential replacement. This section analyses both the strengths and limitations of PPAs as a potential replacement, as identified by interviewees. By positioning the SDE++ discussion before that of PPAs, the chapter emphasizes the shift in financial mechanisms and the market's readiness, or lack thereof, for a subsidy-free future.

The chapter then explores the validation of propositions through the lens of these findings. Putting these validated findings into a broader context, the chapter concludes with the implications of these findings for project finance, the cost of energy and limits of de-risking energy policies. Lastly, limitations of the research are touched upon.

6.1. Negative Price Hours

Negative prices hours turn out as main challenge in financing solar PV projects in the Netherlands, and more broadly in Europe. As interviewee Developer C1 stated, *"The development has been so huge"* that negative price hours are becoming increasingly frequent. This growing trend not only threatens the financial viability of current solar PV projects but also significantly complicates the ability of developers to secure financing for new projects. This is noted by developer C5: *"Due to grid congestion* *and negative hours, new projects are becoming fewer."* The issue is linked to several risk categories identified in both renewable energy theory and PPA risk frameworks, especially those related to price risk, curtailment risk, and cannibalization risk (Egli, 2020; Kapral et al., 2024).

The comparison between solar and wind energy confirms the insight found in the theoretical framework. As Lender B2 explained, *"You're most affected by those negative hours [in solar] because in the winter, the wind still blows in the evening and at night, so it has a different profile."* This variability in wind energy generation provides a natural hedge against negative price hours, allowing wind projects to avoid the worst effects of market saturation.

The phenomenon of cannibalization effect is also a major contributing factor. As solar PV capacity grows in the Netherlands, projects generate more electricity at the same times, further saturating the market. This risk is particularly pronounced for solar PV comparing it to wind again. Developer C3 highlighted that *"solar has a very unfavorable profile... everyone delivers at the same time,"* which amplifies the impact of negative prices. In contrast, wind energy, with its more variable generation profile, is less vulnerable to this risk as well.

The literature supports these findings, emphasizing that cannibalization risk occurs when renewable energy sources essentially drive down their own revenues by driving down prices through overproduction (Kapral et al., 2024). Solar's highly concentrated production windows add to this issue, making negative price hours more common and more damaging to the business cases of solar PV projects. Prol et al. (2020) supports the notion that this price suppression effect is more severe for solar energy compared to wind.

Another issue boosting negative prices is the imbalance between production and consumption, as identified by Developer C1, who pointed out the government's dual focus on stimulating both electric generation and consumption but expressed skepticism about its effectiveness: *"I think the government says, okay, we stimulate electric generation, we also stimulate electric consumption. But in my opinion, nothing is really going to come of the latter."* This mismatch between production and consumption leads to an oversupply of electricity during peak solar hours, contributing to more frequent negative price hours. Policymaker A3 echoed this sentiment, acknowledging that the lack of corresponding demand is a significant issue, stating, *"I think the business case is certainly challenging at this moment because of the lack of demand, which is leading to more and more low and negative hours."* While some, like Investor C4, remain optimistic that as demand for green energy increases the system will stabilize. The current mismatch remains a problem for developers trying to build viable business cases for solar PV projects. Without a parallel growth in demand for green energy, negative prices will likely continue to undermine the profitability of these projects.

6.2. Role of SDE++: Key but with Weaknesses

Results show that the SDE++ has played an important role in de-risking investments in renewable energy projects by providing a guaranteed revenue stream, which is key for securing project financing. As Lender B1 noted, *"the SDE is very important for financing. And it's very safe. It's also definitely one of the main reasons why the solar market in the Netherlands has developed so quickly."* From a theoretical standpoint, this aligns with the idea that FiTs or similar support schemes significantly reduce price risk by guaranteeing a fixed or premium price for renewable electricity. The removal of price risk has been important in attracting high levels of debt financing for solar PV projects, with Lender B4 stating, *"you know you will at least get a minimum cash flow, on which you can structure the deal, so in practice, you actually have an investment-grade loan."*

6.2.1. Success contributes to Cannibalization Effect

However, while the SDE++ mitigates this price risk, it also contributes indirectly to the cannibalization effect. As renewable energy capacity, particularly solar, has grown rapidly under the support of the SDE++, the market has become oversupplied at certain times of day, leading to negative electricity prices as described above. As Specialist C5 remarked, *"it's actually now a bit of a victim of its own success... it has ensured that you have a very large stream of solar production, and that is partly causing the negative prices we are seeing now."* As a result, the SDE++ has unintentionally accelerated a market condition that undermines the long-term economic sustainability of solar projects.

The SDE++ scheme has limitations in addressing this issue of negative prices. Policymaker A4 explained that the subsidy does not apply when prices fall below zero, stating, *"if the product price is negative, you are not allowed to subsidize."* This underscores a flaw in the current design of the SDE++, as it leaves projects exposed during periods of negative pricing, precisely when they need financial support the most.

This dynamic creates an environment where the price risk that the SDE++ was designed to mitigate re-emerges in new forms, driven by cannibalization risk. Although the SDE++ was initially successful in closing the financial gap between traditional and renewable energy, the resulting market saturation has created a new kind of price volatility that is not accounted for by the subsidy scheme.

6.2.2. Banks' Reliance and Declining Subsidy Level

Another issue raised in the interviews is the heavy reliance of Dutch financiers on the SDE++ to guarantee long-term revenues. Policymaker A3 remarked, *"the Dutch market has been spoiled by the SDE. So the financiers are also used to having 15 years of security guaranteed by the government."* This reliance on guaranteed subsidies has reduced banks' willingness to take on market risk, as Lender B4 explained, *"we don't take market risk, so it's easy to reject that because you think it's not necessary."*

As Investor C2 pointed out, *"the subsidies probably made the world too comfortable for the banks."* This over-reliance on SDE++ results in projects not covered by the SDE++, or those exposed to negative price hours, struggle to secure financing because banks are not accustomed to taking on such levels of market risk. This dynamic underscores the need for a more flexible approach to risk allocation in project finance, particularly in a market increasingly characterized by negative prices and oversupply.

Additionally, interviewees also highlighted flaws in the SDE++ design that have failed to keep pace with the challenges of the market described above. Developer C1 criticized the rigid subsidy calculation rules, stating, *"the scheme for 2023 has simply become a very unfavorable arrangement."* As negative price hours become more common, the subsidy amounts have decreased, even further reducing the bankability of new projects.

Lender B1 confirmed that the declining subsidy amounts have made it harder to secure high levels of debt financing, noting, "*the subsidy you get per megawatt hour has been decreasing... to the point where, at a certain level, some projects no longer worked out."* This reflects the broader market trend where the guaranteed revenues provided by the SDE++ are no longer sufficient to cover the growing risks associated with negative prices and cannibalization.

6.2.3. CfD as Successor

Following the SDE++, the Contract for Difference (CfD) is mentioned often as the successor in supporting renewable energy projects. This transition is underscored by policymakers, such as A3, explaining that it will *"automatically skim off profits as soon as they are made, creating completely different incen-*

tives." Policymaker A3 additionally highlighted that the shift to a CfD was partly influenced by European policy mandates, which stipulate that operational support for renewable electricity be structured around the CfD model: *"Europe has also said that if you want to continue offering an operating support system for renewable electricity, it must be through a CfD."*

As noted by lenders, the new structure may not fundamentally alter banks' approach to financing renewable projects. Lender B1, for instance, expressed that CfDs may indeed offer a natural evolution of the current financing approach, and banks will likely view CfDs similarly to how they view the SDE.

However, the interviews reveal the CfD's inability to resolve the increasing issues of negative price hours. Policymaker A4 pointedly noted, *"also in the contract for difference, that's all fine and well, but of course, there's also no solution for the negative hours in there."* This reflects a broader worry that, like the SDE++, the CfD may be unable to offer financial stability during periods of negative pricing. As a result, there is an increasing need for market adaptation.

6.3. PPAs as an Alternative

Following this increasing need for market adaptation, PPAs are being used increasingly as a tool for stabilizing revenue streams, particularly as subsidies like the SDE++ begin to phase out. In theory, corporate fixed-price PPAs could help address the instability caused by negative price hours. However, while PPAs have become a complement to subsidy schemes, there are significant barriers to their adoption as a full alternative to subsidies in the Netherlands.

6.3.1. Current Role of PPAs: A Complement to Subsidies

PPAs are currently used primarily as a complement to the SDE++ subsidy, rather than a standalone solution for financing renewable energy projects. As Lender B1 explained, *"a project that only has a PPA, so fully without SDE, no subsidy at all, there aren't that many of them—you'd have to search with a flashlight to find them."* Most solar PV projects in the Netherlands still rely on the SDE++ to provide the bulk of the financial security needed to attract debt financing. PPAs typically offer an additional revenue stream on top of the subsidy, enhancing the overall bankability of the project. Lender B3 described this as an example of a project with *"an SDE of 50 euros, and someone says to you, yes, I'll pay your fixed price of 60 euros... that automatically means you can attract more debt."*.

However, there is a growing recognition that long-term PPAs could potentially serve as an alternative to subsidies like the SDE++ in the future, particularly as the renewable energy market matures. As Investor C4 optimistically noted, *"corporate PPAs with a fixed price could definitely be an alternative to SDE."* Lender B3 echoed this, *in that case, it's important that the volume is fixed. So they say, I will take everything, pay as produced, and at a fixed price."* Policymaker A4 agreed, stating that *"in the end, it should be just as certain for me,"* reflecting the belief that, under the right conditions, PPAs could provide the same level of revenue certainty as subsidies.

6.3.2. Offtaker Challenges

Although being recognized as potential alternative increasingly, several challenges prevent PPAs from fully replacing subsidy schemes like the SDE++ in the Netherlands. One key barrier is the creditworthiness of offtakers. For a PPA to be bankable, the offtaker must have a strong credit rating to ensure that they can meet their payment obligations over the long term. As Lender B4 emphasized, *"it's about the price in the contract, the duration of the contract, and the counterparty risk. I think those are the three most important components."* This is in line with the theory in which PPAs mitigate price risk but they also introduce risks related to the counterparty.

Many interviewees expressed skepticism about whether PPAs could fully replace subsidies in the near term due to offtaker issues. Lender B1, for example, remarked, *"are PPAs a replacement for that? Well, no, certainly not for the onshore market in the Netherlands."* Securing long-term PPAs with creditworthy offtakers in the Dutch market turns out to be difficult. Most solar PV projects in the Netherlands are relatively small, and as Lender B1 explained, *"the good parties, the creditworthy ones, are not lining up to provide a PPA for a [relatively small] project of 4 to 5 million."* This reflects a mismatch between the scale of solar PV projects in the Netherlands and the needs of large, creditworthy corporate offtakers, who typically want larger volumes of energy. Lender B1 and Policymaker A5 confirmed this by comparing solar PV projects to offshore wind projects, where higher equity contributions, investment-grade ratings, and significantly larger volumes are the norm, making it easier to secure long-term PPAs with creditworthy offtakers.

Also, as Investor C2 pointed out, the market for PPAs from large energy-demanding companies may be nearing saturation. Most of these companies have already signed PPAs, meaning that future demand may come from smaller companies that are more likely to act opportunistically, seeking the most favorable terms without committing to long-term contracts.

Additionally, the prevalence of negative price hours may further complicate the willingness of offtakers to enter into long-term, fixed-price PPAs, as they may anticipate that market conditions will periodically allow them to secure cheaper electricity directly from the grid. As a result, developers may struggle extra to secure creditworthy offtakers willing to commit to these fixed-price PPAs. This creates a dual challenge: while fixed-price PPAs offer a potential way to stabilize revenue in an uncertain market, the same market volatility that makes PPAs appealing to developers may deter offtakers from locking in long-term contracts.

While PPAs offer an important tool for reducing price risk, they are not yet sufficient to drive the level of investment needed to achieve large-scale solar PV deployment in the Netherlands. The limited pool of creditworthy offtakers, combined with the relatively small scale of projects and current market state, means that the market for long-term corporate PPAs remains underdeveloped.

6.4. Contrasting Perspectives

A notable finding from the interviews was the contrasting perspectives among different stakeholder groups regarding the role of subsidies and risk tolerance in financing Dutch PV projects. This divergence in views highlights underlying tensions within the market, particularly between developers, investors, and lenders, about how risk should be allocated and how the market can best transition away from subsidies.

For instance, as mentioned before, some policymakers and developers expressed the view that Dutch banks have become "spoiled", or over-reliant, by the guaranteed revenue streams provided by the SDE++ subsidy, which has enabled them to finance projects with minimal market risk. This reliance on SDE++ is seen by some as having fostered a conservative approach among lenders, who are perceived as reluctant to adapt to market-driven financing structures, such as PPAs, without substantial government backing or strict credit demands. Policymaker A3 reinforced this sentiment, suggesting that the SDE++ has "spoiled" the Dutch market as a whole by creating a level of security that is rare internationally, leading banks to expect long-term guarantees that may not be sustainable.

However, banks and lenders pushed back on this characterization, instead suggesting that it is the developers and the market that have grown too reliant on subsidies. Lender B1 emphasized that the comfort provided by the SDE++ has affected developers' approach to project financing as much as the banks, stating, *"I think you should say that developers and the market have been spoiled by the SDE, not so much the banks."* According to the lenders, the security of the SDE++ has allowed developers to prioritize debt-heavy project structures, often with little equity, to maximize returns. In the absence of subsidies, banks argue that developers would need to adjust their expectations regarding debt levels and take on more risk themselves.

This back-and-forth highlights a difference in how stakeholders perceive the maturity of the Dutch PV financing market. Banks assert that, unlike in other countries where market mechanisms such as PPAs are more common, the Dutch PV sector remains subsidy-dependent and may not yet be ready for a fully market-driven approach. On the other hand, developers and policymakers argue that a transition away from subsidies requires banks to take on more market risk to support the growth of the sector, especially as subsidies begin to phase out.

Additionally, a clear difference emerged regarding attitudes toward the feasibility of a subsidy-free future. While some policymakers, like Policymaker A4, believed that ultimately, *"a subsidy-free market is where you want to go,"* lenders remained cautious, often doubting that the Dutch PV market could function without some form of government support. As Lender B1 noted, *"Don't expect the market to be able to handle everything on its own."* This indicates a hesitation from banks to adjust to a future that may necessitate financing models with more flexible risk profiles.

Overall, the divergence in these perspectives highlights a broader challenge for the Dutch PV sector: balancing the need to reduce subsidy dependency while creating financing structures that are attractive to both developers and lenders.

6.5. Validating the Propositions

The interview findings and the points discussed above offer insights into the current state of solar PV project financing in the Netherlands and validate several propositions derived from the theoretical framework.

The findings provide clear evidence supporting most of the propositions regarding the financing of large-scale solar PV projects in the Netherlands. Proposition 1, which asserts that Dutch solar PV projects rely heavily on debt financing, was strongly validated as stakeholders consistently emphasized that debt, often enabled by the SDE++ subsidy, is the primary funding mechanism. Similarly, Proposition 2 was validated as price risk mitigation was seen as important for securing project finance debt terms. Without this, lenders were hesitant to provide financing or required more stringent conditions.

The SDE++ played a key role in validating Proposition 3, confirming that its function mitigates price risk. However, while corporate PPAs were found to complement the SDE++ (Proposition 4), they are not yet widely used as standalone mechanisms due to the challenges related to creditworthiness and counterparty risk (Proposition 5). Furthermore, while Pay-as-Produced fixed price structures (Proposition 6) increased PPA bankability, their effectiveness is limited by these same risks. Ultimately, Proposition 7 was strongly validated as the Dutch market still relies heavily on the SDE++, and the current structure of the PPA market, with its limited pool of creditworthy offtakers, does not yet support widespread development of solar PV projects without subsidies.

Table 6.1: Validation of Propositions based on Discussed Findings

Proposition	Validation Outcome	Evidence
P1: Dutch solar PV projects are reliant on debt financing.	Validated	Stakeholders emphasized that debt financing is the primary mechanism for funding projects, with SDE++ enabling up to 90% debt financing of CAPEX.
P2: Mitigating price risk enhances solar PV project bankability.	Validated	Price risk mitigation through SDE++ significantly enhances bankability, making it possible to secure high levels of debt. Without price certainty, lenders hesitate to finance.
P3: A Feed-in-Tariff premium mitigates price risk for a solar PV project.	Validated	The SDE++ subsidy was highlighted as crucial for removing price risk, enhancing bankability, and enabling favorable financing terms.
P4: A corporate PPA mitigates price risk for a solar PV project	Validated	PPAs reduce price risk but are generally used alongside SDE++. Bankability depends on PPA structure and offtaker creditworthiness.
P5: Since a private offtaker is involved, a corporate PPA requires mitigating additional risks to achieve the same level of bankability as a Feed-in-Tariff premium.	Validated	PPAs introduce counterparty risk that needs to be mitigated, especially with smaller or less creditworthy offtakers, compared to the security of SDE++.
P6: A Pay-as-Produced volume structure combined with a fixed price or a price floor pricing mechanism increases PPA bankability.	Partially validated	Pay-as-Produced with a fixed price or floor pricing enhances bankability, but challenges like creditworthiness of the offtaker remain.
P7: PPAs alone cannot lead to the desired development of solar PV projects in the Netherlands.	Validated	The market still relies heavily on SDE++ subsidies, and the current lack of creditworthy offtakers prevents PPAs from being a standalone solution.

6.6. Implications

The insights extracted from the interview data and the (partially) validated propositions call for explaining the possible implications of these insights in a broader context.

6.6.1. Project Finance & Cost of Energy

For lenders, the aforementioned risks related to negative prices and hours have profound implications for project financing. As Lender B1 noted, *"Curtailment must be included in your production forecasts"* because failure to account for the increasing frequency of negative price hours makes it difficult to structure reliable cash flow models. These risks decrease lender confidence and impact the bankability of projects, which is closely tied to the predictability of revenues. The unpredictability caused by negative prices challenges one of the key pillars of renewable project finance: stable and predictable cash flows to meet debt obligations (Yescombe, 2002).

This aligns with the broader theory that price risk has increased in importance as renewable energy capacity has expanded (Egli, 2020). Unlike fossil-fuel-based projects, where operating costs fluctuate with fuel prices, renewable energy projects have fixed debt service costs that do not adjust when electricity prices plummet (Christophers, 2022). As a result, price risk in renewable energy projects is asymmetric, with negative price hours now threatening the long-term viability of solar PV business models.

Moreover, as pointed out by Lender B1 on the topic, *”the more uncertainties there are, the more negative the impact on your borrowing capacity.”* In other words, as negative price hours become more common, lenders are likely to demand higher interest rates or require larger equity contributions from developers. This shift in financing conditions could limit the ability of developers to pursue new projects.

This could lead to an increase in the cost of energy, an additional policy challenge for renewable project finance. According to Policymaker A4, *“Yes, but if it doesn’t come from the government, it has to come from the consumer. The question is, how much can you get from the consumer?”* This underscores a tension in financing renewable projects, balancing the financial burden between state support and private investment. Policymaker A3 adds, *“By limiting that risk and keeping financing costs very low, we also ensure that we keep the costs of the energy transition low.”* This implicates keeping financing costs low is important, as higher financing costs would ultimately translate to higher overall costs of energy for end-users. Confirming this statement, Lender B4 notes that taking on market risk will make projects in turn more expensive: *“If you take on market risk... there’s simply more risk in such a project, and that will always affect the price.”*

These insights highlight how the constant changes of project finance and cost of energy are shaped by broader trends of financialization in the energy sector. As Knuth’s work on innovations within finance suggests, the rising complexity of financing structures, of which corporate PPAs are an example, represents a paradoxical response to the same financialization trends that have contributed to increased cost and risk in renewable energy projects (Knuth, 2018). This feedback loop suggests that while financial innovations have potential to lower costs, they are also symptomatic of the sector being marked by financial market volatility, consisent with Ji et al. (2020). Consequently, the debate on how to finance the energy transition continues to hinge on how well these financial innovations can balance the duality of risk management and cost containment.

6.6.2. Risk Mitigation by Re-structuring

The development of risk mitigation strategies such as a PPA guarantee fund could help address the challenges and make PPAs a more viable alternative to subsidies. These tools would help alleviate some of the risks associated with counterparty creditworthiness. Lender B4 supported this idea, *”the concept of having another party guarantee, at least for the creditworthiness of the off-takers, is certainly very valuable.”*

The price tag of establishing such a guarantee fund raises concerns related to the Cost of Energy again. While Lender B4 emphasized its potential value, noting that *”the concept of having another party guarantee, at least for the creditworthiness of the off-takers, is certainly very valuable,”* Lender B1 pointed out that this would come at a cost, stating, *”there is a cost associated with that guarantee fund. It has to be paid for.”*

In addition to the financial concerns, there is also skepticism regarding government involvement in private-sector transactions. Policymaker A4 voiced reservations about governmental guarantees, and Specialist C5 pointed out the current political climate, which could hinder such initiatives: *”Well, we’re currently in a political situation where there’s some cynicism and skepticism toward solar, wind, and sustainable projects. And given the current circumstances, we also expect there will be cuts and reductions in various areas. To then say, we need a billion-euro guarantee fund—that’s not going to happen.”* These challenges show the need for measures that do not rely on government intervention.

Following this, evidence from comparisons to foreign markets suggests that the current debt structures in the Netherlands may need to be reconsidered or revised to adapt to a PPA-driven financing model. Policymaker A3 and Lender B1 both highlighted how PPA-based financing models are more common in countries like Spain, where shorter terms and higher equity requirements are the norm. Lender B1 noted, *"The deals you see there are really quite different. They involve much shorter terms and substantially more equity."* Similarly, Lender B3 pointed out that in other countries, even with subsidies, project gearing rarely exceeds 75%, reflecting a more conservative approach to leveraging debt.

This foreign evidence calls for a rethinking of debt structures in the Dutch market, where projects typically enjoy high levels of debt financing, often up to 90%, due to the security provided by the SDE++. As the market transitions to a greater reliance on PPAs, developers and investors may need to accept a shift towards higher equity contributions and shorter loan terms to reflect the increased risks associated with PPAs. This would align the Dutch market more closely with international practices and reduce reliance on aggressive debt strategies that may not be sustainable without the backing of a subsidy like the SDE++.

6.6.3. Limits to De-Risking Renewables

While de-risking mechanisms like the SDE++ have been, and still are, instrumental in making renewable energy projects more financially viable, there are significant limits to what these strategies can achieve, particularly in the context of market saturation and negative prices. Policy de-risking can reduce investment risks related to policy changes and regulatory uncertainty but it does not address the fundamental market issues that arise when renewable capacity (momentarily) exceeds grid demand, leading to negative prices. For instance, the SDE++ scheme inadvertently contributes to market oversupply, which exacerbates cannibalization risk and leads to negative pricing events. These risks cannot be fully mitigated through policy alone, as they are driven by broader market dynamics, which policy de-risking are known to fail to address (Steckel & Jakob, 2018).

Financial de-risking also faces limitations. For instance, loan guarantee mechanisms like a PPA guarantee fund can reduce the cost of capital for renewable projects, but they do not directly address the issue of negative prices or oversupply in the market. As Đukan and Kitzing (2023) point out, even with substantial financial de-risking, the overall market conditions, like the capacity factors or electricity prices, play an equally important role in determining project viability. In markets where price risk and cannibalization risk are growing, de-risking strategies alone cannot compensate for the structural challenges that threaten the long-term profitability of renewable energy projects. This underscores the need other comprehensive solutions that go beyond de-risking and address the systemic issues in renewable energy markets.

6.7. Research Limitations

This thesis presents several limitations that must be acknowledged. They have been divided into date-centered limitations and scope-centered limitations.

6.7.1. Data-centered

First, the reliability of the data may be impacted by the limited range of interviewees in the development category, with a strong focus on policymakers and lenders. Although the total of 14 interviews, only one solar PV developer was interviewed, which may have steered the findings toward a more financial or policy-centric perspective, rather than capturing the full spectrum of challenges faced by developers. A broader range of developer perspectives would have provided a more validated understanding of the practical realities and risks in solar PV project development.

Additionally, issues of confidentiality and carefulness regarding PPAs and company strategy may have restricted the depth of the data collected. Several interviewees were cautious about sharing detailed information regarding their company's standpoints on PPA agreements and internal strategies, which led to more generalized responses. This limits the thesis to provide a more in-depth analysis of how specific contractual arrangements and influence project financing.

Continuing with the data analysis, the researcher's interpretation of interview data could introduce unintentional bias. While efforts were made to ensure objectivity, there is a risk that the researcher may have interpreted responses in a way that confirmed the existing theoretical framework. This "confirmation bias" could have influenced the findings, particularly in validating the propositions developed through the theoretical framework. Furthermore, while ATLAS.ti was used for systematic data coding and analysis, the interpretation of qualitative data can still be subjective. Especially the deductive coding process may have introduced unintentional bias.

6.7.2. Scope-centered

The thesis is centered around traditional project finance mechanisms, with a focus on debt and equity financing and their interaction with policy instruments such as the SDE++ subsidy scheme and corporate PPAs. While this scope provides a solid foundation, it does not account for newer financial innovations and alternative project finance structures that are gaining traction in the renewable energy sector. Innovations such as securitization of renewable energy assets, green bonds and crowdfunding platforms are increasingly shaping the way renewable energy projects are financed but were not included in this thesis.

Finally, the qualitative focus on the Dutch solar PV market limits generalizability of the results and insights. The findings reflect the regulatory and market conditions of the Netherlands, which may not be applicable to other countries with different energy policies or market dynamics. As such, caution should be exercised in applying these conclusions to broader contexts, particularly in markets with differing levels of renewable energy integration or subsidy schemes. This lack of generizability is also underscored by the qualitative nature of this thesis. For instance, it acknowledges that negative price hours and market saturation are increasing concerns, but the quantification of these risks is not included in this research. Quantitative data on the frequency and impact of negative price hours or business case analysis of PV projects under different financing mechanisms would have strengthened the conclusions and made them more generalizable.

7 Conclusion

The thesis aimed to reseach the role of PPAs in mitigating financial uncertainty for large-scale solar PV projects in the Netherlands, particularly in light of the scheduled termination of the SDE++ subsidy scheme. The thesis was motivated by the need to secure funding for renewable energy projects as government subsidies become less reliable, thereby posing a risk to achieving national renewable energy targets. While PPAs have been used in offshore wind energy projects extensively to secure long-term revenue streams, their application to solar PV projects remains underexplored. The thesis focused on understanding how PPAs are currently adapted in and addressing the specific challenges faced by Dutch PV projects which challenge the transition from support scheme to PPAs. It also examined how different PPA structures can increase project bankability up to the level of support schemes.

This research adopted an exploratory qualitative methodology to investigate the problem. A combination of a literature review, policy analysis, and semi-structured validation interviews with 14 industry professionals was used. The research strategy facilitated a comprehensive understanding by triangulating various data sources.

7.1. Answering the Main Research Question

The research addresses the following main question:

"What is the role of Power Purchase Agreements in mitigating financial uncertainty in large-scale solar PV projects in the Netherlands?"

Experts state that, at the moment, PPAs are mostly used alongside the SDE++ subsidy rather than as standalone. Their role is to provide additional financial stability on top of the guaranteed revenue from subsidies, making projects more bankable. For example, a project might use a PPA to lock in a higher fixed price on top of the SDE++ subsidy, thereby increasing debt financing capacity. However, most solar PV projects still heavily rely on the SDE++ as the primary de-risking mechanism.

Results show corporate PPAs can provide financial certainty by mitigating price risk. This is done by securing a fixed price or floor price for (pay-as-produced) electricity, thus reducing exposure to market volatility. This is especially important in a subsidy-free environment where projects must otherwise operate under merchant financing conditions. However, PPAs introduce new risks due to the involvement of a private offtaker which must be allocated effectively. The interviews highlighted that without strong creditworthy offtakers, the financial stability offered by PPAs is weakened, negatively influencing project bankability.

These creditworthy offtakers are scarce in the Dutch market. Large energy-demanding companies have already entered into long-term PPAs and may not have additional appetite. Moreover, these entities are generally interested in larger-scale projects, creating a mismatch, as many Dutch large-scale PV projects, despite their scale in local context, are relatively small compared to the energy volumes sought by these creditworthy offtakers. Consequently, the smaller project sizes typical of the Dutch solar market are less attractive to these large offtakers.

Additionally, the volatility caused by negative price hours introduces a dual challenge: developers seek stability through PPAs, but many offtakers, anticipating cheaper prices on the grid during negative hours, may be reluctant to lock into long-term, fixed-price agreements. This reluctance creates an extra barrier to the widespread adoption of PPAs in the solar PV market.

7.1.1. Potential for PPAs to Replace SDE++ Subsidy

The findings of this research suggest that, at present, PPAs cannot fully replace the SDE++ subsidy in the Dutch solar PV market. While PPAs can provide financial stability, their effectiveness as a standalone mechanism is limited by the aforementioned factors, namely the scarcity of creditworthy offtakers, the relatively small scale of many Dutch PV projects, and the prevalence of negative price hours.

Therefore, while PPAs have the potential to play a larger role in financing Dutch solar PV projects as the market matures, they are unlikely to completely replace state support in the near future. The transition to a PPA-only financing model will require further market adaptations, such as aggregating projects to attract larger offtakers, developing new financial de-risking mechanisms like guarantee funds, and addressing oversupply. Until these conditions are met, the Dutch solar PV market will likely continue to depend on some form of government-backed support alongside PPAs to achieve financing stability.

7.1.2. Broader Takeaways

In addition to answering the main question, this research revealed a broader set of dynamics within the Dutch solar PV financing landscape:

- **Negative price hours as a central challenge**: The increasing frequency of negative price hours, driven by the generation profile of solar energy and the cannibalization effect, has become a central issue impacting project bankability. These hours may discourage offtakers from entering into long-term fixed-price PPAs.
- **Higher costs in project finance**: The increased uncertainty from negative price hours and revenue forecasting challenges raises project financing costs, as lenders demand higher interest rates or equity contributions. These higher financing costs may ultimately result in higher Cost of Energy levels, potentially hurting consumers.
- **Limits of traditional de-risking mechanisms**: While traditional de-risking mechanisms such as subsidies and secure counterparties have been effective, they fall short in addressing systemic risks from market oversupply. Sustainable, market-driven solutions that tackle these structural issues are needed for long-term financial viability in the sector.
- **Need to adapt Dutch debt structures**: To support a PPA-driven financing model, the Dutch project finance market may need to shift away from reliance on high levels of debt and adopt structures with shorter loan terms and higher equity contributions, similar to practices in other European markets.

7.2. Recommendations for Further Research

This thesis concludes by recommending directions for future research.

First and foremost, future research should focus on quantifying the economic impact of negative price hours on solar PV projects and the Cost of Energy. This could involve collecting and analysing data on the frequency and duration of negative price hours and their direct effects on revenue generation for solar projects. Furthermore, this research could model scenarios that project the future of negative price hours.

Another main challenge identified in this thesis is the scarcity of creditworthy offtakers and their limited interest in relatively small projects. Future research should explore the potential of bundling smaller projects into larger, aggregated portfolios that are more attractive to corporate offtakers. Investigating the financial and contractual structures necessary to facilitate project bundling could help mitigate counterparty risk and appeal to larger, creditworthy offtakers. Additionally, research could assess the benefits of creating centralized PPA platforms or consortia that allow smaller projects to collectively negotiate better terms with larger, creditworthy offtakers. This approach could increase financing opportunities and reduce transaction costs, enabling more small-to-medium-sized renewable energy projects to access the PPA market.

The other way around is just as interesting: future research should focus engaging smaller off-takers, such as local companies and cooperatives, in the PPA market. This could include studies on how to increase their participation and the development of new financial instruments, like credit insurances, tailored to smaller parties.

The thesis identified several policy-related challenges, such as the need for a PPA guarantee fund and adjustments to the SDE++ scheme. Future research should (continue to) evaluate different policy interventions aimed at supporting the growth of the PPA market. Understanding the social cost-benefit implications of these interventions would help guide policymakers in designing effective and sustainable support frameworks.

Implications of the results suggest that the Dutch project finance market is highly dependent on long-term contracts and high levels of debt financing. In contrast, other European markets operate with financing structures that involve shorter contract durations and higher equity contributions from project developers and sponsors. Further research should explore the potential benefits and challenges of restructuring the Dutch renewable energy financing market to incorporate similar practices. Such research could involve comparative studies that analyze the financing models of different European countries. Examining how these markets successfully transitioned to shorter PPAs with higher equity requirements, often as a response to reduced subsidies, could provide valuable insights for the Dutch market.

Lastly, this thesis briefly touched upon the role of battery storage in enhancing the value of PPAs. Future research should continue to investigate the potential of hybrid solutions, such as combining PPAs with battery storage, to address the issue of negative price hours and grid congestion. Research could include modeling different configurations of storage and PPA structures to explore setups for maximising project returns and grid stability. Evaluating the regulatory and technical barriers to implementing hybrid solutions would also be a valuable area of study.

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A

Data Management Plan

Enabling PPAs for mitigting financial uncertainty

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

Xinyan Fan. I met with her on 31/05.

2. Date of consultation with support staff.

2024-05-31

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Literature, reports among other documents	pdf	Google scholar	Literature study	PwC Onedrive	Me
Personally Identifiable Information (email etc)	text	PwC colleagues and e-mail	Communication purposes	PwC Onedrive	Me
Personally Identifiable Research Data (work history, functions)	text	Email and recording the interview sessions	personal data processed for research purposes	PwC Onedrive	me
Interview recordings	mp3/mp4	recording the interview sessions	To understand the PPA landscape in the Netherlands and test my theoretical framework	PwC Onedrive	Me
Interview transcriptions	pdf	transcription of the interview recordings	To understand the PPA landscape in the Netherlands and test my theoretical framework	PwC Onedrive	Me
De-identified Interview transcriptions	pdf	De-identified Interview transcriptions	To be able to share the interview transcriptions	PwC Onedrive	Me and thesis committee
Project data	unknown yet	From real-life cases via involved parties, confidentiality of data is yet unknown	To test the framework that was created	PwC Onedrive	Me and thesis committee
Informed consent forms	pdf	Digitalized forms	To collect informed consent	Personal PwC drive	Me

4. How much data storage will you require during the project lifetime?

- < 250 GB

The largest data files will be the session recordings. According to Microsoft, a one-hour Teams recording is approximately 400 MB. With an expected maximum of 10 interviews, this totals around 4 GB.

II. Documentation and data quality

5. What documentation will accompany data?

- Other - explain below

Data will be shared in appendix of my Thesis Report

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- OneDrive

The OneDrive at PwC.

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)

If you are not sure which option to select, first ask your Faculty Data Steward for advice. You can also check with the privacy website . If you would like to contact the privacy team: privacy-tud@tudelft.nl, please bring your DMP.

- Yes

Participants will be interviewed, and for administrative purposes, their personal data will be stored, such as on informed consent forms. The interviews will be recorded, either in audio or video format depending on the setting, and subsequently transcribed. The transcripts will also be de-identified.

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your Faculty Data Steward for advice.

- No, I will not work with any confidential or classified data/code
- Yes, confidential data received from commercial, or other external partners

There is a possibility that project data from cases involving commercial third parties will be confidential. The specific data required will depend on the interviews, so it will only be determined later whether or not confidential data will be involved.

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager when answering this question. If this is not the case, you can use the example below.

I am the owner of the data, and it will be accessible only to me during the thesis.

10. Which personal data will you process? Tick all that apply

- Signed consent forms
- Data collected in Informed Consent form (names and email addresses)
- Photographs, video materials, performance appraisals or student results
- Names and addresses
- Email addresses and/or other addresses for digital communication

Names, email addresses, MS Teams contact information, and data collected from informed consent forms will definitely be stored. If the interview is conducted via MS Teams, a video recording will be stored. Otherwise, the interview will be voice recorded. Once the interviews have been transcribed and the interviewee has no comments, the (video) recordings will be deleted immediately. Other personal data can be deleted after the research is completed.

11. Please list the categories of data subjects

I will interview professionals involved in Dutch investments in solar park projects. Initially, the interviews will be exploratory, focusing on renewable energy projects as a whole. Later, the interviews will become more in-depth and structured, concentrating on specific case studies. Depending on the results of the initial interviews, additional experts may be included.

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

I will send the informed consent forms to the interviewees before the interview and ask them to return the signed forms digitally before the interview begins. At the start of the interview, I will remind the interviewees of the specific agreements outlined in the informed consent form

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).

If two or more of the options listed below apply, you will have to complete the DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to receive support with DPIA.

If only one of the options listed below applies, your project might need a DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to get advice as to whether DPIA is necessary.

If you have any additional comments, please add them in the box below.

- None of the above applies

22. What will happen with personal research data after the end of the research project?

- Personal research data will be destroyed after the end of the research project

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- I do not work with any data other than personal data

I only use interviews and literature, which will not be publicly shared in the data repository.

29. How will you share research data (and code), including the one mentioned in question 22?

- My data will be shared in a different way - please explain below

Data will be shared in my Thesis Report.

30. How much of your data will be shared in a research data repository?

- < 100 GB

31. When will the data (or code) be shared?

- As soon as corresponding results (papers, theses, reports) are published

32. Under what licence will be the data/code released?

- Other - Please explain

Data will be shared in my Thesis Report.

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

- Yes, leading the collaboration - please provide details of the type of collaboration and the involved parties below

In collaboration with PwC CP&I, graduation agreement with them has been signed.

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

I will handle the data management myself, so no additional resources are necessary.

B

Interview consent form

Interview consent form

Interviewer: Tom Hoogstede

Interviewee: ___________________________

Organisation: ___________________________

Please tick the appropriate boxes

Participation in study	**Yes**	**No**
1. I have read and understood the study information, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves audio-record of the interview for data analysis purposes, after which the recording will be deleted.	☐	☐

Use of data for research	**Yes**	**No**
4. I understand that personal information collected about me that can identify me, such as my name and/or email address, will not be shared beyond the study team.	☐	☐
5. I understand that the (identifiable) personal data I provide will be destroyed.	☐	☐
6. I understand that after the research study the de-identified information I provide will be used for the graduation thesis report and presentation at the Technical University of Delft, unless indicated that information is confidential.	☐	☐
7. I agree that my responses, views or other input can be quoted anonymously in research outputs. Names or personal details will not be used unless agreed otherwise.	☐	☐

Data storage	**Yes**	**No**
8. I acknowledge the publication of the graduation thesis to be archived in the TU Delft educational repository so it can be used for future research and learning.	☐	☐

Signatures

Name of participant	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Researcher name	Signature	Date
Tom Hoogstede		

C

Interview Invitation

Invitation to Participate in Graduation Research

Monday 11th November, 2024

Dear [Name],

With this letter, I would like to invite you to participate in my graduation research, titled "Enabling PPAs for Mitigating Financial Uncertainty." This research is carried out to fulfill my master's degree in Construction, Management, and Engineering at the Faculty of Civil Engineering of Delft University of Technology, and as a graduate intern at PwC Capital Projects and Infrastructure.

This thesis aims to assess the extent to which Power Purchase Agreements (PPAs) can mitigate financial uncertainty in large-scale PV projects in the Netherlands. The research will explore how PPAs and support schemes, such as feed-in tariffs and feed-in premiums, impact the financing of these projects. By understanding the role of these financial instruments in providing revenue stability and managing risk, this study aims to provide insights into optimizing financial stability and investor confidence in the Dutch PV market.

I would like to identify drivers and considerations in practice, compare these with findings within the literature, and understand the current challenges faced by investors and lenders. The interview will last approximately 45-60 minutes. For accuracy, I would like to record the interview to transcribe and analyze the information later. The data will be coded anonymously, ensuring that neither your name nor your company will be mentioned.

Your participation in this study is entirely voluntary, and you can withdraw at any time. If there are any questions you would prefer not to answer during the interview, that is perfectly acceptable.

If you agree to participate, please sign the attached consent form to ensure the confidentiality of your data and answers. Should you have any questions about this research, feel free to contact me at T.J.A.Hoogstede@student.tudelft.nl or +31643190092.

Sincerely,

Tom Hoogstede
Delft University of Technology
Faculty of Civil Engineering
T.J.A.Hoogstede@student.tudelft.nl
+31643190092

D

Interview Design

D.1. From Propositions to Questions

Interview Design		
	Propositions	**Questions**
Financing Solar PV	P1	Can you describe the typical financing structure for large-scale solar PV projects in the Netherlands?
	P2	When assessing potential solar PV projects, what criteria are primarily considered to determine their bankability and decide whether to issue debt?
Roles SS and PPAs	P3	How do Feed-in-Tariff schemes, like the SDE++, impact financing decisions in solar PV projects? What aspects of FiTs make projects more bankable?
	P4	How do you see the current role of PPAs in the financing of solar PV projects in the Netherlands?
Comparison & BP	P5	Are solar PV projects with a Feed-in-Premium and governmental credit guarantees more attractive for financing compared to those relying solely on corporate PPAs?
	P6	What additional considerations and risk management strategies are necessary for a corporate PPA to achieve the same level of bankability as a Feed-in-Premium?
Systemic Challenges	P6	To what extent do you believe PPAs alone are sufficient to drive the desired development of solar parks in the Netherlands? What additional support mechanisms or regulatory frameworks do you think are necessary?

Figure D.1: Interview Design

D.2. From Questions to Protocol

Introduction

- Brief introduction of the interviewer.
- Explanation of the purpose of the research.
- Clarification of interview expectations and estimated duration.
- Confirmation of consent to record the conversation for analysis.
- Ask for the participant's position, organization and background.
- Brief description of the participant's role in their organization.

Grand Tour questions

- Can you describe how large-scale solar PV projects in the Netherlands are typically financed and structured?
- What is the role of the SDE++ in financing large-scale Solar PV in the Netherlands?
- What is the role of PPAs in financing large-scale Solar PV in the Netherlands?
- What are the main challenges in financing large solar energy projects in the Netherlands?

Floating Prompt questions

Financing Solar PV

- Are solar PV projects in the Netherlands always dependent on debt?
- How do you evaluate and manage the risks associated with these projects?
- Do you ever finance projects purely merchant?

SDE++

- Why was the SDE++ firstly introduced?
- Can you exlain how the mechanism of the SDE++ works?
- How effective has the SDE++ scheme been in the development of solar energy?
- Why is the SDE++ likely to be terminated?
- How does the uncertainty around the SDE++ scheme impact project development?
- What alternatives are being considered or do you see for the SDE++ in the future of solar energy projects?
- Did the SDE++ make the financing of solar PV projects too comfortable?

PPAs

- What criteria do you use to evaluate the bankability of PPAs?
- How do PPAs compare to government-backed incentives in terms of providing investment security?
- Can PPA be made as attractive for financing as a feed-in-premium like the SDE++?
- How do PPAs position themselves among other alternatives for securing project financing?

- Do you think the corporate PPAs lead to an uneven playing field in the energy market?

Comparisons

- What is the difference with (offshore) wind projects, as those have been financed purely on a PPA before?
- What is the difference with solar PV projects abroad?

Planned Prompt questions

- To what extent do you think PPAs alone are sufficient to secure the desired development of solar parks in the Netherlands? Why or why not?
- Can PPAs completely replace the SDE++?
- What additional support mechanisms, regulatory frameworks or innovations do you think are necessary to achieve the goals?

Section 7: Summary and closing

- Review of key points from the conversation.
- Opportunity for the participant to provide additional comments or address any unmentioned topics.
- Thank you and explanation of next steps (e.g., how and when the results will be shared).

E

Codebook

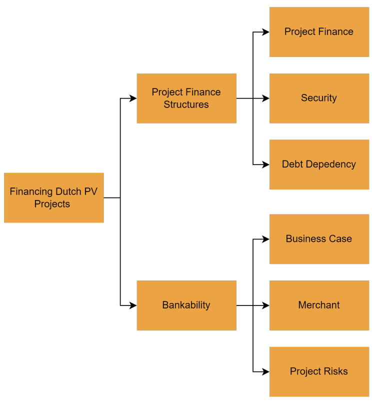
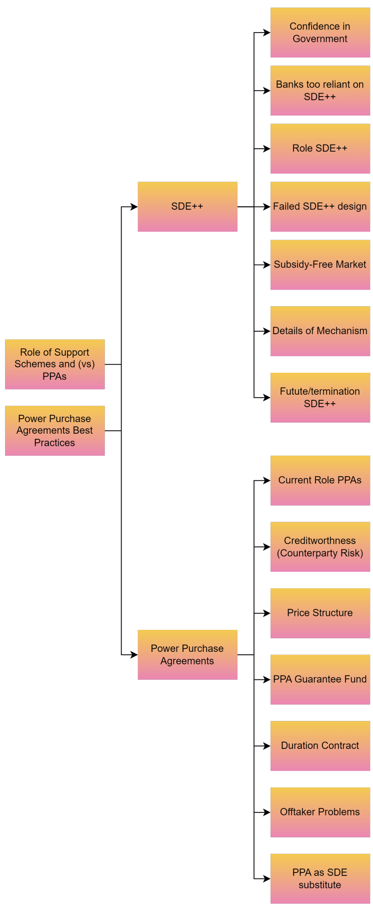


Figure E.1: Codes Financing Dutch PV Projects



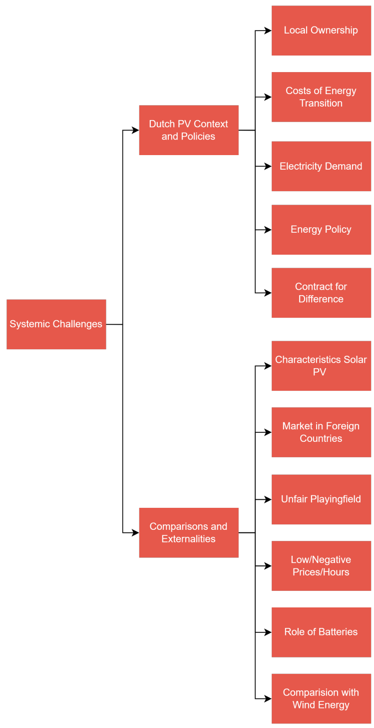


Figure E.3: Codes Systemic Challenges

Figure E.2: Codes Roles SDE++ and PPA

Figure E.4: Codebook Figures