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"The political, economic and environmental impacts of the SDE++ subsidy scheme by introducing solar PV technologies in the Dutch electricity market"

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ACER - Agency for the Cooperation of Energy Regulators

CCS – Carbon Capture Storage

CEP- EU Clean Energy Package

CoO -Certificates of Origins

DSR – Demand-Side Response

EED - EU Energy Efficiency Directive

EIA - Energy-saving Investment Credit

ENTSO - European Networks for Transmission System Operators

ESR - Emission Sharing Regulation

ETS - Emissions Trading System

EU – European Union

EU-ETS - European Emissions Trading System

GHG – Green House Gases

GOs - Guarantees of Origin

IEA – International Energy Agency

ISDE - Sustainable Energy Investment Grant

NECP - National Energy and Climate Plan

NRA - National Regulatory Authority

RED - EU Renewable Energy Directive

RES – Renewable Energy Sources

SCE - Subsidy Scheme for Cooperative Energy Generation

TFEU- Treaty on the Functioning of the European Union

ABSTRACT

The Dutch energy regulatory framework has significantly evolved since the liberalization of the European energy markets. Mainly, it has developed different subsidy mechanisms through policy implementation to achieve international climate objectives and accelerate a clean energy transition. While it is essential to promote a diversified portfolio of renewable energy technologies, it is also essential to do so efficiently. Accordingly, the SDE++ subsidy scheme was an instrument established in 2020 to stimulate the development of multiple renewable energy projects. Although different versions have preceded it, it is largely recognized as one of the most important subsidies in the country due to its breadth and available budget. This thesis report provides a greater emphasis on the role of this subsidy for the adoption of solar PV technologies in the Dutch electricity market, specifically on its political, economic, and environmental impacts. Although the theory of opportunity structures is mainly focused on external factors that can hinder or facilitate actions, this concept is used to evaluate and interpret data collected through semi-structured interviews with government and semi-government stakeholders, relevant corporations, and research institutions in the energy sector on a national level.

KEY WORDS – energy transition, energy market liberalization, energy subsidy, energy market integration, subsidy intensity

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1. Introduction

1.1. Importance

The European Union (EU) is well known for trying to find solutions to homogenize energy regulations within its Member States and enhance cross-border integration of energy infrastructure as an attempt to strengthen and improve energy security and sustainability across its territory. However, the current market designs of each country have had different implementations and policies since the liberalization of the energy markets in 1996. As a result, EU residents' energy security, sustainability, and affordability may be challenged depending on their country's ability to adopt strategies and commitments.

On one hand, a well-designed and diversified energy market can provide all of its participants with adequate incentives and instruments to deal with different financial and operational opportunities. Having a healthy energy market that encourages public and private investment and market openness is "*crucial for promoting economic growth and sustaining social welfare*" (Pereira et al., 2019). Similarly, as the author Souza (2012) mentions, the greatest priority of a country is to provide a well-functioning market that ensures energy security, affordability, and sustainability simultaneously, with competitive market access and management, a significant degree of consumer protection, and appropriate interconnection and generation capacity. And it is safe to say that several European countries are on the right track to meeting these targets. On the other hand, the persistence and perpetuation of old monopolies of some other countries, which do not adapt naturally to market indicators, can hamper competition and slow down the pace of electricity market evolution (De Vries, et al., 2018). This puts these countries at a disadvantage compared to those with more developed energy markets.

The main goal of this thesis report is to analyze the role and the political, economic, and social impacts that policy incentive mechanisms such as energy subsidies have played in encouraging the adoption of clean energy technologies on an industrial level to meet the country's energy transition targets for 2030 and eventually becoming carbon-neutral by 2050. To achieve this goal, special attention is placed on the role that the SDE++ subsidy scheme has played in the adoption of solar photovoltaic (PV) technology since its implementation in the Dutch electricity market. Specifically describing the application process, benefits, and shortcomings of the mechanisms using data collected during interviews with relevant stakeholders in the energy value chain to answer the research question and describe the political, economic, and environmental impacts of the SDE++ subsidy scheme. Furthermore, the progress of solar PV technology initiatives to date and the key SDE++ barriers are identified.

1.2. Contribution

This thesis report contributes to the analysis of the institutional context of the electricity market regulation in the Netherlands through an overview of the evolution of the regulatory energy legal framework on a European Union and national level, from 1996 up until now, when the liberalization of the energy sector took place and importantly changed the way electricity is generated, transported, distributed and consumed all over Europe.

In the past decade, renewable energy generation, specifically solar PV technology, has gone from being one of the most expensive forms of energy generation technologies to one of the most competitively priced and cost-efficient technologies available in the electricity market thanks to subsidies offered by various governments around the world. From the findings, it is evident that subsidies have proven to be an effective tool and incentive in the short term, particularly for industrial production sectors. However, market design and regulation of the energy industry in a competitive market impose challenges on the establishment of rules that encourage efficiency in the sector while also ensuring supply security. The primary concern for policymakers and governmental authorities is to identify the most appropriate instruments to achieve this goal, which is based primarily on the impacts that energy access has on reducing inequality and increasing the overall system's efficiency. The goals of these authorities align to overcome existing market failures in

competitive energy activities, tariff regulation, and supervision of the quality and industrial safety of sectors with preceding natural monopoly characteristics (Joskow, 1996).
However, some stakeholders believe that subsidies are not always necessarily the greatest long-term solution, because subsidies consume resources that may be utilized for development public investment, such as infrastructure, education, health, and the social security system in some countries. To the disadvantage of human capital development, several countries spend more on energy subsidies than on health and public education, for example.

This report makes several contributions to the existing literature. First, the paper's contribution on a theoretical level is the expansion and expansion of opportunity structure perspectives into the Dutch subsidy market, which has not been addressed previously. The opportunity structures approach is primarily concerned with social movements and energy transitions, with the market and subsidy-related opportunity structures for change having received limited consideration. Second, this report makes a methodological contribution, which involves innovative data gathering through semi-structured interviews. This data contributes to developing an in-depth understanding of how the SDE++ supports and incentivizes the adoption and expansion of photovoltaic technologies in the Dutch electricity market.

1.3. Structure

This thesis is structured as follows: in the Literature Review section, a background on the scenario of the Dutch electricity market is presented, as well as how it has evolved since the liberalization of its energy market to the current time. Existing policies and regulating mechanisms that apply to the Netherlands Energy Regulatory Framework will be reviewed through a qualitative assessment, as well as their role in aiding the country in moving effectively towards a clean energy transition.

Similarly, the relevance and participation of key stakeholders in the development and implementation of these policies will be reviewed, and special attention will be dedicated to how they have been performing (highlighting their impacts, strengths, and weaknesses) and where they are headed for the next years in the expansion towards a clean energy transition.

This thesis is largely divided into three sections. The first section, the literature review, provides a background of the Dutch energy market, its regulatory frameworks, key stakeholders, and the incorporation of energy subsidies. The literature review section also contains a discussion on the SDE++ scheme and its methodology. The theoretical framework is part of the second section of this paper, which includes opportunity structures. And the third section is comprised of the findings and conclusions, which describe the political, economic, and environmental impacts of the SDE++ scheme, emphasizing the solar PV technologies adoption and integration into the Dutch electricity system.

2. Literature Review

2.1. Definitions

One of the central concepts in this thesis report is energy transition, which in this thesis report refers to all the connected efforts done towards meeting the Paris Agreement targets and global transformation of the energy sector from fossil-fuel based to a zero-carbon in the following years (IRENA, 2022). Another fundamental concept is energy market liberalization. It is defined as the ongoing transition, which began in 1996 in Europe, towards a more competitive, sustainable, integrated, and efficient retail energy market, in which all Dutch consumers can freely choose their energy suppliers since 2004 (Mulder & Willems, 2019). Energy market liberalization is also described in the literature as the vertical unbundling of the generation, transmission, distribution, and supply stages of the energy value chain. Which resulted in the demand for further infrastructure investment, new regulatory institutions, secure and reliable networks, and increased market transparency (Pollitt et al., 2007).

To have a consolidated European-based energy market, the European Commission (EC) created the concept of energy market integration (EMI), which in this thesis report refers to the cross-border consolidation of all of the European Union Member States' energy markets (specifically electricity) based on the principle "the bigger, the better" (Batalla-Bejerano et al., 2019). It is important to emphasize the intention of the European Union to cover the energy markets among the Member States because as it grows in size, so does its ability to make more efficient use of energy technology and resources (Batalla-Bejerano et al., 2019).

Likewise, the main focus of this thesis report is the concept of energy subsidies. This particularly refers to the SDE++ subsidy scheme introduced by the Dutch government on a national level to accelerate the implementation and comply with the EU directives toward energy transition targets. In addition, the concept of subsidy intensity is described, and its calculation is discussed in depth in section *2.5.2. Subsidy Intensity Calculation.* This value is one of the most important considerations in the SDE++ scheme because it determines when and how a subsidy application should be submitted and represents the amount of money per ton of CO2 avoided emissions into the atmosphere.

2.2. Background: Europe’s Energy Market

Europe's energy markets began to progressively open for competition in 1996 (Böckers & Heimeshoff, 2014). The particular legal framework for this energy market liberalization was established in Articles 194 and 114 of the Treaty on the Functioning of the European Union (TFEU) (Souza, 2012). During that same year, the European Commission started the establishment of the European Internal Energy Market (IEM), which extended across all European Member States (Souza, 2012). The primary goal of this process was to increase the economic efficiency of power utilities, significantly reduce electricity supply prices, attract new investments in electrical infrastructure, make markets more transparent, and generally establish a more efficient and unified system. Nonetheless, this transformation did not happen overnight, it required a tremendous amount of effort since the great majority of countries formerly relied heavily on centralized and vertically integrated energy systems that depended mostly on fossil fuel generation and provided electricity through embedded and state-owned power grids (Souza, 2012). Therefore, the unbundling of generation, transmission, distribution, and supply activities was a crucial stepping stone in this process.

Given that energy reliability, security, and sovereignty are political and social concerns, overcoming economic and physical barriers through market integration and transmission network expansion became a priority for the European Union (Böckers & Heimeshoff, 2014). The European Commission proposed to put into action a general model for the liberalization of the electricity sector for each one of the State Members. As a result, they implemented various legislative measures known as "Energy Packages" followed by several directive revisions and amendments.

Table 1 illustrates in chronological order the energy packages that followed after the liberalization of energy markets in the EU. However, only those relating to electricity will be given special consideration, as the primary goal of this paper is to focus only on solar PV technologies.

TABLE 1. *Energy Packages for Liberalization of Energy Markets in the European Union.*

Directives	Regulations	Main objective
First Energy Package	96/92/EC	Adopted by the European Commission in 1996, with the primary goal of splitting up vertically integrated energy companies and opening up electricity activities (generation, transmission, distribution, and supply) to competition by establishing a standardized set of rules and requirements (Böckers & Heimeshoff, 2014). This directive lays the foundation for what was later known as the European Union Integrated Energy Market (IEM) and, it introduced the first mechanism for energy tenders, as well as a new technological network operation.

Second Energy Package	2003/54/EC	Implemented in 2003, allowing domestic users to freely select their electricity suppliers from a diverse variety of competitors. However, it caused transparency concerns among transmission network operators. The implementation of this new regulation did not result in a balanced manner across all Member States, from which later, benchmarking studies between countries stressed the need to remove barriers to guarantee competition and meet targets.
Third Energy Package	2009/72/EC	Introduced in 2009 as an amendment to the previous package to further liberalize electricity markets and establish the legal framework for the IEM. In this directive, cross-border cooperation between the Member States was reinforced through the establishment of the European Networks for Transmission System Operators (ENTSO-E for energy and ENTSO-G for gas). Likewise, some of its key aims were to strengthen transparency and the authority of national regulators to determine access tariffs and connection conditions to electricity networks to ensure the protection of vulnerable competitors.
Fourth Energy Package	2019/941/EU	Introduced in 2019, including three regulations (*) and one directive. With the main goal of implementing what is known as the "new electricity market" standards for renewable energy. Offering consumer incentives and establishing restrictions for power plants to be eligible for subsidies. Likewise, this year the "Clean Energy for all Europeans" package agreement marked a significant step toward implementing the Energy Union Strategy.
	2019/942/EU*	
	2019/943/EU*	
	2019/944/EU*	
Fifth Energy Package	Delivering the European Green Deal	Recently presented in July 2021, with the primary goal of aligning the European Union's ambitions towards the 2030 Agenda for Sustainable development and the Net Zero targets for 2050. Introducing the Emissions Trading System (ETS) as a key strategy for cutting greenhouse gas emissions.

Reference: European Commission (2020); European Parliament (2022)

Nonetheless, the European Commission's development of these Energy Packages does not necessarily imply that all State Members adopted the same strategies. Simply, because each country has internal objectives to meet and will have to adapt these objectives as accurately as possible to their national legal systems. Despite these initiatives, energy markets continue to face the challenges of improving competitiveness, ensuring grid stability, diversifying energy generation sources, and commissioning new, and more sustainable energy production facilities, while keeping consumer prices affordable. These challenges are known as the "energy trilemma," (Khan et al., 2021) and they may be present in practically every modern energy system around the world.

Understanding the background of the European energy market is important for this thesis report because several Dutch energy policies refer to or are based on these energy directives, which eventually contributed to the emergence of energy subsidies.

2.3. Dutch Electricity Market Overview

This study focuses on the Netherlands in particular because it is regarded as one of the most committed nations to a clean energy transition and is recognized as "one of the key players" in European energy markets (IEA, 2020). The primary goal of the Dutch energy policy is to achieve an energy transition to a low-carbon economy using different regulatory mechanisms, and it is characterized by product innovation, particularly for green energy (Mulder & Willems, 2019). One of its main objectives is to address the socio-technical challenges related to the energy trilemma in a sustainable, affordable, and secure way. In contrast to other countries, Dutch regulation includes a form of price regulation in which the regulator evaluates all new retail prices before they are introduced to the market to avoid excessive retail pricing. The wholesale electricity market in the Netherlands has remained highly competitive, with retailers offering an increasing range of solutions.

The Dutch energy regulation consists of four major components: 1) structural measures to encourage competitors to enter markets, 2) establishing contract restrictions, 3) prioritizing transparency, and 4) constant monitoring (Mulder & Willems, 2019). Even though these policies are founded on decentralization principles, network management and infrastructure ownership remain in the hands of local and national governments. This is intended to preserve the independence of infrastructure operators, enhance competition, provide energy security and welfare, and enable decentralized renewable energy generation (Mulder & Willems, 2019). Additionally, it is characterized by innovative renewable energy schemes, government assistance, environmental regulation, and ongoing efforts to reduce CO2 emissions (IEA,2020). As a result, recent energy policies have been more climate-related and strictly enforced than in the past. Annex A provides a timeline of the climate-related agreements that have existed in the Netherlands from the present, back until 2011.

The Climate Agreement of 2019 is part of the Dutch climate policy involving and calling for collaboration among different stakeholders from across the Dutch economic and political system (IEA, 2020). It includes detailed measures and strategies to facilitate the achievement of a reduction of their GHG emissions by 49% by 2030 and then 95% by 2050 (based on pre-industrial 1990 levels). Likewise, the Climate Plan, the National Energy and Climate Plan (NECP), and the National Climate Agreement contain policies and measures to achieve these climate goals (Government of the Netherlands, 2020). The Dutch energy market was privatized in 2004. Since that date, customers have had the opportunity to compare and choose their electricity provider (Mulder & Willems, 2019). The benefits of privatization have to do with increasing a country´s economic liquidity and freeing it from possible debts and liabilities, which can be key in times of severe economic need (Mulder & Willems, 2019). Likewise, this market liberalization allows the entry of more companies to participate and compete in the electricity market and end former monopolies. This revolutionized the notion of competitiveness by increasing the variety of energy suppliers (*Figure 1*), prices, and contract types (Energievergelijk, 2020).

Figure 1. *All energy suppliers in The Netherlands.*
Reference: Energy suppliers in the Netherlands. Energievergelijk, 2021.

Furthermore, multiple levels of regulation and actors coexist on a national, regional, and corporate level to monitor fair tariffs and efficient practices for all consumers across the whole electricity value chain. Table 2 shows a classification of the key stakeholders involved in the Dutch energy sector.

TABLE 2. *Key stakeholder's categorization.*

Level	Actor	Role
National	Ministry of Economic Affairs and Climate Policy- *Ministerie van Economische Zaken en Klimaat (EZK)*	Formulates general energy policy, implements initiatives to meet energy targets, and shares energy efficiency responsibilities with other ministries.
	Ministry of Education, Culture, and Science	In charge of the nation's energy research, development, and demonstration (RD&D), through publicly funded projects with universities and research centers.
	The Netherlands Authority for Consumers and Markets (ACM)	Responsible for energy market competition and regulation. Protects consumers' rights and regulates electricity TSOs and DSOs.
	The Netherlands Bureau for Economic Policy Analysis (CPB)	Research institute responsible for conducting policy analysis and evaluating how the Climate Agreement's proposed policies influence the Dutch economy.
	The Netherlands Enterprise Agency - *Rijksdienst voor Ondernemend Nederland, (RVO)*	Provides a direct link between energy producers and consumers, and it is responsible for carrying out the Ministry of Economic Affairs and Climate Policy's directives.
	The Pollutant Release and Transfer Register (PRTR)	Database collection for pollutants in the air, water, and soil and shares annual reports.
	TenneT	The national power transmission system operator (TSO) is entirely government-owned by the Ministry of Finance.
Regional *(DSOs)*	Liander (Alliander)	Managing the network of the provinces of Gelderland and North Holland entirely, and in large parts of Flevoland, Friesland, and South Holland.
	Enexis	Provinces of Groningen, Drenthe, Overijssel, North Brabant and Limburg.
	Stedin/Enduris	Enduris manages the energy network for around 200,000 households and businesses in the province of Zeeland.
	Delta (DNWB)	Mainly in the province of Zeeland.

	Endinet (Alliander)	Concentrated in the provinces of Gelderland and Noord-Holland, and covers about one-third of The Netherlands.
	Westland Infra	Located in Westland, Midden-Delfland and Botlek Rotterdam.
	Rendo	Provinces of Drenthe and Overijssel.
Organizational	The Netherlands Environmental Assessment Agency (PBL)	Independent research institute under the charge of the Ministry of Infrastructure and Water Management and it is in charge of proposing and elaborating policy analysis regarding the environment, nature protection, and spatial planning of the country.
	CBS Statistics Netherlands (CBS)	Independent agency in charge of data processing and collection for publishing national statistics.
	Energy Suppliers	In the Netherlands, there are approximately 45 energy suppliers, each with its own set of contracts and terms (*Appendix B*).

Note: *The electricity distribution system operators (DSOs) in charge of the Netherlands' low and medium voltage grids play an important role in the energy supply chain and are strategically placed across the country and vary in size and relevance. They are frequently faced with many different issues as the amount of renewable energy generation connected to the grid increases, as well as the number of users.*

For strategic and market reasons, different stakeholders and companies are located in different provinces of the Netherlands inside the distribution of the Dutch electrical system. *Figure 2* shows the distribution by province (or city) of the different DSOs in the country. Likewise, in the Netherlands, there are approximately 45 energy suppliers, each with its own set of contracts and terms. Figure 1 is an infographic that outlines all of the energy suppliers that are currently available to Dutch consumers.

Figure 2: *Grid management of different DSO's in the Netherlands per province.*

2.4. Energy subsidies and incentive mechanisms in the Netherlands

Energy prices are determined primarily by demand and supply behaviors in global energy markets, as well as policy interventions such as restrictions, tax policies, and, in certain cases, investment subsidies. According to Diaz Arias & van Beers (2013), there are five primary reasons why financial support mechanisms for energy prices are frequently offered: 1) Reduce dependence on energy imports, 2) Alleviate poverty, 3) Encourage economic diversification, 4) Maintain domestic employment and 5) Promoting renewable energy production for environmental protection.

Due to the tendency of increased the prices of electricity (Figure 3), new energy sources have become more attractive. When determining who will receive incentives, it is important to consider which actors and users will have the most opportunity to innovate with new technologies in the near future, as well as the possibility to manage and maintain the systems' performance over extended periods (Diaz Arias & van Beers, 2013). Because, according to the findings, it is quite common for projects that have already received the subsidy to be unable to continue with construction or be carried out due to a variety of factors such as permits, grid capacity, investment return, and organizational decisions, among others.

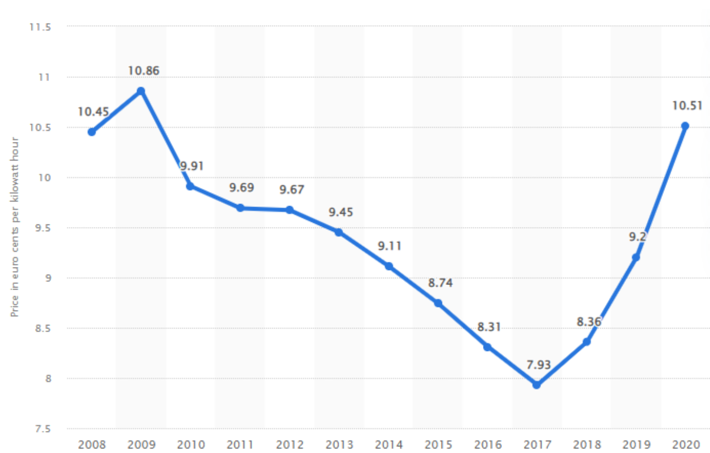

Figure 3: *Prices of electricity for the industry sector in the Netherlands from 2008 to 2020 (euro cents per kilowatt-hour). Reference: Statista, 2021*

As a consequence, enterprises and households can now apply for a wide range of incentives and subsidies provided by the government for alternative energy generation technologies, thus, impacting positively the energy transition (Diaz Arias & van Beers, 2013). The incentive mechanisms available in the Netherlands for various categories of energy consumers and generators are listed in Table 3.

TABLE 3. *Energy Incentive Mechanisms in the Netherlands.*

Incentive	Goal
I. Sustainable Energy Transition Incentive Scheme (SDE++)	Auction process to award subsidies to technologies based on avoided CO_2 emissions, including carbon capture and storage (CCS) and low-carbon hydrogen.
II. Energy Efficiency Obligation (EEO) Programme	Mechanism to meet energy savings targets on Obligated Parties (OP) which may be retailers, DSOs, or TSOs.
III. Partnering for Green Growth (P4G)	An international platform to promote equitable and resilient economic growth through green partnerships.
IV. EU Emission Trading Systems (ETS)	Tradable emission credits to drive emissions reductions across the EU.
V. Certificates of Origins (CoO)	EU tradeable certification system for electricity production.
VI. Energy-saving investment Credit (EIA)	Companies are permitted to deduct 45.5 percent of investment costs from taxable profit.
VII. Subsidy Scheme for Cooperative Energy Generation (SCE)	For household and energy cooperatives that aim to produce renewable energy through solar (PV), wind, or hydropower.

Reference: Netherlands Enterprise Agency (RVO) ´Subsidies and programs´, 2022.

2.5. The SDE++ Scheme

The Stimulation of Sustainable Energy Production and Climate Transition Scheme (SDE++), or by its Dutch name Stimulering Duurzame Energieproductie en Klimaattransitie (SDE++), is an operational subsidy that encourages the use of renewable energy technology and generation by phasing out energy generated from fossil fuels on a mass scale. This subsidy is revised and granted by the Netherlands Enterprise Agency RVO and the amount is determined by the specified capacity and production. Each technology's production is capped at a certain number of full-load hours, which translates to the maximum number of production hours at the rated output per year for which the subsidy will be received.

The Stimulering Duurzame Energieproductie en Klimaattransitie (SDE++), or Stimulation of Sustainable Energy Production and Climate Transition, is an operational subsidy that encourages the use of renewable energy technology and generation by phasing out energy generated from fossil fuels on a large scale. The Netherlands Enterprise Agency (RVO) revises and grants this subsidy, and the amount is determined by the specified installed capacity and production efficiency. The output of each technology is limited to a particular number of full-load hours, which translates to the maximum number of production hours at the rated output per year for which the subsidy would be received.

Moreover, it is a government subsidy specifically aimed at the industrial and large-scale sectors. Eligible companies, businesses, and non-governmental organizations (NGOs) must meet several standards and characteristics, as well as operate as producers with the primary purpose of lowering CO_2 emissions. There is also the possibility of qualifying for the subsidy when operating as a 'partnership,' and when more than one party collaborates on the construction and operation of a generating facility. Through highly competitive bidding processes, beneficiaries are selected. The support level and the aid amount distributed can be periodically adjusted based mainly on the evolution of the appropriate market price and the selected applicants can be benefited through a variable premium contract that can last up to a maximum of 15 years (Podesta & Astuti, 2020).

2.5.1. SDE++ Mechanism

The mechanism of this subsidy is that it is distributed over a period of 12 to 15 years, depending on the technology selected. Similarly, the amount subsidized will be determined by the level of CO_2 reduction achieved and which must be verifiable at all times. The amount of the subsidy contribution is also determined by the revenue generated from the energy supplied (subject to a certain limit). The higher the revenue, the smaller the SDE++ contribution, and vice versa. The grant is divided into different categories as given in Table 4 to ensure that the competition between projects is fair. It is important to mention that there is a limit of only one application per category and per location of the production facility when participating as a producer during each round of applications.

TABLE 4. *Subsidy categories sub-categories classification.*

Category	Subcategory
Renewable electricity	Osmosis Hydropower Wind Solar PV
Renewable heat (CHP)	Biomass Fermentation Biomass combustion Composting mushroom compost Geothermal (deep and ultra-deep) Solar Thermal
Renewable gas	Biomass fermentation Biomass gasification
Low-carbon heat	Aqua Thermal Daylight greenhouses Solar PVT panels with a heat pump Electric boiler Geothermal Use of waste heat Industrial heat pump
Low-carbon production	CO_2 capture and storage (CCS) CO_2 capture and use (CCU) Advanced renewable fuels Electrolytic hydrogen production

Reference: Netherlands Enterprise Agency (RVO), 2022.

2.5.2. Subsidy Intensity Calculation

A different amount is set per category depending on a specific calculation that takes into account a base price which accounts for the maximum amount of the subsidy you can apply for and when applying for a reduced amount, the chances of receiving the asked amount may increase because of a high level of competition. The subsidy is comprised of the following components: 1) base amount, 2) corrective amount, and 3) subsidy incentives with maximum and minimum values predetermined.

First, the base amount and application amount are fixed for the entire duration of the subsidy. Following the selection of the subsidy amount, there is a correction amount that applies to the amount that is partly determined by the energy market value price and is revised and updated annually. The corrective amount considers Market Value price, Guarantees of Origin (GO), and the European Emissions Trading System (EU-ETS). However, the GO is subject to the determination from the PBL of the equivalent average annual value. Additionally, the base amount minus the corrective amount equals the maximum subsidy. However, because there is a distinction between electricity that will be fed into the grid (grid supply) and electricity that will be self-supplied, there are two different correction amounts especially for the 'Solar PV' categories (non-grid supply).

The corrective amount, in this case, may not be lower than the base energy price or the base greenhouse gas amount, which is based when taking into account two-thirds of the average expected revenue of the project over the entire duration of the subsidy. The correction amount must be less than the base energy price or the base greenhouse gas amount, which are calculated by taking into account two-thirds of the project's average expected revenue throughout the whole subsidy period. If the corrected amount is equal to the base energy price or base greenhouse gas quantity, for example, the maximum subsidy will be granted.

Finally, subsidy intensity considers the requirement per ton of CO_2 reduction. Because the scheme is technology-neutral, this variable is the only criterion used to determine which projects receive grants. It defines when and how a subsidy application should be submitted, and even how it should be rated. Furthermore, for the case of solar PV technologies, it is significant because they commonly achieve good results in this regard and are relatively cheap compared to other technologies because the market for them is established. The formula is as follows:

Subsidy intensity = (Application amount - Long-term price) / Emission factor

Where:

• *Application amount: the amount requested for the project, as well as the amount that will be awarded.*

• *Long-term price: The unweighted average of actual energy, product, or ETS prices over the subsidy period, as determined by the International Energy Agency (IEA).*

• *Emission factor: Emissions avoided due to the technology's implementation (e.g., electricity 0.2160 kg CO_2/kWh).*

Subsidies will be applied and granted per unit of measured electricity, heat, renewable gas, hydrogen, advanced renewable fuel, or reduced CO_2 emissions. However, it is important to note that to rank and interpret all types of projects into the same unit measures, the values must first be converted into subsidy intensity through the formulas presented in Table 5

TABLE 5. *Subsidy Intensity Formulas*

All categories except for CO_2 capture and storage (CCS) and CO_2 capture and use (CCU):	
$Subsidy\ intensity = \frac{(application\ amount) - (long-term\ price)}{(emission\ factor)/1000}$	Where: $Subsidy\ intensity = [euro/kWh]$ $Long-term\ price = [euro/kWh]$ $Emission\ factor = [kgCO2/kWh]$
CO_2 capture and storage (CCS) and CO_2 capture and use (CCU):	
$Subsidy\ intensity = \frac{(application\ amount) - (long-term\ price)}{(emission\ factor)/1000}$	Where: $Subsidy\ intensity = [euro/(tonne\ CO2)]$ $Long-term\ price = [euro/(tonne\ CO2)]$ $Emission\ factor = [kgCO2/(tonne\ CO2)]$

Throughout the year, there are four application rounds, with a total budget for 2022´s edition of 13 billion euros (previously in 2021: 5 billion euros). The corresponding phase for application corresponds to the subsidy intensity of the project. The specific dates and times of the most recent subsidy rounds are shown in Annex B with the corresponding subsidy intensity limits, an example calculation is shown in Figure 5. Participants may apply with a lower subsidy intensity than required to maximize their chances of receiving a subsidy, as projects with lower subsidy intensities will receive priority when evaluated.

This example is based on a building-mounted Solar PV system with 40% grid supply and 60% non-grid supply, with 500 kWp output.	
Category: Solar PV ≥15 kWp and <1 MWp connection >3 * 80 A, building-mounted	
Maximum application amount in phase 1	0.0704 €/kWh
Maximum application amount in phase 2	0.0724 €/kWh
GO value solar PV grid supply	0.0040 €/kWh
2021 provisional corrective amount for grid supply*	0.0272 + 0.0040 = 0.0312 €/kWh
2021 provisional corrective amount for non-grid supply*	0.0706 €/kWh
Provisional 2021 SDE++ subsidy for the maximum application amount in phase 1:	
Grid supply	7.04 - 3.12 = 3.92 ct/kWh = € 39.20/MWh
Non-grid supply**	7.04 - 7.06 = 0.00 € ct/kWh = € 0.00/MWh
Provisional 2021 SDE++ subsidy for the maximum application amount in phase 2:	
Grid supply	7.24 - 3.12 = 4.12 €ct/kWh = € 41.20/MWh
Non-grid supply	7.24 - 7.06 = 0.18 €ct/kWh = € 1.80/MWh
Maximum number of eligible full-load hours	900 full-load hours
Total rated output	0.5 MWp
Maximum annual production eligible for a subsidy for a system with a 500k Wp output:	0.5 * 900 = 450 MWh
Provisional 2021 SDE++ subsidy for the maximum application amount in phase 1:	
Grid supply: (40% * 450) * € 39.20 =	€ 7,056
Non-grid supply: (60% * 450) * € 0 =	€ 0
Total	**€ 7,056**

Figure 5. *Calculation example for solar PV. Reference: SDE++. RVO, 2021*

2.5.3. The importance of solar PV projects in SDE++

The subcategory of 'Solar PV' in the electricity category only applies to facilities that are connected to a large-scale energy connection. For a large-scale energy connection to qualify for the subsidy, the solar panel facility must have a peak output of 15 kWp. In order to apply, a feasibility study, as well as a map of the solar PV project, must be completed. Specifying the facility's orientation and whether extra facilities will be required to be constructed on the site. For the installation of solar panels, more than one formal permission issued by a competent authority is often necessary.

Since its first opening in 2008, solar PV has been the category with the most applications each year within SDE (first version). Since 2016, solar PV has also been the technology that claims an increasing share of the budget every year. By the end of 2020, the Netherlands had 10,717 MW (10.7 GW) of operational solar PV installed capacity, with more than 6.1

GW of large-scale and 4.6 GW of small-scale capacity (RVO,2021). Only in 2020, it account for approximately 5.3 GW of the 6.1 GW of large-scale projects installed (RVO,2021). Small-scale solar projects are installed without SDE support because they are encouraged by the net-metering system. Therefore, it is safe to say that this scheme is responsible for a growing proportion of the annual solar capacity installed in the Netherlands.

As previously mentioned in this report, in 2020 the SDE+ was changed to the SDE++. Figure 4 illustrates the development of solar PV projects in the Netherlands until 2020 from an assessment report carried out by the RVO on behalf of the Ministry of Economic Affairs and Climate Policy. In the figure, it is specifically differentiated which projects were implemented with and without an SDE subsidy, those in the pipeline but have been granted a subsidy, and the release capacity of SDE. However, these are considered only projections because, according to the RVO (2021), large-scale solar projects greater than 1MW on a roof can take more than a three-year completion period.

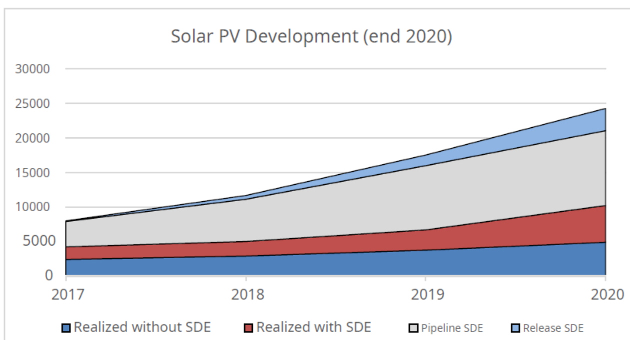

Figure 4. *Installed operational solar PV capacity.*

Reference: Monitor Solar PV 2021 in the Netherlands (RVO,2021)

The Climate Agreement sets a clear preference for rooftop solar PV projects to protect agricultural lands and it states that no more SDE subsidies (in all of their versions) will be provided to large-scale solar PV after 2025, or earlier if the 35TWh target is met. This means that by 2031, the sector must be able to implement projects without SDE subsidies (RVO,2021).

3. Theoretical Framework

3.1. Opportunity Structures

The ´opportunity structure´ theory is used to evaluate and explain the data collected through the interviews and the literature review of this thesis report. This theory is a well-established concept in social science studies that are primarily based on legitimate and socially acceptable means of achieving specific goals. Specifically, opportunity structures can be seen as the context in which collective actions are hindered or facilitated. For this study, the concept of opportunities refers to the political, economic, and environmental aspects of the SDE++ subsidy scheme that have hindered or facilitated the introduction of solar PV technologies into the Dutch electricity market. It is important to mention that opportunities are not always necessarily structural, but can also be the cause and a consequence of individual or collective actions. Additionally, because outcomes may differ depending on specific contexts, the results of this thesis report will also be explained based on three different types of structures: political, industry, and corporate opportunity structures.

First, due to the numerous and different types of stakeholder levels (national, regional, private, and independent actors) involved in the SDE++ scheme governance and implementation processes, the Political opportunity structure (POS) will be used to provide a method for portraying the connection between national policies in the Netherlands and international institutional politics as described by Meyer & Minkoff (2004). Likewise, the POS concept allows for analyzing the content and consistency of arguments between the different key stakeholders across time. This is why it is used to explain policy emergence and the evolution of the SDE++ scheme throughout the years. Likewise, some authors like Shurman (2004) also recognize a cultural element within POS. Where culture can shape people's expectations of political institutions and demand for what seems to comply with their rights as citizens depending on their sense of power. This directly relates to the current bottom-up approach in policymaking present in the Netherlands, where community acceptance is an essential element.

Secondly, the industrial opportunity structures (IOS) concept is used in this thesis report to explain how different groups of interested actors, such as regulatory institutions and private companies, can transform and create new social constructs over time depending on their understanding of the world. And, to particularly explain how the industrial sector plays a key role in the existing institutional practices, economy, and culture of a country (Schurman, 2004). Additionally, this perspective will help understand which characteristics are necessary to influence the creation of new regulatory frameworks.

Additionally, the corporate opportunity structures (COS) concept will help to demonstrate how the extent of regulation and the relationship among stakeholders can shape an industry (Soule, 2021). This thesis report demonstrates how the introduction of incentive mechanisms has shaped the electricity system in the Netherlands since the liberalization of its energy market. In this thesis, besides describing the current electricity context in the Netherlands, these three concepts will help understand how opportunities have translated into operational actions, in the form of incentive mechanisms such as energy subsidies.

3.2. Opportunity Structures and Energy Transition

The literature review provides a good background of the evolution of the energy sector, since its liberalization. Similarly, it explains how the Netherlands, as a Member State, has grounded its energy reforms on international goals and agreements in accordance with the European Commission directives. Additionally, particular focus is placed on the specific subsidy mechanisms to support a more accelerated energy transition within the country, resulting in the most recent and broad scheme which is the SDE++.

Nonetheless, for this thesis report, it is important to understand the history of energy evolution. Because many of the benefits associated with the liberalization of markets, including subsidies, have different political contexts and purposes. Furthermore, they would perhaps not exist if climate-related regulations which must be complied with were not in place. Precisely because these financial incentives, such as subsidies, serve as mechanisms for operationalizing policies such as the Climate Act, Paris Agreement, and net-zero targets, and encouraging individuals to actively take part. Whether it be through developing large-scale renewable energy projects or investments.

However, it is essential to consider that, although many efforts have been undertaken to create mechanisms to facilitate the operation of certain international agreements, this is not a general practice in all European countries, and neither is it in many other regions of the world. Just as political circumstances in the Netherlands have supported and prioritized sustainability issues and adjusted their legal frameworks accordingly, does not mean it is the case for other countries. It mainly depends on how open or closed are governments, to social movement claims (Lee & Hess, 2019). That is why political opportunity structures might play a key role in the development of subsidies as aiding mechanisms for complying with energy transition initiatives. And in the same way, subsidies are not static nor permanent tools. They are constantly modifying, adapting, and shaping accordingly to previous results and political interests (RVO,2021). For example, the difference between the SDE++ and the previous edition (SDE+) is that the former covers new forms of carbon dioxide emission-reducing technologies, such as Carbon Capture and Storage (CCS). As a result, most likely, the next edition of the subsidy will have different variables to consider and more stringent guidelines and conditions depending on the government in turn (Ministry of Economic Affairs, 2022).

Additionally, based on the findings, new industry opportunity structures emerge when political opportunity structures are generated since there are new alternatives available on the market and new regulations to adhere to. As a result, the energy sector develops throughout time and sees an acceleration in its growth. For example, considering the Guarantees of Origin (GOs), one of Europe's most popular energy attribute systems (Mulder

& Willems, 2019). These instruments did not instantly revolutionize the whole energy industry just because they were established. However, they support the transition to a cleaner and more energy-efficient industrial sector (Proka, et al., 2018) because, the greater the demand they convey in the market among consumers, the greater the pressure on the industry as a whole to accelerate the transition necessary to be capable of fulfilling this demand.

3.3. Research Question

Throughout the various sections of the thesis report, the following research question will be developed to explain, review, and evaluate these components*: "What are the economic, political, and environmental impacts of the SDE++ scheme on solar PV technologies in the Dutch electricity market?"* Specifically, on the implementation of solar PV projects and the adoption of this technology on a large scale in the industrial sector. Specifically, on the implementation of solar PV projects and the adoption of technology in the industrial sector. Specifically, on the implementation of solar PV projects and the adoption of technology in the industrial sector. Specifically, on the implementation of solar PV projects and the adoption of technology in the industrial sector. Specifically, on the implementation of solar PV projects and the adoption of technology in the industrial sector. Specifically, on the implementation of solar PV projects and the adoption of technology in the industrial sector. Specifically, on the implementation of solar PV projects and the adoption of technology in the industrial sector. Specifically, on the implementation of solar PV projects and the adoption of technology in the industrial sector. This review process can enable the identification of improvement opportunities and greater policy integration.

This question was raised because there may not be enough information available in the literature based on SDE++'s achievements. This is mostly because it is a recent edition (released in 2020), and plenty of the projects that have already obtained the grant are still in the pipeline and are awaiting completion or were even forced to abandon due to a shortage of power grid capacity. Which prevents a detailed assessment report. However, this thesis report will be able to share evidence on the impacts that the SDE++ has had thus far in the political, environmental, and economic spheres through semi-structured interviews with experts on the subject, including national authorities such as the Ministry of Economic Affairs, government organizations, research institutions, and companies that offer particular consulting services either in the energy sector and specifically in subsidies.

4. Data and Methods

4.1. Data collection

The primary method of data collection is semi-structured interviews. The interviewees include relevant institutions and energy regulatory organizations to determine how these stakeholders perceive and can advise based on their experience, about the benefits, hurdles, and shortcomings of the integration of solar PV technology into the Dutch electricity system, through the SDE++ subsidy scheme.

Contact with the institutions was mostly established through email, LinkedIn, and phone calls. Initially, an invitation to participate in the interview was sent out, requesting the interviewee's permission and approval. Consequently, the intended questionnaire (*Annex C*) was distributed beforehand so that they could assess the questions and decide whether or not they had adequate knowledge or desire to participate.

Prior permission and authorization have been requested from each participant at the start of each interview to record the interview on video and extract the transcript to obtain a complete record of the data collected and to be able to analyze in depth what was discussed and the insights of each interview. Each participant accepted and expressed their prior consent, as long as their identities were managed and kept anonymous, and the integrity of the institution to which they belong was not jeopardized. All of the interviews were performed online via Microsoft Teams, except for those with the RVO, who answered the questionnaire in a written form. Table 6 provides detailed information on how the data collection interviews were conducted. Including the name of the organization, the participant's job position, and the date of the interview.

TABLE 6. *Interviewing Process Layout*

#	Company/Institution	Category	Job position	Date
1	**Deloitte** Energy Department	Consulting Firm	Senior Manager (Energy & SDE++)	13-May-22
2	**PBL** - The Netherlands Environmental Assessment Agency	Dutch Research institute	Senior Researcher (Energy & Climate Sector)	16-May-22
3	**BCG** - Boston Consulting Group	Consulting Firm	Associate Director (EU Energy regulation policies)	27-May-22
4	Liander	DSO	Consultant (Energy Transition)	27-May-22
5	EGEN (PNO Consultants)	Consulting Firm	Senior Consultant	30-May-22
6	**TNO** -Toegepast Natuurwetenschappelijk Onderzoek	Dutch Research institute	Solar PV Modules and Applications	30-May-22
7	**TNO** -Toegepast Natuurwetenschappelijk Onderzoek	Dutch Research institute	Solar Energy (Market & Program)	30-May-22
8	**RVO** - The Netherlands Enterprise Agency	Government Agency	Policy advisor (SDE++)	10-Jun-22
9	**RVO** - The Netherlands Enterprise Agency	Government Agency	Policy advisor (SDE++)	10-Jun-22
10	Cata Subsidies Advies *(De Jong & Laan)*	Consulting Firm	Senior energy subsidy advisor	15-Jun-22
11	EGEN (PNO Consultants)	Consulting Firm	Senior Consultant	16-Jun-22
12	Ministry of Economic Affairs and Climate Policy	Government Agency	Policy advisor	22-Jun-22
13	*CertiQ (TenneT TSO B.V.)*	Government Agency	Relations Manager	22-Jun-22
14	Technische Universiteit Delft (TU Delft)	Dutch Research institute (public University)	Solar Energy Researcher	23-Jun-22

4.2. Data analysis

Using the data collected through semi-structured interviews with the different stakeholders, the political, economic, and environmental impacts of the SDE++ scheme will be assessed through the opportunity structures theory.

This thesis report relies on qualitative data collected from the interviews and literature review for background context of how the energy policies have evolved in the Netherlands throughout the years to provide a more comprehensive overview of the topic.

5. Results

5.1. Background

5.1.1. Energy Subsidies Perspective Overview

Regarding the implementation of subsidies in the energy sector, different stakeholders showed during the interviews that they have both positive and negative perspectives, depending on whether they want to support or hinder certain types of technologies. However, most interviewees participating in the public and private sectors agree with the idea of subsidies being effective mechanisms for scaling up and consolidating certain technologies in the market in the shortest possible time. However, they tend to be most effective when used as temporary instruments to scale technology when it is not market-ready nor sufficiently competitive. For example, Liander (interview 4) stated,

> "you could subsidize new technologies which are desirable for a short period, especially when they are not market-ready, not competitive. And then its market introduction needs a little help". [Liander (interview 4)]

This argument was also evident in another interview with CATA Subsidies Advies (interview 10), where it was stated,

> "…when technologies are more expensive, they (companies) will not do it (invest) unless there are subsidies. It is the only way for a quick acceptance of new technologies." [CATA Subsidies Advies (interview 10)].

Moreover, when it comes to the governance around subsidies, consultants share similar opinions regarding energy subsidies. For example, EGEN (interview 5) mentioned that

> “subsidies are means of society to steer technology… we need subsidies. But subsidies are useless without also having regulations in place, so you need to ´stick and carrot´”. [EGEN (interview 5)].

Explaining how only recurring stringent regulations or taxes can cause harm to society and, that having too many subsidies can also cause harm to the economy. Therefore, it was concluded that striking a balance between the two is essential. Particularly in the context of the energy transition, where fundamental change needs to be incentivized.

In general, a more neutral perspective regarding subsidies prevailed with this interviewee since it was also mentioned that subsidies are very important in the sense that they can make or break markets. Depending on their implementation and contexts. Discussing how, even though free markets are supposed to provide the basis for a well-functioning economic system, government intervention can fill in certain gaps with incentive mechanisms. Consequently, on the other hand, this market distortion can undermine market efficiency mechanisms to the extent that the subsidy recipient is under less financial pressure to become competitive. However, it may also enable inefficient recipients to remain in the market.

Based on these findings, the opportunity structures framework is relevant because some interviewees agreed that subsidies can be useful mechanisms and opportunities in the market that open a new window of opportunity for fundamental change in the energy sector. By addressing the opportunity with a response mechanism based on companies' interest in investing in new forms of energy production and facilitating the policy framework and financial means that encourages them to do so.

5.1.2. The role of SDE++ in Incentivizing the adoption of solar PV technologies in the Dutch electricity system.

This subsidy is originally intended to run until 2025, with a quite significant total budget of around 30 billion euros (Podesta & Astuti, 2020). According to EGEN (interview 11), this subsidy is

> "one of the most important grant schemes in place as an instrument for supporting climate policy in the Netherlands". [EGEN (interview 5)].

Likewise, a consultant at Boston Consulting Group (interview 3) stated,

> "from my perspective, it is a combination of governmental and industry views… with the objective to achieve Decarbonization in the most sustainable way". [Boston Consulting Group (interview 3)].

Over the last decade, it has been essential to lower the cost of solar PV technologies to achieve more efficient energy production through different land-use combinations and meet climate targets through innovative technologies. If it was not for the widely adopted strategy of introducing subsidies as incentives, solar PV technologies would have not been introduced at the same rate as they have. As some of the most innovative technologies right now, they would have been available only to very few people. Simply, because diffusion would have been much slower without a financial incentive. Therefore, solar PV technology may be a good example of long-term successful strategy integration.

In an interview with TNO (interview 7), it was mentioned that,

> "Without steering from the government in terms of subsidies… then almost nothing would have happened on the energy transition now. So, we would be in an even worse position than we are today". [TNO (interview 7)].

Explaining how subsidies have played a crucial role in technology integration in the Netherlands. Even though there is still much to be done towards achieving a clean energy transition.

A similar argument was mentioned by a consultant from EGEN (interview 11) where it was stated that,

> “subsidies really paved the way to a market for solar panels” [EGEN (interview 11)].

Referring to how, for some years now, there is a different scenario for solar projects where they can participate in a more competitive electricity market because the technology has already passed the scaling-up phase. Additionally, according to interviewee 11, to realize large-scale solar projects, both on the roof or in the field in the Netherlands, the SDE++ is a very important instrument. Even though, there is a shortcoming when it comes to the grid infrastructure because it is not currently able to cope with all the solar panels that are being installed.

Finally, referring to pricing it was also mentioned,

> “looking at the high electricity prices at this moment in time, it is a no-brainer to invest in solar panels” [EGEN (interview 11)].

Because the prices of this technology have been progressively lowering at a sort of a stable level due to mass production.

Based on these findings, the opportunity structures framework has political (POS) and industry (IOS) importance. Since there is an increasing demand for affordable energy due to the high energy prices in the market, governments must provide incentive mechanisms such as subsidies to make solar PV investments more accessible for industries to ensure people's well-being. As energy is needed in almost every economic activity, when energy prices rise, the prices of products and services will most certainly follow behind.

5.2. Political impacts of the SDE++

During nearly every interview, participants agreed that the most influential and important stakeholders in the SDE++ scheme during the decision-making process are The Ministry of Economic Affairs and Climate Policy itself and the RVO. This is because they are in charge of the policymaking, implementation, application process, and they ultimately decide who receives and keeps the grant.

As TNO (interview 7), the national research organization in the Netherlands stated that the whole scheme might be overall considered as a simple distribution of responsibilities:

> “in general, it is a two-step process. So first, there is the design of the regulation and then it is the execution of the regulation. What I see is that the execution of the regulation by the RVO is pretty straightforward and nicely well defined.” [TNO (interview 7)].

Explaining the relevance of the political actors within the implementation of the SDE++ and highlighting that the greatest weight falls under the Ministry of Economic Affairs' responsibility since the legislation of financial stimuli is in line with the general common interest of the energy sector.

Monitoring during the subsidy period is another crucial component. The subsidy provider is responsible for monitoring to verify that the subsidy is being used as intended (HM Treasury, 2007). After receiving the grant, applicants must submit purchase orders and contracts to the governing authority 18 months later to demonstrate that the project will be carried out successfully. However, as discussed during interview 1, if the project does not generate any energy, the grant can be taken away from them, to ensure that the initial business case conditions are met.

In a contrasting opinion, other important stakeholders that were mentioned by CATA Subsidies Advies (interview 10) were the energy companies and the TSO. Because they play an important role in the energy supply chain because they are in charge of maintaining a healthy electricity network. They both act as the enabler of the electricity service, therefore, being the main actors. Likewise, during the SDE++ application process, capacity approval from the TSO of the project installation is needed during the permitting phase. Because expanding the network is a challenging task that requires significant resources, it is critical to strike an appropriate balance and be strategic in the technologies and types of projects that are permitted.

According to the findings from the interview with EGEN (interview 5), solar PV is a noble and preferred technology because,

"the source of energy is democratic, so it cannot be monopolized." [EGEN (interview 5)]

The sun indeed shines across the entire planet to differing extents in different locations, but there is constant daylight everywhere. In the same way, subsidies are similarly democratically controlled. Every year, choices must be made about budget allocation, time frame changes, and objective adjustments. Many of the details are set in legislation, yet there is still room for improvement. As a result, the SDE is continually changing over time. Even though, the presence of a subsidy usually attracts interested parties who may participate politically to lobby for larger, more permanent subsidies, redirecting a subsidy becomes more difficult for private parties because their implementations and conditions depend on governmental authorities. Likewise, regardless of the energy service sometimes being regarded as a commodity, energy is still a matter of national welfare because practically all economic activities rely on its efficiency and operations, therefore it must be democratically governed under the public interest of the great majority (Inchauste & Victor, 2017).

According to the findings, it can be concluded that the concept of political opportunity structures is closely tied to the actor whom the interviewees perceive as the most significant stakeholder in the whole scheme (Cerna, 2013). Similarly, the concept of political opportunity structures can be understood as a collection of characteristics of an institution that determines a certain group's ability to influence the decision-making process within that institution. (Princen & Kerremans, 2008). In addition, Princen & Kerremans (2008) also mention that political opportunity structures can be seen as “required circumstances for social movement action” because social movements are often unlikely to become active in the absence of favorable opportunities in the political sphere. Both authors also mention that to measure the actual effects of political opportunities, it is important to (1) identify specific opportunities, (2) the existence of social groups that are interested in related political activities, and (3) have enough resources to enable social movements that can capitalize on those opportunities and they are a necessary but not sufficient condition to inspire group activity (Princen & Kerremans, 2008).

Based on the findings, It is essential to emphasize that this whole scheme would not exist if the Ministry of Economic Affairs' directive would not be established. Because of this, the government and the RVO, the organization that the Ministry has designated as responsible to carry out the administration and implementation of the subsidy, hold the highest authority. Being these, governmental authorities. But ultimately, it all comes down to the importance of how various similar subsidy mechanisms can result in the energy market from a single political opportunity. Several subsidies or incentive schemes in the Netherlands are ground-based on policies that were created to comply with international goals such as the Climate Act or the Paris Agreement.

5.3. Economic aspects of the SDE++

Subsidies are generally used to promote a wide variety of government policies and address a wide range of market failures. As described by EGEN (interview 5),

> "markets may be regarded as social constructs, so we make them. And we can also deconstruct them". [EGEN (interview 5)].

Further discussing how a possible consequence of subsidies is that these can distort competition between firms undertaking similar activities, particularly when subsidies are large and only available to a selection of the firms that compete with each other.

Competition, through efficient markets, delivers lower prices, greater choice, and more popular products to consumers. Moreover, subsidies that are closely targeted at the particular policy objective and with few restrictions on their use would be less likely to have a significant effect on competition (HM Treasury, 2007).

Subsidies are available in a multitude of forms. Some are taxed for industry, some for the government, and some for consumers for a specific policy purpose. Several examples of subsidies in Germany and the Netherlands were mentioned by Boston Consulting Group (interview 3). The conclusion is that one of the most difficult challenges is determining how cost-efficient would that particular sort of subsidy can be.

On another note, a different idea was presented by PBL (interview 2), stating that,

> *"granting a subsidy does not automatically mean that parties are looking for the lowest production costs."* [PBL (interview 2)].

Explaining how rather than focusing excusably on short-term economic benefits and providing the lowest cost instead of the highest value, certain other aspects should be considered. For example, the region or landscape's usage, environmental elements, and biodiversity.

Furthermore, greater emphasis was placed by EGEN (interview 5) on the idea that a subsidy might aid in the presentation of a business case and approval of financial organizations that offer loans for developing energy projects, such as banks. because banks are usually risk-averse firms and can be very conservative. Therefore, having a subsidy can benefit the applicant of a bank loan.

These findings support the idea that, from an economical perspective, corporate opportunity structures and subsidies may be correlated. Because they provide businesses the chance to develop into new markets and obtain greener sources of energy by funding large-scale initiatives. The corporate opportunity structures concept can be described as the key role that the personal values, ideas, and core beliefs of decision-makers play within a corporate structure (Forrest, et al., 2014). As a result, and based on the findings, financial institutions are often more likely to grant different financing opportunities and increase the likelihood of diversifying the electricity grid, to projects that have already been granted with a government subsidy such as SDE++. This is because financial institutions tend to have more confidence and trust in projects that include in their business case a government subsidy because they are perceived to be solid enough to be granted a bank loan since they previously went through a strict process with the RVO and the Ministry of Economic Affairs to receive the grant. This is because obtaining the authorization of these institutions is viewed as substantial evidence by financial institution decision-makers that the project is well-grounded and will be carried out properly.

5.4.1. Importance of budget allocation

The amount of the subsidy might increase every year for a variety of reasons. When subsidies are too big, and projects have too much money available, competitiveness decreases, as stated by the PBL (interview 2). For the SDE++ application of this year, there is a significant budget allocation increase and it can be attributed due to small setbacks in previous calculations or projects already in the pipeline and awarded with a grant, but not yet finished.

A similar argument was shared by EGEN (interview 11), where the interviewee explained that certain participants have filled out an application, and claimed the budget, but are ultimately unable to implement the project for whatever reason. Consequently, this would benefit next year's applications since it would imply that there would be more funding available for other projects. Thus, to have a proper budget allocation, the RVO and the Ministry of Economic Affairs must strive to minimize the risk of non-realization.

5.4.2. Accessible and technology-neutral application processes

The entire SDE++ application process and its stages are meant to be completed online, via a clearly outlined method and an official website. The main objective is to provide all competitors with an equal opportunity and the same starting point. As long as they have the permissions granted while completing the application and internet access.

According to the application requirements, the decision on which projects receive the grant is mostly determined by the subsidy intensity calculation previously describes in this report and the timing of application submissions, which needs to be preferably on the first day of the phase in which the project is ranked, as recommended by EGEN (interview 11).

As stated by BCG and TNO (interviews 3 and 6), the SDE++ strives to be ´technology neutral´, which means that no technology will be favored over another. However, there may be government interest in incentivizing more specific technologies than others. This explains why the success of solar PV project integration in recent years has been due to the technology's declining capital and operating costs, rather than because they were favored during the process. With a success rate of application above 80% as perceived by Deloitte (interview 1), PBL (interview 2), and EGEN (interview 11) based on their perception and expertise. Demonstrating that solar PV projects are among the most cost-effective and efficient technologies currently available on the Dutch energy market.

Based on the findings, the interviewee's perceptions can be linked to industry opportunity structures. Because, in essence, the SDE++ scheme creates a good opportunity for projects of all sorts to participate since it does not favor one technology over another and is considered technology-neutral. Private companies all over the world who manufacture different technology equipment can be equally benefited from the integration of this subsidy, and can successfully capitalize on the new opportunities that the SDE++ subsidy presents to the Dutch electricity Market within the industrial sector (Roberts, 2009). This enables the energy sector to diversify in a way that the most effective technologies end up standing out or obtaining the most subsidies.

As a result, the market is encouraged to have competitiveness, and the most affordable options prevail. This does not imply that some technologies will not take predominate negatively over others in the future or that this situation cannot change. As a result, there are plenty of opportunities to develop diverse projects in the energy industry, which is open and flexible. as long as they fulfill the requirements and acquire the necessary government permissions.

5.4.3. Grid Capacity barriers to implementation

Large-scale renewable energy projects, for example, are quite common in the eastern part of the country since there is more land and space available; nevertheless, the grid infrastructure may need to be further expanded to cope with the generation or have adequate storage capacity to back it up. Whereas the western half, which has larger electricity demands and a stronger network, has a shortage of available spaces and projects may find it difficult to obtain a permit due to grid capacity issues and congestion. As a consultant from BCG (interview 3) mentioned,

> *"We need to kind of match infrastructure and have a coordination between demand and supply." [*BCG (interview 3)]

Explaining how, as part of the SDE++ application, each project must provide grid operator authorization for the connection.

Adding to this argument, the national DSO Liander (interview 4) mentioned that projects that sign a contract for grid capacity may receive grid capacity directly. Once reserved, a corresponding payment is necessary to guarantee the required capacity. However, if it is not paid or the procedure is not immediately continued, the reserved capacity and grid access may be allocated to different projects *´by the rule of first-come, first-served´,* as is frequently the case. However, the biggest challenge that grid operators usually experience is the challenge of connecting projects, and providing them with appropriate transport capacity, in a suitable period, which was previously done under approximately 18 weeks. Another important challenge mentioned is the need to further regulate transportation tariffs. Because customers who supply energy to the grid generally do not have to pay for transportation, whereas users who consume power from the grid must pay a corresponding transportation fee for their use.

Similarly, interviewees of PBL (interview 2), TNO (interview 6), and EGEN (interview 11) mentioned that the most difficult part for applicants is getting these permits. And how, from their perspective, although there can be many kinds of reasons why installations are not implemented, the main reason for projects dropping out is because of permitting issues. Correspondingly, what Liander and EGEN (interviews 4 and 11) encourage is considering the possibility of installing smaller PV systems on rooftops and self-supply, because a permit is not required up to a specific capacity, and this might result in reduced grid transportation demand.

5.4.4. Efficiency over innovation and the importance of monitoring

It was mentioned by several interviewees that SDE++ is not an incentive created to encourage innovation. Since the subsidy intensity is the only criterion considered to grant the subsidy, more emphasis is put on costs and efficiency.

As the PBL (interview 2) stated,

> "The SDE is not an instrument to support innovation. It is designed to implement technologies commercially so that all technology should be economically viable. You get a subsidy based on the production that you have. If you have an innovative technology, then you're not certain about your output… One thing they want to know for certain is how much energy is going to produce and how much income are you going to generate". [PBL (interview 2)].

Explaining how, for the government, the most important factor to consider is to have high confidence and a way of accurately forecasting future energy production.

When there are multiple entry barriers, and a lack of follow-up and progress monitoring, the risk of a subsidy leading to inefficiency increases (HM Treasury, 2007). As previously indicated, subsidies can allow inefficient businesses to continue without addressing their inefficiency. If new competitors cannot enter to compete away this inefficiency it will last longer, at the expense of consumers increases (HM Treasury, 2007).

Although, as mentioned by Deloitte (interview 1),

> "The amount of money granted under the SDE++ is a final decision, and the government is not allowed to change that" [Deloitte (interview 1)].

There is a variable considered within the scheme known as the ´corrective amount´. Which is used to avoid under or overcompensating projects in the long-term.

Based on these findings, these responses can be linked to political and industry opportunity structures. Because, even though subsidies are frequently given to technologies that are in the scaling-up phase, this is not the case with SDE++ in particular. By using this mechanism, the Ministry of Economic Affairs aims to boost the number of renewable energy projects while prioritizing the most affordable ones, regardless of how much innovation they contribute to the sector. Because of that, other subsidies are available, as the Ministry of Economic Affairs explained. This subsidy offers the opportunity to employ effective and affordable technologies which nonetheless enable the decarbonization of the energy sector and encourage industry investment in these activities.

5.4. Environmental impacts of the SDE++

While striving for Decarbonization, the European Union as a whole is working together to accomplish international environmental goals. During the interviewing process, the question of whether these types of energy subsidy schemes are essential emerged. From Liander´s perspective (interview 4), certain subsidies might not be essential for CO2 reduction because emissions are already regulated and limited, given that there are currently effective mechanisms in place to accelerate the energy transition, such as Emission Trading Systems (ETS).

A good and suggested approach is targeting the SDE++ subsidy only to companies that are not subject to ETS regulation. Which are small and medium-sized companies, to focus efforts on assisting them in reducing emissions. However, in other interviewees´ opinion, extra funding for projects is always welcomed when it comes to encouraging the energy transition. Because having more wind and solar technologies could directly help in the phasing-out of fossil fuel power plants.

5.4.1. Carbon footprint and GHG emission reductions from solar PV technologies

The SDE++'s main goal is to meet environmental objectives for GHG emission reduction and eventually attain net-zero emissions by 2050. Therefore, the amount of the subsidy awarded is determined by the type of technology employed and takes into consideration the CO_2 reduction achieved, with a maximum compensation amount of €300 per ton of CO_2 reduction (RVO,2021). As a result, it is reasonable to conclude that sustainability and accelerating the Dutch energy transition are fundamental to the SDE++ objectives.

On the other hand, the carbon footprint caused by the manufacture of solar PV panels is an important consideration. During the interview with TNO (interview 6), the distinction between mono-facial and bifacial solar panels was explained. Because of the high costs of land in the Netherlands, the most popular is the first, in which, the panels are arranged one next to the other, allowing less sunlight to reach the ground. As a solution, the researcher suggested using bifacial technology and trackers to find a better balance between energy, ecology, and agriculture. The technology in these semitransparent panels could be a potential future option for getting more out of PV panels and even producing additional power by exploiting the panels' rear. Because the cells can look through the glass, sunlight can flow through and reach the ground, creating more space for vegetation to grow underneath. This provides for a better trade-off between the business case and societal needs without sacrificing the environment. Mono-face solar panels are still less expensive than bi-facial solar panels at the time, but this does not rule out the possibility of them becoming the new dominant technology soon.

5.5. A future without solar subsidies in the Netherlands

When asking the interviewees about their perception of a future without energy subsidies in the Netherlands, specifically in solar PV technologies, the answers ranged from highly positive to negative. For example, from the TNO (interview 6) perspective,

> "…the disappearance of subsidies is not a yes or no question, but rather more of a question of time". [TNO (interview 6)].

Explaining that because they are regarded as a market distortion, they may push systems into an economically unnatural state.

On the other hand, Deloitte (interview 1) considers that,

> "Subsidies will continue for a long time in the market, because, to achieve energy transition there is a combination of technologies needed, not only one technology" [Deloitte (interview 1)].

Referring to, how perhaps for some market-ready technologies subsidies may not be a possibility anymore, but for new technologies, subsidies will most likely prevail.

There is generally a sense of unconcern among interviewees as to whether by removing subsidies for solar technologies, the rate at which these projects will continue to be introduced will decrease, because they all are sure that these types of technology will only get cheaper by the day. Nevertheless, it will be interesting to closely observe which type of project will be the first to carry out a solar installation without any form of subsidy and assess its success. During this transition time, however, subsidies will continue to exist as long as society is unwilling to pay the real price for products.

To summarize the findings, key perspectives and insights were conveyed, with some interviewees agreeing, some disagreeing, and some having a more neutral perspective on the importance of subsidies in the context of large-scale solar PV technology projects for the Dutch electricity markets within the industrial sector. Although almost every interviewee agreed that energy subsidies can be excellent mechanisms for scaling up and steering desired economic, political, and environmental outcomes, several possible considerations were discussed, such as only subsidizing certain types of technologies for a limited time or imposing more stringent conditions for obtaining the grant.

Nonetheless, monitoring the projects' implementation and maintenance processes is also as important as assessing the application and business cases, because many projects are bottlenecked in the implementation pipeline due to several factors. Non-realization of approved projects was initially strongly reduced by dividing into technology subcategories and improving application requirements, however, factors such as not receiving the necessary permits from the governmental institutions or the Dutch electricity system not having enough power grid capacity in the region where the applicants want to install their projects are often the most common causes of not taking the projects to a conclusion stage.

Based on findings from the semi-structured interviews with public and private relevant stakeholders actively participating in the scheme, it can be determined that without having in place mechanisms such as the SDE++ energy subsidy and its preceding versions, most projects that have been successfully implemented in the Netherlands in the last years, would have had more difficulties for being financially viable. As a result, the scheme remains important specifically for the realization of large-scale solar PV energy projects due to the sharp investment cost reduction. However, smaller projects such as ´self-consumption´ projects are also highly encouraged, to lessen the pressure and demand for a broader power grid infrastructure in the Netherlands.

Based on the interview results, there is no doubt that this scheme will continue to exist in the coming years. However, the main consideration will be to closely monitor under which circumstances and observe how it changes, evolves, and adapts to the needs of the Dutch electricity system, its market participants, and international emission-reduction targets.

6. Conclusions

6.1. Summary

To keep solar PV technologies affordable and accepted within the Dutch electricity market, an integrated approach across energy policy domains is required, as well as good coordination between government and semi-government parties, corporations, social organizations, and the industry's influential stakeholders. Based on the findings, it is feasible to conclude that, while the SDE++ has mainly positive effects on the economic aspect, it also has political and environmental impacts.

Initially, an overview of the evolution of the European energy sector, the different energy packages introduced by the European Commission to steer the energy transition, and the available subsidy mechanisms in the Netherlands were presented. During the last decades, the Dutch electricity system has gone through different policy implementations that enabled better competition, energy efficiency, a secure supply, and, most importantly, affordable energy access for all Dutch citizens.

The perspectives, insights, and points of view of several interviewees relevant to the Dutch energy sector, based on their expertise in the field of solar PV technology, were presented throughout this thesis report. Participants ranged from the national government and semi-government stakeholders, and major organizations, to research and educational institutions engaged in the energy industry. Each of them is involved in the scheme at a different level and with varied interests. Some of them are now the regulators, while others are facilitators who help participants to complete a successful application and, hopefully, receive the grant.

The data collected through multiple semi-structured interviews served as the base to answer the research question: *"What are the economic, political, and environmental impacts of the SDE++ scheme on solar PV technologies in the Dutch electricity market?".* First, on the political aspects, the degree of engagement and ability to enable the conditions, standards, and guidelines to the participants is essential to the success of the greatest number of renewable energy projects. As well as the level of collaboration among the different stakeholders involved. It is vital to understand who is the policymaker, who supports the application process, who issues permits, and who manages the grid's power capacity to identify possible bottlenecks within the scheme and who to turn to solve them. In terms of the most important political aspects, it was generally agreed that, because the subsidy is entirely a government initiative, the Ministry of Economic Affairs is the major stakeholder and the entity with the most responsibility, in close collaboration with the RVO. Second, the most relevant economic impacts to consider resulted in the following: the importance of budget allocation, guaranteeing an accessible application procedure, and establishing a technology-neutral approach to provide equal opportunity to all sorts of renewable energy technologies.

Finally, in terms of the environment, it is essential to consider the carbon footprint generated from solar PV technologies, such as the materials used in the manufacture of the panels and working to ensure competitive prices with high-quality resources while guaranteeing a sustainable life cycle and disposal of the equipment. Furthermore, for the SDE++, the ability to trace back the actual amount of GHG emission reductions is necessary to properly analyze if the subsidy is an effective mechanism for energy transition or if it should be reinforced with the scaling up of certain technologies.

Nonetheless, when participants were asked their thoughts on a future without subsidies, specifically for solar PV technologies, the responses ranged from positive to negative to neutral. For some, allocating the budget for solar is no longer necessary because the technology is currently mature enough in the market and does not require additional resources. Others argue that it is critical to continue supporting the most cost-effective technologies because there is still more progress to be made to bring us closer to international goals, particularly if we are to achieve net-zero status by 2050. For others, there must be a balance and encouragement for innovation and change the "business as usual" approach, but rather use the subsidies more strategically.

Furthermore, while the Netherlands supports an integrated approach to national policy, adopting an international perspective has impacted the types of instruments available to achieve an energy transition. According to the findings, the Netherlands can continue to benefit from the potential that having a subsidy in place implies for project developers while also meeting the challenges of ensuring prosperity and well-being for all of its citizens. However, it is the Dutch government's responsibility to develop the necessary regulations and political structure to foster conditions favorable to Dutch interests. Similarly, it may be argued that the RVO should conduct more frequent and in-depth monitoring and assessments of ongoing projects, as well as make data analysis publicly available on an annual basis. Additionally, greater information on various subjects should be presented to applicants to reduce the required realization periods and avoid bottlenecks in the permitting and implementing phases. Similarly, because of the current grid capacity circumstances, the SDE++ scheme should make self-consumption projects more financially attractive, to reduce grid congestion and allow large-scale projects to have sufficient capacity available.

6.2. Future Research

In general, a subsidy is expected to cause market distortions, but these can be controlled and minimized (HM Treasury, 2007). Therefore, with the results obtained, it would be interesting to explore whether other mechanisms, aside from subsidies, can boost the adoption of new technologies. Because subsidies are a way of boosting niche technologies, likewise, it would be interesting to investigate what other technologies should be subsidized and promoted in Dutch electricity markets. Furthermore, the biggest challenge in the electricity sector is matching the time of production with the time of consumption; therefore, more research and investigation of the possibility of providing subsidies to energy storage research and development and project development would be very interesting.

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8. Appendix

APPENDIX A. *Climate agreement timeline in the Netherlands.*

DATE	CLIMATE AGREEMENT
December 2019	National Energy and Climate Plan (NECP) submitted to the European Commission
November 2019	First Climate Plan presented to the Senate and the House of Representatives
June 2019	National Climate Agreement presented
May 2019	Senate adopts the Climate Act
December 2018	House of Representatives adopts the Climate Act
October 2018	Government response to the proposed outline of the National Climate Agreement - the start of the second round of negotiations by sector bodies
July 2018	Outline of the National Climate Agreement presented
June 2018	Climate Act presented to parliament
May 2018	Government announces coal-fired power plants to be banned as of 2030
May 2017	Energy-intensive industries present energy efficiency agreement
December 2016	Government presents Energy Agenda
January 2016	Energy report presented
December 2015	The new international climate agreement reached (Paris Agreement)
October 2013	Government presents Climate Agenda
September 2013	Energy Agreement for Sustainable Growth signed
November 2011	Local Climate Agenda

Reference: Government of the Netherlands. Climate Policy, (2020).

ANNEX B. *SDE++ application rounds for 2022*

Phase	Start and end date 2022	Subsidy intensity phase limit (€/tonne CO_2)
Phase 1	28 June, 09:00 CET to 11 July, 17:00 CET	65
Phase 2	11 July 17:00 CET to 29 AUGUST, 17:00 CET	75
Phase 3	29 August, 17:00 CET to 12 September, 17:00 CET	105
Phase 4	12 September, 17:00 CET to 26 September, 17:00 CET	165
Phase 5	26 September, 17:00 CET to 6 October, 17:00 CET	300

Reference: https://english.rvo.nl/subsidies-programmes/sde

ANNEX C. *Interview Questionnaire*

QUESTIONNAIRE – RESEARCH PROPOSAL

- **Research Question:** *"What role does the SDE++ subsidy play in determining the success of PV technologies in the Dutch electricity market?"*

Dear participant,

Thank you very much for taking the time to answer these questions and for participating in this project. This interview is part of a Master's Thesis Research Proposal for the Environmental & Energy Management postgraduate program at the Faculty of Behavioral, Management, and Social Sciences (BMS) at the University of Twente.

The main purpose is to learn how you, as a key stakeholder, perceive the role of the **SDE++ subsidy** in the Netherlands. In particular, I will be asking about how the subsidy helps and supports successful introduction of solar PV technologies in the electricity market as part of the transition to a cleaner energy future.

Your responses to these questions will be treated with confidentiality and your personal information will be anonymized. However, I would appreciate your permission to include your position within the company in the master's thesis.

The duration of this interview is estimated to be around 45 minutes.

INFORMATION

1. What is your position within the organization?
2. What are your responsibilities and main activities in that position?

SUBSIDIES IN GENERAL

3. Is it necessary to resort to subsidies to encourage or hinder the adoption of specific clean energy technologies?
4. Can subsidies be attributed as one of the main drivers for the recent increased use of solar PV technologies?
5. How different do you believe the situation would have been if there had been no incentives to encourage the adoption of solar PV technologies?

SDE++

1. What role has SDE++ played in the development of new renewable energy technologies? (specifically solar PV technologies)
2. Apart from the subsidy intensity calculation, what criteria are used to rank and assess applications?
3. What is the project application success rate?
4. Which type of technology innovations are more likely to receive the grant?
5. What happens if the project's generating efficiency changes during the grant period, resulting in lower emissions reduction? Is the amount reduced to the *´corrective amount´ regarding the amount of money granted,* or the same amount agreed upon at the start is kept?

6. In your opinion, what is the most difficult requirement for projects to meet to apply for the grant?
7. Generally speaking, what do you consider the SDE++ scheme's biggest benefits and shortcomings are?
8. Is there any documented evidence or reporting of how much SDE+ or SDE++ has lowered GHG emissions in the Netherlands?

STAKEHOLDERS

1. Which stakeholder has the most influence in the decision-making process, and why?
2. Apart from the RVO, which additional stakeholders do you consider can play a significant role in the application process?
3. What kind of information, and how often, must selected projects provide during the grant period?
4. After the grant has been received, which stakeholder follows up on the selected projects?

ADDITIONAL

1. What other variables, besides subsidies, can encourage the adoption of new technologies?
2. How do you envision a future in which subsidies either do not exist or are drastically reduced? Would this be beneficial or aid in the consolidation of the energy transition in the Netherlands? (specifically for solar PV technologies)