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Master Thesis

Sunny Collaborations

Unleashing Public-Private Partnerships to Supercharge the Solar Photovoltaics Diffusion in Norway

Anders Graff Nygård

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Sunny Collaborations

Unleashing Public-Private Partnerships to Supercharge the Solar Photovoltaics Diffusion in Norway

Sunny Collaborations: Unleashing Public-Private Partnerships to Supercharge Solar Integration into the Norwegian Power grid

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Faculty of Social Sciences, University of Oslo

http://www.duo.uio.no

Abstract

Despite Norway's heavy presence in the petroleum industry Norway are highly committed to climate goals. Norway is in the process of electrifying the country and hydropower secure much of the required energy. However, electricity security is a concern due to the expected increased consumption from the electrification process. Apart from pursuing offshore wind, solar power present itself as a potential choice. Recent report prove that south-eastern Norway's sun irradiation levels are equal to those of Germany, which controls one of the biggest national solar PV markets. However, the market seems to be severely underdeveloped compared to its potential. The total installed capacity in Norway in 2022 was 321 MW, which indicates a steady but slow increase. The thesis aims to first identify the market barriers for solar PV development in Norway and then explores PPP as a potential model to overcome these barriers to enable the rapid solar power diffusion in the country,

The thesis first adopts TIS structural analysis so that to identify the market barriers for solar PV development in Norway, which shows that there are both financial and regulatory barriers. The thesis maps out different stakeholders involved in Norway's solar PV development. Limited knowledge sharing and incentives among different stakeholders to build efficient investment networks have been regarded as one of the crucial barriers to build the market structures in Norway. Therefore, this thesis proposes and explores the role of Private Public Partnership (PPP) as one of the potential solutions to address the barriers. Furthermore, to empirically investigate the role of PPP and how it can play a role to incentive solar PV development, the thesis investigates a case study of Ullevaal Stadium to discuss how the PPP can play a role in its one recent solar PV project. Going beyond the specific case study, the thesis discusses how in general PPP can de-risk the early investment and furthermore can gear different actors from different sectors towards a common goal, so that to align their efforts and enable them to utilize their expertise and work together to diffuse solar PV in Norway. Moreover, the thesis also reflects on the potential risks and institutional conditions of applying PPP in Norway's context.

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And last, thank you to all my classmates and colleagues at Amnesty International and NFF for exchanging ideas, and all your constructive critique.

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List of Abbreviations:

PPP	Public-Private Partnership
TIS	Technological Innovation System
PV	Photovoltaics
MWh	Megawatt-hour
SDG	Sustainable Development Goal
NVE	The Norwegian Water Resources and Energy Directorate
KWh	Kilowatt-hour
NOK	Norwegian Krone
NFF	Norwegian Football Federation
m^2	Square meter
UEFA	Union of European Football Association
KUD	Ministry of Culture and Equality
BOT	Build-Operate-Transfer
TWh	Terawatt-hour
MW	Megawatt
UN	United Nations

Contents:

“Oh Sunshine! The most precious gold to be found on earth.”

-Roman Payne

1. Introduction

1.1 Setting the Agenda

In Antonio Guterres' 2017 COP 23 speech the Secretary-General of the United Nations (UN) said: *"Climate change is the defining threat of our time… We need to do more on five ambition action areas: emissions, adaption, finance, partnerships and leadership."* These words have not lost an ounce of relevance since. Despite the urgency of the matter, the progress has been too slow and the follow-up on climate agreements like the Paris Agreement and the Kyoto Protocol have been neglected in several highly prioritized areas. If we do not change our approach towards a significantly greener energy production to limit our emission, we consequently minimize our chances to prevent a further surge in the global temperature (IPCC, 2023). 80% of the total global emission comes from fossil energy and that is simply not sustainable. Ideally, that number should be closer to zero. The best way to decrease the amount of emission is rapid expansion of green energy sources and the construction of the infrastructure to support a greener energy sector (Fagerberg, 2023).

Norway has been an oil and gas producing state. The petroleum industry in Norway provides thousands of jobs and is the backbone of the Norwegian economy (Gavenas et al., 2015). There is no doubt the rapid sustainable transition will affect the Norwegian economy and society (Fagerberg, 2023). To minimize the economic consequences of the green shift and brace the society for what is to come, a gradual transition, commencing now, would ease the entire transition. In accordance with the UN's sustainable development goals (SDG), oil and gas will eventually be phased out, and reliable and fully established substitutes must be in place when that happens. A sustainable transition is not viable without sufficient substitutes, as the energy demand will remain high, and likely grow in the coming decades. Although there already is a viable and developed option in hydropower, the industry itself cannot replace the economic gains from the petroleum sector. Norway covers roughly 92% of the energy demand with hydropower (IEA, 2022), but there are limitations to how much the industry can expand due to environmental impact and the limitation of waters to exploit. Moreover, hydropower is subject to seasonal variations like precipitation and temperature. The two most common and severe consequences of this are low-capacity hydropower batteries and fluctuating steep energy prices. It becomes evident that the Norwegian energy portfolio needs to diversify into several energy sources, especially with Norway's outspoken ambitions towards electrification driven low-carbon goals in mind.

Wind power is already established as a potential contributor and there are already over 50 wind parks in Norway (NVE, 2019), however there is huge controversy and debate regarding windmills in Norway. Despite wind power's growth, hydropower is still completely dominant in the Norwegian energy production market. However, a solid portfolio should be broad and diverse. There is one industry of particular interest, one that has gotten less attention than hydro and wind power, namely solar photovoltaic (PV). Solar PV have become significantly cheaper after Chinas entrance to the global market and the continuous incremental development of the technology together with the effectivization of processes along the value chain will keep the price of solar PV technology relatively low (Chasanidou et al., 2021). Continuous affordability can possibly make it a viable option considering that the energy demand is predicted to rise significantly in the foreseeable future (Rosenberg et al., 2013). Moreover, the electricity prices are predicted to rise in the next decades according to The Norwegian Water Resources and Energy Directorate (NVE) (Hovland, 2023b), and this shortens the payback time for investment in new energy.

In general, the intensity of the sun fades as you move further away from the equator, but factors like snow (extra reflection) and cooler weather compensate for the fading intensity by improving the performance of the solar panel (NVE, 2019), additionally the cooler temperatures prevent the solar panels from overheating. A recent report showed that the potential for solar PV in southern Norway is comparable to that of Germany (Xue et al., 2021), a country which had the third highest solar PV energy production per capita in 2022 (IEA, 2023). Evidence shows it is physically feasible to install and utilize solar energy in Norway. However, the market seems underdeveloped and there is no strong market incentive for the country to upscale solar PV as a mean to diversify its energy production. A huge uncertainty in the solar PV market, and other financial and regulations barriers should be addressed before a rapid diffusion can occur.

1.2 Research Question

Brinkerhoff & Brinkerhoff (2011) said "that solutions to societal problems require the combined efforts of the public, private, and voluntary sectors is a truism". This is also the aim of Public-Private Partnerships (PPP), and it can be part of the bigger picture in that sense.

Innovation theory claims that grand wicked problems, which are complex, systemic, interconnected, and urgent in nature, can be solved through close attention and expertise from a multiplicity of perspectives from multiple fields of study, industries, sectors, and people all at once (Mazzucato, 2018). A Norwegian development of solar PV can potentially be a part of the solution to the climate change issue. A possible model to overcome them is PPP. The PPP model brings public and private expertise together and facilitate a platform for communication and a chance to address concerns, risks, and ideas. Although there is a huge demand and great potential to install solar PV in Norway, there is still very limited scales taken up. Hence, the thesis addresses the following research question:

RQ1: "To what extent can PPP accelerate the diffusion of solar PV in Norway?"

2. Solar Power Development in Norway

2.1 Putting Norway's Solar Development in the Global Context

The amount of solar PV generated energy in Norway has been significantly lower than countries that have similar solar irradiation levels (Germany, UK, and Sweden), both in terms of household and large-scale commercial solar PV (Inderberg et al., 2018). Compared to these countries, Norway already has a sustainable option in hydropower, and has therefore not the same incentives and schemes in place for the expansion of solar PV (Inderberg et al., 2018). Despite the relatively low output of solar PV energy, the PV industry in Norway has long and established roots. The Norwegian solar PV industry started in the 1990's. In this period, Scanwafer, Norway's first solar PV company was established. Initially, the industry focused on the upstream production. Easy access to cooling water and cheap energy, combined with an established silicon industry lined the pieces up neatly for a market that mainly sold materials to international developers. This experience gave vital insight into the industry and provided the Norwegian PV industry a solid knowledge base to build upon.

With China's entrance to the global solar PV market, the efficiency and prices of solar PV decreased significantly, enabling the global diffusion of solar PV. Solar PV was relatively costly in its formative stage, but with new technology and a supporting market and infrastructure, solar PV became cheap and accessible on a global basis (Chasanidou et al., 2021). Despite the global diffusion, the solar PV market in Norway remains small. It is significantly smaller than their closest neighbors, Sweden, and Denmark and it is evident by the annual solar PV capacity addition through 2014-2019 (illustrated in Figure1).

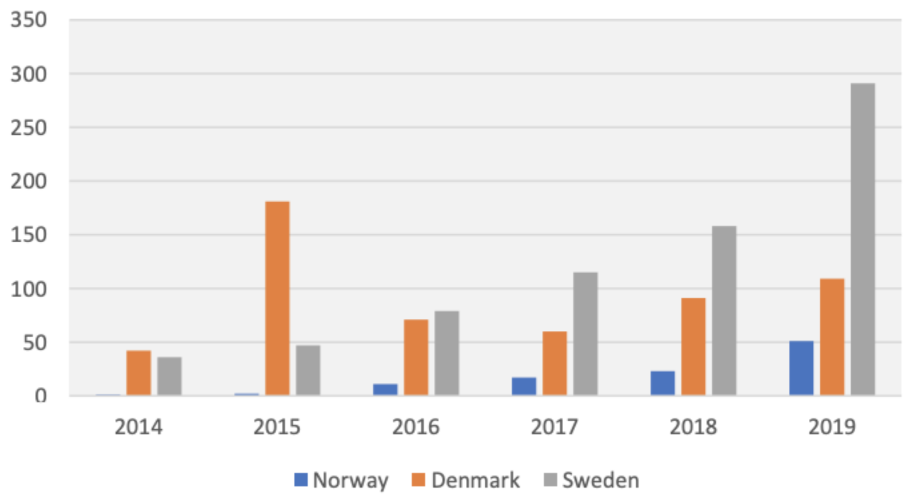

Figure 1: Annual Solar PV capacity additions, MW per year (IEA PVPS National survey reports 2014-2019)

The solar PV energy output in Norway has grown steadily the last decade, although it has been significantly slower than in Denmark and Sweden (Chasanidou et al., 2021).

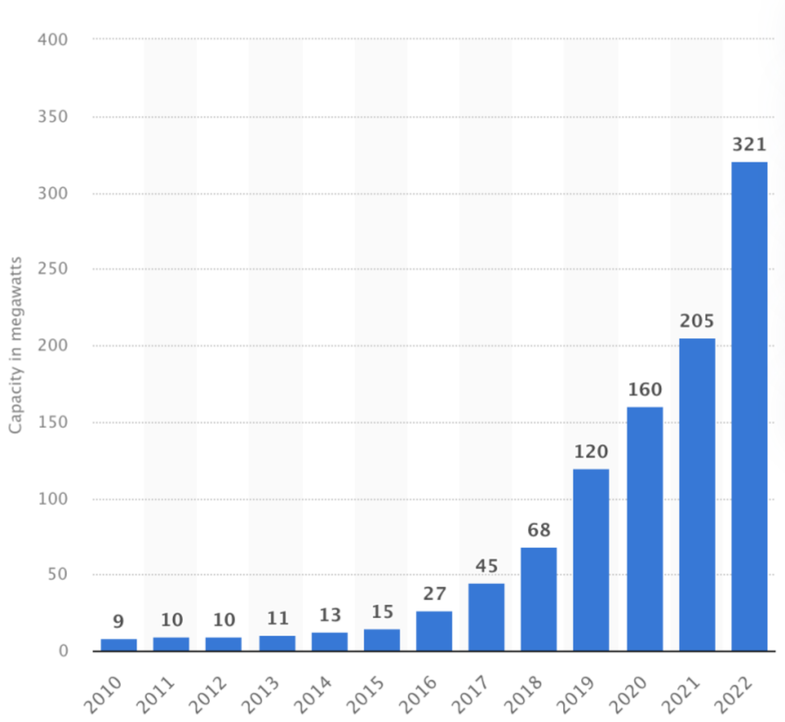

Figure 2: Installed solar PV capacity in Norway from 2010-2022 (Statista.com)

Regardless of the current market, the potential for solar PV in Norway remains huge, both for households and for large-scale consumers. As figure 3 below shows, parts of Norway have a similar solar irradiation level as European continental producer. Kristiansand is equal to München, and Oslo to that of Brussel. The Southern and South-Eastern parts of Norway is hence suitable for solar PV energy production. There is one major obstacle for the expansion of solar PV in Norway, as Norway already have access to sustainable power generation via hydropower, solar PV does not make up a significant part of the country's plan for a future sustainable energy portfolio. This means that solar PV production is not actively encouraged, and the development of the solar PV industry in Norway could stumble upon certain market barriers.

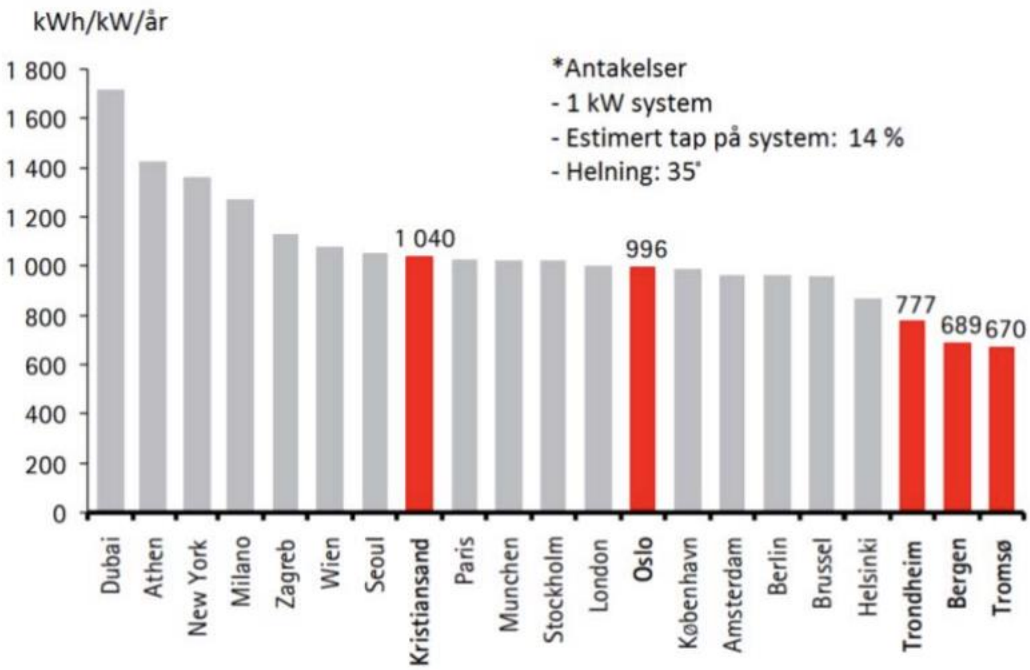

Figure 3: Insolation data for global cities (Accenture/WFF)

2.2 Actors in the Norwegian Solar PV Industry

Despite the lack of incentives, many actors are aware of the potential of solar PV in Norway and several companies are already involved with solar PV and more are showing interest. Both international and national companies are involved in Norway's solar PV industry to a varying degree. Domestic companies like Scatec (private) and Statkraft (public) have increased their investment in solar PV in Norway recently and expanded their production via takeovers (Chasanidou et al., 2021). Prosumers have also increased in numbers, although many opt for this based on identity and status, rather than for financial reasons (Chasanidou et al., 2021). However, further expansion of prosumer activities might force the governing bodies to accommodate the financial aspect of solar PV (Inderberg et al., 2020). The increase of prosumers also installs a deeper understanding of solar PV, sustainability, and the energy market in the prosumers, which potentially can benefit the expansion of sustainable energy on a larger societal scale (Inderberg et al., 202) Clearly, there is an interest in solar PV from both the public and the private sector. The prosumer increase also points to a heightened interest from the consumers as well. With the rising interest, the governmental body regulating solar PV in Norway, NVE, might have to constitute new policies and schemes to accommodate the rising demand and interest in solar PV (Inderberg et al., 2018).

NVE is responsible for the oversight of solar PV concessions, regulations, legal framework, etc. Hence, they play a vital role in the future of solar PV in Norway. A joint bottom-up push from prosumers, private and public companies might force the government to reconsider their approach on solar PV and implement solar PV into their energy portfolio (Inderberg et al., 2020). The interconnectedness between actors, stakeholders and policymakers in the Norwegian solar PV market is understudied and requires more attention to fully explain the relationship between the involved actors (Inderberg et al., 2020).

The Norwegian solar PV industry is dominated by small companies, often compromised by less than 10 employees. The bigger companies tend to have main activities outside of solar PV but has departments exploring solar PV on the side (Chasanidou et al., 2021). The industry has actors in both the upstream and downstream industry. The upstream companies focus on raw material extraction and supplying it to the downstream companies, continuously improving their procedures to slim down extraction cost and increase efficiency to compete with an international market, where most of the materials are sold. This upstream industry enables the downstream industry to offer lower prices and increase financial accessibility, although the upstream industry outpaces the downstream industry in Norway (Chasanidou et al., 2021). The solar PV industry in Norway have been built from bottom-up, and the knowledge and capacity exist to support a bigger national market. Should the regulative organs in Norway choose to support the knowledgebase and open for a wider diffusion of solar PV, the industry is developed enough and have the motivation to grab that opportunity (Chasanidou et al., 2021). The pieces appear to be lined up for a successful market, but the road map is absent. Financial and market incentives are limited, initial cost and risk are high, limited societal awareness and knowledge, satisfaction with the current energy system, limited information sharing among actors and unfavorable public policies constitutes major roadblocks for the solar PV industry (Xue et al., 2021).

3. Literature-Review

The chapter first reviews technological innovation systems which serves as a foundation to identify the barriers for technology diffusion. It then reviews the general barriers, the common identified death valleys from demonstrations to upscaling green technology for energy transitions. It then reviews public private partnership (PPP) which will be explored in the later chapters as one of the key instruments to overcome these potential barriers.

3.1 Technological Innovation System

For further examination of solar PV in Norway, the assessment of the technological innovation system (TIS) can further emphasize the potential, the barriers, and the performance of solar PV in the Norwegian context, as it has become a popular and useful analytical framework for examining emerging industries and markets, and helping public actors create favorable policies (Hanson, 2018). The innovation system analyzed does not necessarily have to be fully developed, but can also be vaguely established, emerging and in its formative stage (Bergek et al., 2008). TIS in mainly a framework to analyze the actors, network and institutions surrounding a certain technology (Markard, 2020). The actors consist of agents involved with the innovation process like suppliers, manufacturers, researchers, public entities, and organizations. The Institutions is about the legal framework, regulations, policies, culture, norms, and other intangible aspects. The Networks are the interplay between all the actors and the institutions, formal and informal collaborations, alliances, inter-organization, and disputes (Bergek et al., 2008). It might be natural to think that the entire system is coordinated and strive towards a common goal, but innovation systems are complex and often experiences push and pulls internally.

TIS is mainly a framework to highlight the dynamics and functions of an innovation system and to see how a technology or a sector emerge, develop, and diffuse. Moreover, it examines how the economy and how the society is impacted by the new technology or industry (Bergek et al., 2008). In the formation of a TIS, new actors enter the system, and networks and institutions are established, or they simply adapt existing ones if that is possible (Bergek, 2019). With time, the emerging system dynamics will stabilize themselves, as actors enter and leave constantly. The starting point of a TIS is always a focal technology or industry, and the TIS framework centralize the technology or industry in the analysis (Bergek, 2019).

TIS has developed over time, originally it stems from technological systems, and the functions approach (Bergek, 2019). The concept of technological systems was developed during the late 1980' into the early 1990's as a tool to help policymakers create better technology policies. The framework was made up from literature on economics of technology, and technology & structural changes in an industry. The technological system revealed the need of examining institutions and actors and the interplay between them (Bergek, 2019). The functions approach was established around the turn of the millennium, and had its focal point aimed at understanding the development, diffusion and use of new technology and processes. The function approach took inspiration from innovation system theories and based its assessments on how the functions of an innovation system worked (Bergek, 2019). The technological system and the function approach led us to TIS as we know it today, and based on its usage throughout academia, it appears to be especially suitable for analyzing sustainable innovation (Bergek, 2019). Therefore, the analytical framework of TIS, could potentially be an ideal way to analyze the context of the Norwegian solar PV industry.

The TIS framework's ability to analyze functions is what makes it ideal for the analysis of sustainable innovation (Bergek, 2019). The analytical process can be divided into six steps, which is not necessarily linear, the process goes back and forth, but a stepladder makes the process and the sub-analyzes clearer for the reader (Bergek et al., 2008). The functions approach of an innovation system is tied to TIS and this is the ideal scheme of analysis for technological change (Hekkert et al., 2007). We will utilize the framework Bergek et al. (2008) outlines in chapter 6. Barriers for Solar PV development to analyze the solar PV market in Norway on a later stage, which is heavily focused on assessing the functions of the market (Hekkert et al., 2007).

3.2 Death valleys: from demonstration to Upscaling

One common problem for green technology diffusion is the valley of death, which means that after the government invest several demonstration projects and there is still no strong private investors investment in the market, which ends up with still limited diffusions in the market. There are several market barriers in the Norwegian Solar PV context The markets further diffusion depends on whether it is capable to circumvent these barriers. The valley of death occurs in the early stages of innovation, between research and commercialization. At this stage, innovation normally struggle to attract capital. This is the critical make or break point.

Without financial incentives and accessible capital at this stage, the chances of the technology to enter the market decreases dramatically. Financial incentives often happen in accordance with accommodating policies, which foster an encouraging environment for further expansion of said technology (Ellwood et al., 2022). The cultural differences between R&D and commercialization makes the crossing of the valley difficult, as the R&D operates with different norms and logics, whereas the commercial side is more business oriented. This is where the barrier occurs. How do you go from invention to innovation (Ellwood et al., 2022)? Crossing of the valley of death is characterized by uncertainty. Is there a market for the technology and is there capital and financial means to support it? It is proposed that a wide societal construct to support the crossing can smoothen the process (Ellwood et al., 2022). This is where the solar PV industry in Norway is located now. The lack of funding, financial incentives and public demand prevents the further development of the Norwegian solar PV market (Xue et al., 2021). In the current climate, the financial risk is likely to outweigh the potential monetary return. A scheme or model is required to bridge the gap and enable an up scaling of solar PV.

The upscaling of solar PV in Norway includes a society-wide change to the approach on solar PV. This entails a change in technology, organization, institutions, policies, and culture (Naber et el., 2017). Technological changes are on its own not sufficient to scale up, but also rely on regulatory amendments, public support, and a supporting infrastructure (Naber et al., 2017) as sustainable technology often tend to require new societal structures and social change (Hermans et al., 2013). At this point, there is not really a supporting infrastructure, nor policy or culture for a wider spread for solar PV in Norway (Chasanidou et al., 2021). This can be addressed by the up-scaling valley, which is another valley that must be bridged to solidify an established solar PV market in Norway. For upscaling to be feasible, a thorough understanding of the market and the industry must be at the bottom. Moreover, a collective aim of multiple actors to reach a goal must be in place. Combined with an understanding of available resources and capabilities, these factors add up to the foundation of upscaling (Nader et al., 2017). Both the valley of death and the upscaling valley appears to be relevant to the Norwegian context.

3.3 Public-Private Partnership

3.3.1 Definition of The Public-Private Partnership

This section aims to install a better understanding of how PPP is defined, based on previous literature and which definition the thesis will operate with.

Public-Private Partnerships has historically been vaguely and broadly defined which has led to confusion of what it entails, resulting in a multiplicity of vaguely and inconclusive definitions (Brinkerhoff & Brinkerhoff 2011). This may be caused by the lack of empirical research on PPP or due to the fact that it simply is too broad of a term to narrow it down in a single definition (Azarian et al., 2023). Strangely enough, this vagueness is what has made PPP attractive as it naturally becomes a versatile and capable model for meeting complex societal issues (Folkestad & Lindén 2014).

However, there are some characteristics that is omnipresent in PPP, and they serve as a guideline to what a minimal PPP must include. Those characteristics include a partnership between at least one non-commercial public actor and a commercial private actor. A collaboration on a project where the risk and rewards are shared. And lead to a result that has social value (Strasser et al., 2021). These characteristics are further emphasized in the greater literature (Folkestad & Lindén, 2014), (Solheim-Kile et al., 2014). How do you then go around to define something which is vaguely defined by design? It seems hard to pin down exactly, as the definition appears to be contextual and location specific. For example, in the UK, any PPP project must surpass 24 million EUR in expenses in order to be defined as a PPP project (HM Treasury 2003). If that was part of the universal definition, many cases of PPP in Norway, would have had to be labelled differently as they fall dramatically short of the requirement presented in the UK definition (Thomassen et al., 2016). In the case of a narrow definition, we run the risk of excluding projects that in nature are PPP but lack certain characteristics. Therefore, it would be more orderly and holistic to go with a wider generic and more inclusive definition of PPP to encompass the wide range of PPP projects. There are several lesser and greater definitions presented in the literature, with a varying degree of specificness. The accumulation of the lot seems to aggregate closely to the forementioned characteristics. Hence, this general definition presented by Strasser et al (2011) is utilized: "A PPP is collaborative arrangements between public and private actors, which aim to achieve a common goal by sharing risks, responsibilities, resources, and competencies between minimum a public and a private actor."

3.3.2 The Political nature of PPP

Originally PPP was a broad term for a diffuse and wide range of collaboration between public and private actors, in a more arbitrary sense than it exists today. The original term was based on a loose transition from government to governance, which ties itself to the neoliberal concept of efficiency and less public involvement into what can be considered the area of the private sector (Petersen 2011). From its loosely established origin it has developed and adapted aspects and knowledge from other fields of study, evolving into the more developed, but far from complete form. Peterson (2011) addresses the expansions of the literature, starting around the turn of the millennium, as cross-disciplinary inputs. The following fields of study were adapted by PPP: public management, public administration, construction management, legal studies, and finance/accounting together with other less significant areas. All these fields of study directly link to the core aspects of the modern day understanding of PPP. Which is administration, construction, juridical frameworks & risk, and financing (KPMG 2003). In hindsight, the development can be seen as logical, given the influx of influences in the literature. Legal studies contributed in the contracting and tendering part. The construction management attributed knowledge to the construction side of PPP. All the management fields directly lead to the development of project administration, and finally the economic input help develop the finances of PPP.

It is unclear when exactly it came into existence, excluding some primitive examples of public-private collaboration between merchants, pirates and the Spanish state in the 1500’s (Petersen 2011) and the partnerships between the private elite and the U. S. government during the 1800’s and 1900’s (Azarian et al., 2023), the origin is usually traced to one of two eras. Some scholars tie its establishment to the wave of privatization during the 70’s and 80’s (Greve & Hodge 2012) while others draw parallels back to the 90’s and onwards as a result of the New Public Management reforms (NPM) (Rhodes 1996). The UK were pioneers regarding PPP’s and quickly embraced what they called Private Finance Initiative (PFI), which enabled PPP to be widely available, and after a couple of decades with PPP, the UK has made PPP an efficient and feasible option for development for both public and private actors (Azarian et al., 2023).

However, revisiting the political nature of PPP, the ties to privatization and the New Public Management reforms explains the skepticism, as the politicians cannot fully agree whether

PPP is something to be pursued or not. The left sided parties tend to be more skeptical than the right leaning ones on the political spectrum as the right sided parties generally are positively geared towards private actors' involvement in areas which traditionally used to be the sole responsibility of the public sector. (Bakke, 2011) and (KPMG, 2003). Despite this political disagreement, the use of PPP has seen a steady increase over time (Aarseth & Urdal, 2015). One possible explanation is the limited financial budget of the public sector (Sanner et al., 2010). Another explanation could be the transfer feature of PPP. The transfer feature, which is standard in most PPP contracts, eventually enables the public sector to reclaim responsibility over the service at the end of the PPP contract (KPMG, 2003). PPPs are long-term investments, where the full price is not paid up-front, it draws parallels to a governmental credit-card where the cost can be dispersed over time (De Clerck et al., 2021). Critiques of PPP fear failed promises (Bakke 2011), while advocates of PPP cling to and hail the same promises (KPMG 2003), and both opinions are equally valid. No matter its origin, PPP remains somewhat controversial, and it seems you either root it for its potential to accelerate processes (KPMG 2003) or denounce it for its shortcomings on promised results (Bakke 2011). A possible solution to this political polarity could be a standardized framework for PPP projects, which potentially could circumvent some of the uncertainty surrounding private and public domain (Thomassen et al., 2016).

To sum up, although loosely defined and versatile, PPP is still a very politized topic. There is a dispute whether it is simply a glorified version of privatization or if it serves as an ideal collaboration between the public and private sectors to bring out the best of both sectors (Folkestad & Lindén 2014). It is quite possible that the inherent political viewpoint of a person dictates their opinion on PPP. It has been a trend that the Norwegian political left-side is more suspicious towards PPP than the right-side. This is due to the left's tendency to favor public sector and the right side's tendency to favor privatization (Sanner et al., 2010) & (Bakke, 2011). This issue can be traced back to the origins of PPP.

3.3.3 Actors in The Public-Private Partnership

At the core of any PPP there are three stake holding actors, namely the public actor, the private actor, and the people. Although the partnership is mainly between the public and the private actor, it is often dependent on social acceptance and fulfilling societal needs. The actors' have their unique responsibilities, concerns, and interests, although they all share common goals like sustainability, financial stability, and reliability (Xue et al., 2021). The public actor is the governmental organization recognizing the needs of the consumer and are responsible for attracting and searching for potential partners. The private actor is derived from the world of private business, driven by commercial forces. Their main objective in a PPP is to bring their expertise into the project and seamlessly find a way to collaborate with the public actor to find sustainable long-term solutions to the specific need they try to fulfil. The people are the consumers, end-users as well as the society in immediate proximity of the project and the population affected, in any way, by the project (Sihombing et al., 2020). Additionally, some attention must be given to non-governmental organizations (NGOs), academic institutions and the media, due to their ability to influence the popular opinion on.

The public sector is concerned with serving their constituency and provide efficient and quality services, without overstretching their normally limited fiscal budget. The private sector is mainly driven by the opportunity to make a profit, but have a social responsibility to satisfy consumers, partners, and other stakeholders. Additionally, they must comply with the set standards of operations, construction, and legal framework. The people are concerned with having functional and easily accessible services to a reasonable price. Moreover, the people's support for sustainable initiatives, which offer no visible discomfort, nor health hazards are immense. The people tend to strongly resist projects that create negative externalities which directly impact their quality of life (Xue et al, 2021).

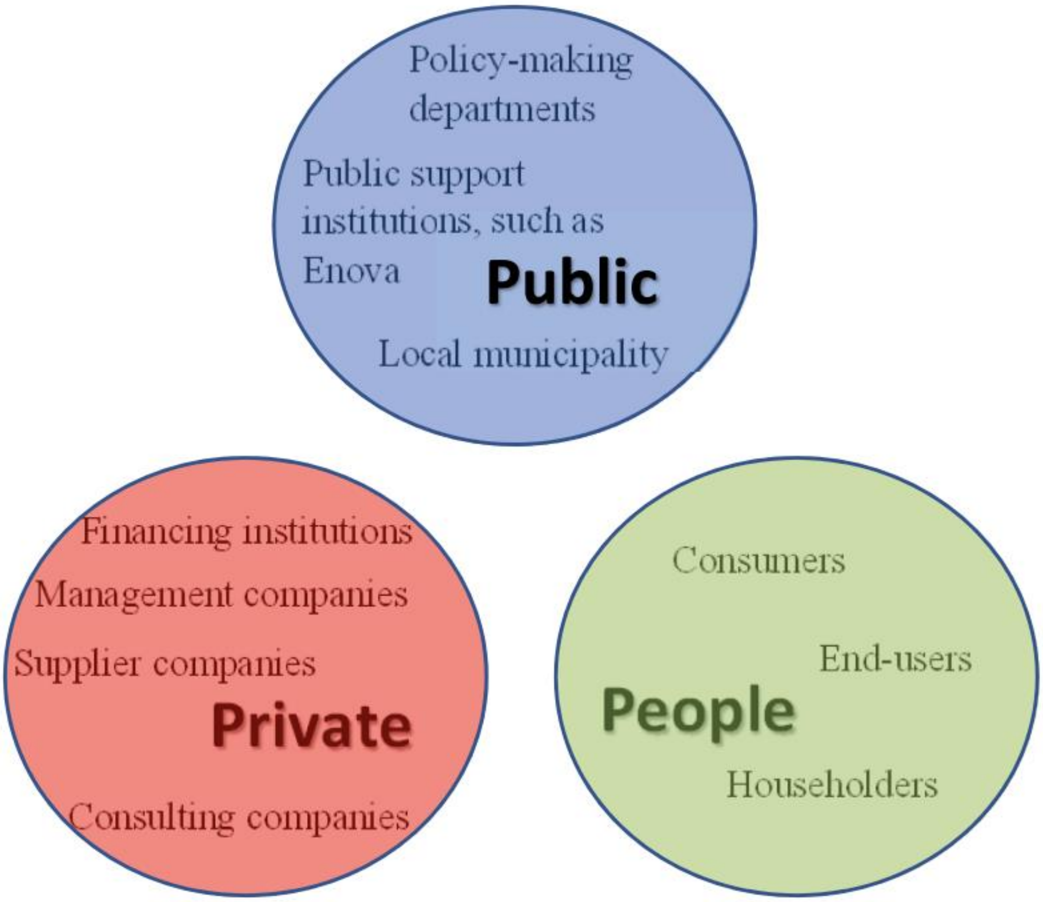

Figure 4: Actors in the context of solar PV (Xue et al., 2021)

3.3.4 The Public-Private Partnership Process

PPP has distinctive features that deserve and need a further explanation. Per the chosen definition of PPP, some of its features become evident and the literature further expand on these (risk allocation, capabilities, and tendering). Before elaborating further about the features, it is essential to lay out the common process of a standard PPP model. This is straight forward as the vast majority of PPP goes through these steps presented by the World Bank (2017) and the Asian Development Bank (2018):

> *NB* - As noted by the Asian Development Bank (2018), the assessment can alter depending on location and context. Country specifics play a vital role.
>
> *Step 1* - Initially it stars with a need, often of a social character. The public actor starts the initial planning and assess what the need encompasses and the possibilities of investments for said project.
>
> *Step 2* - The advanced planning phase, where an outline and thorough assessment of

the project’s plausibility is conducted. This includes examining the affordability of the projects. What kind of technical expertise is required? Which risk and rewards the project entails and who carries/receives them. The public actor sets a timeline and examines whether there is a commercial interest to attract bidders with a relevant and applicable skillset. The public actor also establishes standards for the completion of the project.

Step 3 - If the project seems plausible and suitable for a PPP, a public notification of the imminent tendering process must be publicized attached with an information form for potential bidders. The form serves as a self-evaluation questionnaire for potential bidders to see whether they possess the right know-how and expertise to take on the project.

Step 4 - After the initial round of application (depending on the number of applicants), the public actor creates a shortlist with the most relevant bidders and they receive the Invitation to Tender, which means the bidders can prepare their final formal offers for the project.

Step 5 - The public actor receives the final bids and select their preferred partner based on the compatibility. In the case of several bidders, two or three bidders might be selected to a final bidding round presenting their best offer.

Step 6 - When the public actor has chosen a compatible private partner the partnerships must be approved by the right organs.

Step 7 - After the forementioned approval, the negotiation of the contract commences. Ideally, the contract should be as close to the initial outline the public actors drew up in the advanced planning phase. This is the phase where context and location kicks in, as unique projects have specific needs. Furthermore, this is where the risk and award allocation are formally agreed and signed upon. The responsibilities of all parties are clearly stated in the contract. This includes terms of construction, quality of procedures, maintenance, operations, finances, transfer of ownership, etc. Normally the private actor takes on the financial responsibility, and the parties constitute a payback plan, where it determined how the public actor will reimburse the private actor. Usually, in the form of annuity, but other methods can be agreed upon. The contract is the legal document formalizing the agreement, but the real partnership starts with the implementation of the project and frequent communication.

Step 8 - The payment installations delay until the construction is completed and can often be based on whether the agreement of the contract is continuously fulfilled. For example, should the standard fall below what is expected and agreed upon, payments might be withheld until said standard is obtained restored.

Step 9 - At the expiration of the contract, depending on the terms and conditions, the project is normally (unless specified differently) returned to public ownership and the partnerships is deemed completed.

These steps conclude the general process of PPP, emphasizing again that PPP is a vague and versatile concept, and the process can be influenced by context and location (Asian Development Bank 2018).

3.3.5 Public-Private Partnership's Features

The process presents itself in an orderly and almost recipe-like manner, and a couple of steps on the ladder is due for some deeper examination because of their obvious connection to the earlier mentioned features. These are Tendering (Thomassen et al., 2016), Risk Management (Eshun et al., 2020), and Capability and Competency Development (Eshun et al., 2020).

Tendering - The lack of experience and a standard legal framework for PPP drives up the cost of tendering, which possibly makes it unnecessarily expensive. Establishing a common set of guidelines and common understanding of PPP could potentially slim down the cost related to negotiation, bid evaluation, bid process, and additionally derive specific subcontractors. A streamlining of this process could minimize the waste of precious and limited public funding (Thomassen et al., 2016). The actual implementation of a standard framework is somewhat controversial, as PPP is significantly contextual and location-specific (Asian Development Bank, 2018). This hint toward a compromise where regional, and/or sectoral standards could be part of the solution. This would, however, require further research and attention.

Risk Management - A fair and balanced allocation of risk can potentially contribute to a win-win scenario for both all parties involved (Eshun et al., 2020). A risk is defined as an uncertainty who might or might not come to fruition during the time of the project (Rosseland & Elefsen, 2014). There are four ways to handle the risk at different stages of the process:

> *(1) Reduce risk:* Establish preventive measures to minimize the chance of a given risk to occur and minimize the effect said risk will have. Risk reduction can and should be done throughout the whole process (Rosseland & Elefsen, 2014).
>
> *(2) Avoid risk* - If the consequence of a risk appears imminent or there is a clear path towards it, it is advised to change the certain aspects of the projects that triggers said risk. Early maneuvering and assessments can help the project steer clear from potential risk down the road. Late response to risk hampers the effectiveness of said preventive measure.
>
> *(3) Risk transfer* - Very common in PPP. The actors who is best equipped to handle a certain risk, is naturally the one to take on the responsibility. This is tightly connected to their expertise (Folkestad & Lindén, 2014). The risk is not gone, but strategically located with the most capable actor. This usually happens at an early stage.
>
> *(4) Retain risk* - Certain low-probability-severe-consequence risks like flashfloods or earthquakes are tricky, but unlikely. It remains with the original keeper, who simply must accept the risk of a scenario that has minimal probability (Rosseland & Elefsen, 2014).

As forementioned, the risk allocation is based on capabilities. Meaning public and private actors accept risks based on their expertise. The private actor tends to, depending on the nature of the agreement, to handle risk tied up to construction, design, and operations. All of which is related to the economic risk, which is also transferred from the public to the private actor in most PPPs. The main purpose of the financial risk transfer is to alleviate some of the financial restrictions the public sector usual balances, but a partnership would not find place without prospective gain for both actors. In sum, it can be said that the private partner provides a service, rather than an asset. In PPP theory, the long-term financial responsibility of the private actor ensures that there is nothing to gain from cheap and weaker construction, since any maintenance would be covered by the same actor in the future. Hence there is an incentive to be thorough from the start and no reason to opt for cost-saving measures that would render the construction fragile and prone to frequent maintenance work (Solheim-Kile et al., 2014).

The public actor is not completely free of financial risk either, even in the case where most of the financial risk is transferred to the private actor. Regulatory, legal, and political risks are generally placed with the public actor. Any changes in said risks can lead to unforeseen costs like inflation, new legal standards of construction, and changing terms and cost of loans to name a few (Norwegian Government Agency for Financial Management, 2023.

Capability and Competency Development - In order to develop capabilities and competency in an inter-sectional partnership, it is imperative to align the efforts and strive towards a common goal. These goals include, but are not limited to economy, standards, project management, publicity, and progression. Aligning your expectations, values and efforts is of crucial importance for a transparent and learning-positive environment. If you can trust in your partner's intentions and actions, it will enhance the performance of both. If you on the other hand must second guess and follow up on every decision said partner commit, the process become tedious and draining. (Åm & Heiberg, 2014). When there is a high level of trust, the transaction of information and knowledge flows effortlessly and safeguards a mutually beneficial partnership. (Ling et al., 2015). Both parties come in with a different set of skills, and the idea of a PPP is for those two different skillsets to complement each other. General capabilities like communication, problem-solving and dispute resolution should be at the core of both parties. Furthermore, skills like managerial and operational diligence, sustainability-consciousness and financial stability further enhances the likelihood for a win-win scenario. It is also worth mentioning the experience and procedures of implementing PPP, seasoned partners with a solid knowledge of PPP increases the chance a successful partnership. In terms of specific expertise, it is the private actor's responsibility to bring in the know-how of design, construction, and commercialization. For the public actor, the desired capabilities consist of well-designed legal and regulatory frameworks, fertilizing a business and investment climate, institutional and political capabilities, and technological knowledge (Eshun et al., 2020)

3.3.6 Benefits and Challenges with Public-Private Partnership

There are several positive and negative consequences from using PPP as a model for construction projects. It is peculiar how volatile certain features of PPP can be. For example, the longevity of a project is seen as a strength but depending on your perception and the nature of the partnerships, it can also be precepted as a restraining legacy and duty inherited by previous decision-makers (Folkestad & Lindén, 2014) & (Sanner et al., 2010). This emphasizes the significance of stable partnerships designed for a win-win scenario, ensuring interest and diligent follow-up on agreements (Eshun et al., 2020). Folkestad & Lindén (2014) point out three significant advantages and disadvantages regarding PPP. The lifecycle aspect of PPP incentivizes robust and rugged constructions, with a smart design to minimize maintenance and enabling potentially altercations to meet new user needs. Moreover, the clause of payment which activates after the finalization of the construction accelerate the process and promote effectivity. The third advantage presented by Folkestad & Lindén (2014) hails the longevity of the contracts, often spanning over several decades. A pre-agreed standard must be maintained as a guarantee for future payments. On the flip side, we find three disadvantages. Completing a PPP project requires high contracting and financial competency in the early stages of the tendering process. Furthermore, lack of said expertise could potentially weaken your monetary loan conditions (related to risk, which actor gets the better loan deal). Finally, the longevity of the contract might not be able to adapt to evolving user needs, standards, and other unknown scenarios.

Sanner et al., (2010) elaborates further on several PPP benefits and challenges, and they are explained orderly below. Benefits are marked with (B) and challenges are marked by (C).

> *(B1) Cost efficient:* PPP has the potential to slim costs related to construction, operations, and maintenance (Sanner et al., 2010). Messy and excessively elaborate tendering processes can increase the cost of the project initially (Bakke, 2011), but a win-win scenario will save both parties money in the long run (Eshun et al., 2020).

> *(B2) Long-term financial predictability:* PPP contracts span over decades, usually between 20-30 years, but they can be even more extensive. This longevity enables the public actor to disperse cost over a longer period (Sanner et al., 2010). Folkestad & Lindén (2014) also categorize this as a positive if the partnerships remain relevant and

mutually beneficial. There is always a risk of contractual breaches or new user and technological needs. Preventive measures include continuous communication, rigorous planning, and a dynamic contract design. The disperse of cost generally allows for a faster commencement date. No major public investments are required in the early stages, enabling the construction phase to move on faster than it would otherwise (Sanner et al., 2010).

(B3) Circumvent maintenance backlog: The public sector struggles to keep up with infrastructure maintenance due to limited funds. The PPP contract circumvent this issue by including operations and maintenance in the long-term contract signed in the initial stages. The private actor is legally bound to maintain a pre-agreed standard. Moreover, this frees up resources and time for the public actor to focus on other urgent issues (Sanner et al., 2010).

(B4) Less bureaucracy: Sanner et al (2010) advocates that PPP will lead to less bureaucracy as public actors do not have micro-manage projects. Bakke (2011) on the other hand argues that PPP will lead to more bureaucracy as higher demands of legal and contracting expertise will be required. It appears that the processing is speed up, but whether there is more bureaucracy involved is unclear (KPMG, 2003).

(B5) Stimulate innovation: The competitive nature of the tendering process and the pressure of effectivization and cost minimizing is believed to stimulate innovative solutions (Sanner et al., 2010)

(B6) Risk allocation: A fair and strategic allocation of risk is essential in every PPP project. Every risk is carefully examined and placed with the party deemed best capable of handling said risk and consequentially both parties are allowed to play their strengths (Eshun et al., 2020). This best-play structure allows for maximal utilization of resources and promotes efficiency through clear areas of responsibility (Sanner et al., 2010).

(B7) Expertise and experience: The public sector does not always possess the relevant expertise and experience in all phases from planning to finalization of a project.

Tapping into private expertise in areas where it is lacking facilitates cost-effective measures and quality throughout the process (Sanner et al., 2010).

Briefly summarized, the three most significant aspects of PPP are: 1. Introduction of private expertise into public sectors. 2. Cost reduction, and access to private capital. 3. Efficient processing and acceleration of sustainable development. PPP is uniquely tailored for projects where there is a lack of expertise, lack of funding and a lack of progression/development. (Sanner et al., 2010).

Although there are plenty of benefits to PPP, it is equally important to address some of the potential fall pits.

(C1) Private funding: Private actors do not have the same accessibility to favorable loan terms. In cases where the private actor enters the private market to obtain funding, the interest may be significantly worse than that of the public counterpart. In the private market, the loaner and the loanee carries the risk. Whereas the risk of public loans is carried by the society (Sanner et al., 2010).

(C2) Bankruptcy: Dealing with private actors always involve the risk of bankruptcy. The public actor has no way to safeguard the project from this but must prepare preventive initiatives and formulate a backup plan if the event unfolds (Sanner et al., 2010).

(C3) Tendering: The literature has firmly established the excessive cost of tendering. From a public point of view, spending excessively of a limited monetary budget on a tendering process rather than the project itself can dissatisfy taxpayers, as it potentially can be interpreted as a waste of public money. Familiarity, experience and routines regarding PPP and the drawings of contracts offers a solution to eliminate parts of the excessive cost of tendering (Thomassen et al., 2016).

(C4) Undervaluation: During the tendering process, there is a running risk that private bidders undervalue their project to improve their selection chances. The idea of financial risk transfer from public to private sector operates as a preventive measure and renders undervaluation pointless as the actual cost will be higher than "estimated"

and the private actor ultimately takes the bill for efforts of undervaluation (Sanner et al., 2010)

(C5) Longevity: A average PPP contract lasts between 20-30 years. Financial and political predictability is created. Newly elected bodies of government cannot ignore or cancel legal contracts. Although predictability is a catalyst for stability, it also binds politics and funds. Possibly, making politics less dynamic (Sanner et al., 2010).

3.3.7 Different Types of Public-Private Partnerships

As 90% percent of the Norwegian energy production stems from public sector (Leithe, 2016), it offers an explenation to why PPP have not been tested out in the enrgy industry. It seems likely that public ownership must be retained, and PPP is capable of that GKRS, 2022). There are several types of PPP. Naturally, their popularity and usability vary. Hence, there is no point in broadly elaborating all of them. The different types vary in these factors: Design, Build/Rehabilitate, Finance, Maintain and Operate. Instead of slightly touch upon all of them, the emphasis will fall on the most common type in Norway, as that serves the larger purpose (GKRS, 2022).

The most common type is Build-Operate-Transfer (BOT), or other forms closely related to it. In BOT, the private actor builds the project, then operates it for the agreed timeframe and then transfer it back to public control (The World Bank, 2022). The content of the contract dictates financial agreements in relation to how much of the profit each party gets and who pays for what. The contract also establishes whether the public actor pays for the private actor through a pre-agreed annual fee or whether the profit from the users is used as the private actor's reward. Other variations of BOT are Build-Own-Operate-Transfer (BOOT) and Build-Transfer-Operate (BTO). BOOT always includes private finances, whereas it is not always the case in BOT and BTO (The World Bank 2022).

There are other variations of PPP that do not include transfer or new constructions, but these types are left out deliberately. The only other type of PPP worth mentioning is PPP as a joint venture company. In this scenario a company is established specifically for the project and both parties take on a joint ownership. This imply that finances and operations are shared. Both parties still bring their capabilities, just like in any BOT project. Emphasizing that approximately 90% of the energy production in Norway comes from the public sector (Leithe, 2016), it is intrinsic to focus on BOT and other types that promote public ownership in the long run, as it is less politically disruptive.

3.3.8 Public-Private Partnerships in Norway

PPP is a relatively new model in Norway and has been sparsely utilized. Initially it has mostly been chosen for road construction (Sanner et al., 2010), and the first instance of PPP in Norway, was indeed for road construction (E39 Øysand – Thamshamn) back in 1999 (Greve, 2003). The private actor financed the project; however, the public actor reimbursed the private actor through annual fees and tolls. As shown in the table, annuity is the preferred payment method in the Norwegian context.

Project	Finance	Balance sheet	Payment profile	Performance measures	Seperate or single payment stream.
Aquarama	Shared	Shared	Annuity	Access/quality	N / A
Arendal Brannstasjon	Private	Private	Annuity	Regular leasing contract	Finacial Lease
Asak skole	Private	Private	Annuity	Access/quality	seperate
Bogstad skole	Private	Private	Annuity		
Bråset bo- og omsorgssenter	Private	Private	Annuity		
Campus Grimstad	Private	Private	Annuity	None	Seperate
E18 Grimstad - Kristiansand	Private	Private	Annuity	Access/quality/road safety	Single
E39 Klett - Bårdshaug	Private	Private	de-escelating	Access/quality/road safety	Single
E39 Lyngdal - Flekkefjord	Private	Private	Annuity	Access/quality/road safety	Single
Eidsvoll tinghus	Private	Private	Annuity		Finacial Lease
Florø Politihus					
Follo politihus	Private	Private	Annuity	Regular leasing contract	Finacial Lease
Follo tinghus	Private	Private	Annuity		Finacial Lease
Gjestad sykehjem og Gystadmyr bo-	Private	Private			
Gjøvik Tinghus	Private	Private	Annuity		Finacial Lease
Glåmdal tingrett	Private	Private	Annuity		Finacial Lease
Hamar Politihus	Private	Private	Annuity	Regular leasing contract	
Haugaland tingrett	Private	Private	Annuity		Finacial Lease
Hønefoss tinghus	Private	Private	Annuity		Finacial Lease
Høybråten videregående skole	Private		Annuity	Access/quality/functional	Seperate
IKA Kongsberg	Private	Public	Annuity	Access/quality	Seperate
Jæren tingrett	Private	Private	Annuity		Finacial Lease
Larvik brannstasjon	Private	Private	Annuity	Regular leasing contract	Finacial Lease
Midtåsen sykehjem					
Nordre Vestfold tingrett	Private	Private	Annuity		Finacial Lease
Nødetatene i Lunner og Gran	Private	Private	Annuity	Access/quality	Separate
Persbråten videregående skole	Private		Annuity	Access/quality/functional	Separate
Politiets data- og materielltjeneste	Private	Private	Annuity	Access/quality	Separate
Politihuset i Trondheim	Private	Private	Annuity	Regular leasing contract	
Politihuset Østfold	Private	Private	Annuity	Access	Separate
Søreide ungdomsskole	Private	Private	Annuity		Seperate

Table 1: Finance of Norwegian PPPs (Solheim-Kile et al., 2014)

The contract length was between 25-30 years, which appears to be the approximately the standard length. This means the first ever PPP in Norway is still active almost two-and-a-half decades after its commencement (TerraMar, 2001). As it originally was a pilot project, it can be seen as a door opener for future projects, as three new road constructions projects chose PPP as their project model in 2001 (Solheim-Kile et al., 2014).

Project	Sector	Project Cost (million EUR)	Contract period	Construction completed
Aquarama	Recreation	120	60+20	2013
Arendal Brannstasjon	Fire department	18	25+10	2013
Asak skole	Education	14	25+15	2011
Bogstad skole	Education		25	2005
Bråset bo- og omsorgssenter	Healthcare	37	20+10+10 / terminated	2004
Campus Grimstad	Education	53	30	2010
E18 Grimstad - Kristiansand	Transportation	425	25	2009
E39 Klett - Bårdshaug	Transportation	184	25	2005
E39 Lyngdal - Flekkefjord	Transportation	168	25	2006
Eidsvoll tinghus	Court	0,6 p.a.	20	2004
Florø Politihus	Police	9		2008
Follo politihus	Police	13	20	2008
Follo tinghus	Court	5	20	2006
Gjestad sykehjem og Gystadmyr bo-	Healthcare	20	20+5+5	2002
Gjøvik Tinghus	Court	7	20	2008
Glåmdal tingrett	Court	0,3 p.a.	20	2006
Hamar Politihus	Police	15	20+5+5	2009
Haugaland tingrett	Court	0,7 p.a.	20	2008
Hønefoss tinghus	Court	6	20	2007
Høybråten videregående skole	Education	23	25	2008
IKA Kongsberg	Archive	10	25	2014
Jæren tingrett	Court	0,6 p.a.	20	2006
Larvik brannstasjon	Fire department	5	25 / terminated	2000
Midtåsen sykehjem	Healthcare	23	20+10	2004
Nordre Vestfold tingrett	Court	0,4 p.a.	20	2005
Nødetatene i Lunner og Gran	Police	12	25+10 / 15+10	2013
Persbråten videregående skole	Education	31	25	2007
Politiets data- og materielltjeneste	Police	12	30+10	2010
Politihuset i Trondheim	Police	26	20+5+5	2004
Politihuset Østfold	Police	21	15	2014
Søreide ungdomsskole	Education	25	25	2014

Table 2: Project scope of PPPs in Norway (Solheim-Kile et al., 2014)

Positive experiences with PPP on road construction projects allowed new sectors to explore PPP. Referring to the table, PPP has difused into the contruction of public buildings like Police Stations and Schools (Solheim-Kile, 2014). Xue etal. (2021) argues that it can positively benefit the energy industry as well. This conclude the section on PPP.

4. Framework

4.1 PPP in Addressing Market Formation in TIS

Hypothetically, we want to examine PPP's ability to address and possibly strengthen the inducement mechanisms and weaken or remove the blocking mechanisms in the focal TIS, laid out by Bergek et al. (2008). The focal TIS is the Norwegian solar PV industry with a focus on the market, and the technological scope is narrowed down to solar panels. The application scope is narrowed down to prosumer activities, rooftop installations and large-scale solar parks. We have already established that the prosumers operate as a key actor (Inderberg et al., 2018). Moreover, NVE is the regulatory organ in the market (Inderberg et al., 2020), and it is also established that companies like Statkraft and Scatec have interests in the solar PV market (Chasanidou et al., 2021). These are some of the actors directly involved in the PV industry network in Norway. The institutional framework is dictated by governmental body of NVE. Any legitimization goes via them. By analyzing the interconnectedness and dynamics of the networks structure, we can address how PPP might overcome any structural issues. Further, the forementioned benefits of PPP could potentially address and strengthen the market formation function (Bergek et al., 2008).

PPP's ability to establish platforms for knowledge and capability sharing directly addresses the function of knowledge development and diffusion (Åm & Heiberg, 2014). The same quality of the TIS can potentially also influence the direction of search, as the involved partnership requires aligned effort and expectation. As Sanner et al. (2010)) pointed out, PPP stimulates innovation. This quality together with the quality of logically allocating risk between actors addresse the entrepreneurial experimentation function. The risk allocation can potentially limit the uncertainty and give room for novel experimentation in order to be cost efficient. By definition, PPP is a partnership between a public and a private actor. Aligning these sectors, could potentially increase legitimacy from the get-go, as the public actor is closely tied to the institutional framework. A PPP gives access to private capital (KMPG, 2003), and can hence aid in the market formation and circumvent the valley of death, by attracting capital in the early stages. Resource mobilization can potentially be addressed by the partnership itself. PPP brings the expertise from both sectors (human capital), and grant access to private and public funding, hence effectively mobilizing and moving resources (Eshun et al., 2020). The development of positive externalities can potentially be addressed by the overall contribution to the industry by the PPP. Ideally, several PPPs can help the industry grow and include more and more entrants, which consequently strengthen the overall system with new ideas, resources, and knowledge.

What occurs within a TIS is not merely a product of the internal dynamics, the external forces also shape the internal dynamics. An overview of the blocking dynamics created by the external environment is therefore crucial. The mechanisms materialize in different ways: 1. The advocating voices of a new technology might lack the organizational strength to effectively legitimize it, and hence be dealt an institutional blow. Consequently, this can potentially hamper the market and institutional development. 2. Vague and underdeveloped customer capabilities can potentially lead to poor articulation of needs, stunted market formation, and misdirect the direction of research and the entrepreneurial experimentation. 3. Weak connectivity in the actor network hampers the support of new technologies and worst case, led to a "lock-in" effect, which deters suppliers and customers away from the new TIS. These mechanisms can affect the development in several ways at different stages, rendering the achievement of higher functionality difficult (Bergek et al., 2008).

The formative phase is heavily affected by both inducement and blocking mechanisms. The inducement mechanisms include but are not limited to the belief in growth potential and governmental R&D polices. These are examples of positive mechanisms. The blocking mechanisms include but are not limited to lack of standardization, unaware customers, and vague need articulation. These are examples of negative mechanisms. The blocking mechanisms can potentially possess a snowball effect and influence several functions within the TIS. Harm minimizing of these mechanisms ought to be high up on the list of the policymakers in order to facilitate the TIS's development.

4.2 PPP in Addressing Upscaling Death Valley

It has been established that the solar PV market in Norway is underdeveloped compared to countries with similar sun irradiation levels (Inderberg, 2018). This is partly because the economic incentives and the regulatory frameworks do not promote the expansion of solar PV (Xue et al., 2021) A major reason for this is the access and abundance of cheap hydro energy, which dominates the Norwegian energy industry (Xue et al., 2021). Hence, the Norwegian solar PV industry become subject to weak institutional framework, stunted policies, minimal economic incentives, and weak organization among actors (Xue et al.,2021). The thesis hypothesizes that the implementation of the PPP model can organize actors in the pursuit of a common goal and consequently strengthen the market organization. Moreover, a joint public and private effort might increase the legitimacy of the market and influence the institutional framework and unlock new capital and economic incentives. A PPP could potentially signal a belief in the market which might have a cascading effect. Increased attention to the market may alter the policy approach. Eventually, over time and through several PPPs, the market might overcome the blocking mechanisms and accelerate the diffusion of the Norwegian solar PV market.

5. Methodology

The methodology section will extensively describe and offer a rationale for the chosen methodology utilized in the thesis. The section constitutes of four parts: Research design, Data Sampling, Analytical Framework, and Reflections & ethics. The first two parts will thoroughly explain how the research design is constructed plus how and why the data was collected. The two latter parts, outlines the analytical framework, followed by reflections and ethics of the chosen methodology.

5.1 Research Design and Analysis

The thesis applies case study as a method as it can offer rich context. For the analysis, the thesis first applies TIS analysis to identify market barriers for solar PV development in Norway. It then applies specific case study to investigate how PPP can play a role to accelerate solar PV diffusion in Norway. The inclusion of a case study is justified by its ability to provide rich context and elaborative information. The case study approach offers an in-depth investigation into a specific case and captures nuances and the complexity of the broader picture. It also provides deeper understanding of how events unfold in the real world and has the ability to assess the situation context.

The choice of quantitative analysis is justified by the necessity to elaborate in depth knowledge of why certain events/ partnerships formalized, which is difficulty to be achieved through quantitative approach. The rationale lies in the sense that regulations and policies affecting the market tend to be of a qualitative nature and hence the qualitative approach aligns itself with the chosen topic of interest. The available PPP articles possesses the same qualities which further emphasizes the need of a qualitative approach. Additionally, a qualitative approach ability to capture complex and inter-connected pieces of information added to its weight. This type of data grants ample in-depth information, facilitating a platform to conduct elaborate qualitative analyses.

To enable the rich analysis, the thesis adopts multiple data sources include, both second hand and primary data. The secondary data is collected through extensive document analysis in the form of academic journal articles, governmental reports, documents, legal documents and webpages, and news articles, which constitute the assessed second-hand data. The search key

words consist of the following words “solar power”, “PV”, “barriers”, “obstacles”, “PV in Norway”, “PPP”, “PPP in Norway”, and “Renewable energy”.
The primary data include statistical data from international and national organizations, as well as obtained from semi-structured interviews and frequent conversations with an informant from the Ullevaal Stadion solar PV project. The semi-structured interview method is designed to include open-ended questions and allows for a natural flow of information in the interview process. Additionally, it enables the interview subject to provide context and complex information. Both factors align with the qualitative approach of choice. The rationale for this model is its flexibility, the interviewer is not bound to the planned questions and can hence follow up on interesting information and manage time more efficiently. Secondly, the open structure allows the informant to address the relevance and significance of the conveyed information. Additionally, it is the ideal interview method for case studies.

The rich data allows the researcher to go deeper into an applicable case and examine the practices rather than relying on theories. The Ullevaal Stadion case was chosen for two reasons. Firstly, it grants inside information to solar PV project in Norway, enabling the researcher to match theory with practice. Secondly, the researchers’ part-time job in NFF presents a unique proximity to the project and constant access to information. This allows for up-to-date information and unique access to informants.

5.2 Data Sampling

The sampling is centered around quality rather than quantity. Which explains why there is only one informant. Despite the low number, the on informant was able to fulfill the research needs. Continuous communication with one informant serves the research interests to a higher degree than what multiple informants with limited communication. The research interest revolves around the market barriers, and thorough understanding of one case was prioritized over limited insight into several cases. Hence, the choice to focus on the one case of Ullevaal Stadion.

To not reveal the informant’s identity and keep anonymity, the exact position of the informant will not be divulged, however the table below reveal some information about the informant to provide the reader with a context of where the information stems, but not enough to make it traceable to the informant.

Informant:
Leader position, Private firm involved in a solar PV project

Table 3: Informant

The collected data originates from interviews, and continuous communication with the informant. The interviews were made in person at the project site, and the researchers' proximity to the project enabled insight into the project over time and made it possible to track the progress and challenges throughout the process. The same proximity provided frequent updates on the project through less formal channels in the form of conversations regarding the project.

5.2.1 Trustworthiness of Sampling

The limited number of informants can lead to biased information, however there is a trust built up over time between the researcher and the informant that makes up for that. The inclusion of informants of actors in other sectors could potentially broaden the understanding and complemented the case study, however the informant possessed information from other sector obtained via the projects communication platforms, hence reducing the need for external sources. In sum however, several informants may complement the case study and render the data more trustworthy.

5.3 Applying TIS Analysis

For the analysis, the chosen method was a TIS structural analysis with an emphasis on the market formation function. The analysis aims to identify the market barriers preventing solar PV from diffusing in Norway. The thesis utilized an accommodated version of the analytical framework proposed by Bergek et al. (2008) with more attention to certain steps, but the whole six-step process will be presented in detail below.

Step 1- Defining TIS in focus

The analyst must make a range of choices. 1. The first choice is the focus of the study whether they want to focus on a specific products like solar panels, or a broader knowledge field like renewable energy technology. 2. The second choice is regarding the scope of study. The analyst must choose between depth and breadth. Additionally, the scope encompasses what applications you examine, the analysst can choose to see it in a specific context or in several/all contexts. 3. The third choice is the geographical focus. Normally, TIS is seen in a global context as technological diffusion has no geographical boundaries. However, if there is a specific reason to narrow the focus for a specific reason, it must be thoroughly explained, and the global context must be taken into consideration. 4. Flexibility and change make up the fourth choice. As you dive into research, you might learn more and an expansion of your focus might be required to encapsulate the necessary information. 5. The fifth and final choice is the type of TIS. TIS is not exclusively for established systems, but can be used to examine emerging systems, or systems that merely exist as an idea (Bergek et al., 2008).

Step 2 – Identifying structural components of TIS

The second step revolves around applying the TIS concept and assessing the structure in the chosen system.

Identifying the actors: Initially, the analyst aims to identify and place key actors in the system. The range of actors include but are not limited to businesses throughout the entire value chain, academic institutions, researchers, governmental organizations, non-profit organizations, investors, and other actors contributing to establish the industry standard. These actors can be discovered in several ways, including examining bibliometrics, interviews, patent analysis, etc.

Mapping the Networks: The next task constitutes the mapping of the network within the system. It is crucial to capture both the formal and the informal ties. The function of the networks ranges from standardization of technology to establishing relationships between actors, for example between producers and consumers. The ideal way to unearth network relations is through consulting an industry expert, review collaborative actions like co-patents and co-publications, or other forms of collaboration.

Recognizing the Institutions: The last task is concerned with identifying the formative institutions in the system. The institutions encompass the legal framework, regulations, the culture, norms, etc. The institutions operate as a flood gate and determines the growth and integration of a new technology, by either facilitating for change or status quo. The absence of institutions can be equally influential, as it hampers the standardization process in the specific market. The identification process of structural components is naturally complex and constant subject to change (Bergek et al., 2008).

Step 3 – Mapping the functional pattern of the TIS:

The third step emphasizes the functional aspect of the TIS. The aim is to understand the TIS functions in the terms of specific key processes, and not to make normative judgements about the performance of said function, which comes later (Bergek et al., 2008).

F1 - Knowledge development and diffusion: The first out of seven key functions examine the breadth and depth of the current knowledge base, how it has developed over time, how the knowledge diffuses and to what extend it is combined & used. The knowledge pool includes technological knowledge, market knowledge, scientific knowledge, etc., and is derived from R&D, imitation, experimentation & learning, etc. (Bergek et al., 2008).

F2 - Influence on the direction of search: This function is about assessing the mechanisms and forces which influence the direction of the TIS's search for new technology, knowledge, markets, applications, and business models. The search is determined by expectations, visions, regulations, demographic trends, apparent demands, technical bottlenecks, and the perceived relevance of certain knowledge (Bergek et al., 2008).

F3 - Entrepreneurial experimentation: TISs is normally characterized by uncertainty in regard to technologies, applications, and markets. The best way to reduce uncertainty is through entrepreneurial experimentation, as it provides answers and platforms for learning. Post-experiment, analysts much assess the diversity of the experiments and retain information about applications, technologies, and new entrants (Bergek et al., 2008).

F4 - Market formation: This function looks at the market formation. Initially, depending on circumstances, there might not even exist a market. The assessment is concerned with the nurturing and growth of a specific market. The market goes through three stages, the early stage of "nursing markets", which is a fragile stage of the development with few actors. Then it grows into "bridging market" and welcome in more actors. Ultimately, normally decades after the initial formation, it grows into "mature markets", also known as the mass market. This is where the number of actors and volume of production peak (Bergek et al., 2008).

F5 - Legitimation: A TIS's legitimacy is closely tied to the acceptance and alignment of the current institutions. The relevant institutions dictate the availability and mobilization of resources, the industry direction, and the state of the market. Legitimacy can be pursued in three different ways: 1. Conformity to current institutions. 2. Manipulation of current institutions or 3. Implementing an entirely new institutional framework (Bergek et al., 2008).

F6 - Resource mobilization: Mobilizing resources is a key aspect in the development of a TIS. Human and financial capital are the most crucial resources, but not the only ones in the TIS. The mobilization of resources can be tracked through an analysis of available capital and the changes in capital volume. Additionally, it can be analyzed through the quality and quantity of human capital, and the development of additional complementary resources (Bergek et al., 2008).

F7 - Development of positive externalities: The final function is the development of positive externalities. This is where positive effects of a system spreads to participating parties. Briefly explained, when a new entrant enters the system, they have a chance of benefiting the growth of the entire system, which significantly benefits the incumbents of the system. The new entrant can serve several functions like reducing uncertainties, increase legitimacy and add political and financial influence.

Bear in mind, that these functions are not separated, but operate in an interconnectedness. Positive externalities and the benefits it brings, emerge with the entrance of new actors. This becomes extra evident with geographical proximity which enables an easy sharing process of resources, ideas, and knowledge. A rising tide lifts all boats. These external benefits enrich the overall TIS experience (Bergek et al., 2008). Further Bergek et al., (2008) addresses that the strength or the weakness in a function does not necessarily indicate a problem nor an advantage, and hence does not determine whether a function is working well or not.

Step 4 – Assessing the functionality of the TIS and setting process goals:

The fourth step is about examining the functionality of the TIS and establishing the process goals. The quality of the functions does not reveal the relative quality of the function. This constitutes a difficult challenge for the analysts and the policymakers. Hence, a deeper examination of the extent of the research and the shared learning among the actors is required. Two methods have been identified to aid this process, namely: *The phase of development of the TIS* and *Comparisons between TISs*. For full effect, both should be conducted.

Developmental Phase: Referring to the forementioned market formation, the functionality in the different stages can vary significantly from the formative stage to the more mature stages. The analysts are tasked with determining whether the functionality aligns with the needs of the current stage or the next one. This analysis helps determining if it is ideal to continue in the same direction. The functionality is analyzed in relation to the needs of each phase. The initial formative stage is plagued by uncertainty. Both in terms of the technology and the market. The formative stage is the time for extensive experimentation. Ideally, in this phase, the influence on the direction of research and the mobilization of resources opens up and explore technological options. If the system catches the eye of an actor in a competing system, a high degree of legitimacy can ward off the consequences of new actors and technologies which advocates institutional change. Extensive collaboration among actors in the system is crucial for knowledge development, especially in relation to producers and consumers. At a certain point, the TIS goes from a nurturing market to the growth phase where it becomes more self-sustaining. When the system reaches this stage, the focus turns to expanding the system and diffusion of the technology. Hence an establishment of bridging markets and, potentially mass markets. The development dictates how functionality is measured, and it is pivotal to acknowledge that TISs are unique and do not follow the same development, hence there can never be a policy amendment that fits every TIS.

Comparisons Between TISs: Comparing the focal TIS with other TISs in different regions is a useful tool to improve the policymakers’ understanding. The analyze of other TISs and their performance offers insight and what to expect in terms of the focal system’s development. Moreover, it helps identifying the key functions. These two methods present a potential map to make preliminary decisions in regard to the functionality of the focal TIS. This offers an idea of how the TIS ought to evolve in order to achieve higher functionality, establishing process goals. Having clear goals aid policymakers in their job and simplifies the process of analyzing the efficiency of a policy. However, the uncertainty of the early stages of a TIS may complicate and shroud the process of defining the final goals (Bergek et al., 2008). Moreover, successful policies in one TIS do not necessitates success in another TIS with the same policy implementations.

Step 5 – Identifying inducement and blocking mechanisms:

The fifth step deals with identifying advantageous and disadvantageous factors which encourage or hamper development of the focal TIS. Niche and novel industries/technologies tend to lag compared to the established ones. The current climate favor incumbents and established systems. Formative systems tend to struggle with weak functional dynamics and slow development. The stunted development can potentially be a result from internal structural weaknesses and from external forces in the environment which the focal TIS operates within.

Step 6 – Specify key policies:

The sixth is connected to the identification of the specific key policy issues in relation to the blocking and inducement mechanisms which influences the TIS's development of a functional pattern.

The policy issues originate in the step which identify process goals and aims to highlight poor functionality in the TIS and promote inducement mechanisms and remove as many blocking mechanisms as possible. This step is concerned with system failures, rather than market failures. Hence, step 6 strives to unearth functional weaknesses rather than structural problems within the TISs. Through an analyze of the functional weakness in TISs, it is possible to identify the key blocking mechanisms, which enables the analyst to discover the specification of relevant policy issues that can assist in the improvement of the functionality of these TISs (Bergek et al., 2008).

5.4 Reflections and Ethics

This subsection will present my personal reflections on the data collection and address the ethics of the research.

5.4.1 Reflections

In retrospect, relying on one informant, might affect the validity of the sampled data. No matter the quality of one informant, there may be other perspectives worth exploring which add to the thesis value. Additionally, the prospect of me being biased in the face of my employer's project could potentially reduce the credibility of the collected data.

However, measures were taken to combat this, as I deliberately questioned and challenged the informant through the design of my interview question. The questions aimed to obtain both positive and negative information The trust between me and the informant enabled honest conversation where complex and sometimes challenging topics were brought up.

In conclusion, there are challenges and benefits to my approach, but navigated diligently, it can avoid the negatives and emphasis the positives.

5.4.2 Research Ethics

The conducted research complies with the set standards of the University of Oslo and the Norwegian National Research Ethics Committee. The research application was also processed in the right channels and gained approval. The collected data was stored according to ethical standards and inaccessible via a lock-mechanism. Throughout the process, I kept a research journal, enabling me to get the objective information down directly after the interviews and maintain an objective approach. I acknowledge that my values and perceptions can affect the way I perceive the data and the journal figured as a tool to prevent the influence of my own biases.

The informant was informed about their right to withdraw their consent at any point. Additionally, the informant was notified about the right to refuse recordings, and the right to alter or withdraw any given statements. Lastly, identity of the informant is kept confidential and anonymous to maintain ethical integrity and not put any extra strain on the informant.

6. Barriers for Solar PV Development

In this section, we will conduct a TIS structural analysis to identify the key actors, networks, and institutions, so that to identify the main barriers for market formation for Norwegian solar PV development. It will pay particular attention to the market formation, one of TIS's functions, as it is perceived as one of the identified key barriers for solar PV diffusion in Norway. As specified in the study's interests, which aims to understand the diffusion of solar PV instead of focusing on the industry development in the country per se.

6.1 TIS Structural analysis: Actors, Networks, and Institutions

There are several key barriers linked to the market formation of solar PV in Norway. Hence the narrow focal point on the market formation, the scope is narrowed down to capture the essential aspect to the solar PV diffusion in Norway. We operate with a regional scope, where the Norwegian solar PV market is the focal point. The application scope is narrowed down to the diffusion of prosumer activities, rooftop installations and large-scale solar parks. The technological scope is limited to solar panels, as it is the technology involved in most solar PV projects.

6.1.1 Actors

In our analysis we have identified the key actors in the three different categories presented by Xue et al., (2021) in the literature-review, namely public, private and people.

The Public actors has been identified as NVE, the regulatory organ in charge of policymaking and legal frameworks (Henden & Ericson, 2019). Public support institutions, especially Enova which offer financial incentives to PV development (Enova, 2022). Political decision-makers like Regjeringen and Kommunal-og-Distriktsdepartementet, responsible for enacting said policies, offer juridical guidance, and in instances, financial support (Olje- og energidepartementet, 2023). Furthermore, state owned companies like Statkraft are responsible for 90% of the energy production in the country (Chasanidou et al., 2021), effectively ensuring public control of the energy production. The political party SV have promoted the idea to establish a state-owned solar PV company to accelerate the diffusion by the process of renting rooftop areas from public budlings, private companies and apartment complexes to increase the capacity (NRK, 2023), however, no such company exist, nor are there any concrete plans for it.

The private sector is constituted by the Norwegian upstream producers of raw material, especially the cultivation of silicon. The large downstream companies like Scatec and Susoltech (Chasanidou et al., 2021), together with various smaller downstream companies, such as Over Easy, and Solgrid, who all are responsible for deployment of solar PV in Norway. Moreover, you find economic institutions, energy suppliers, consulting firms and management companies as participating stakeholders.

The people, the consumers and their needs play a crucial role in the system as well. Additionally, the prosumers, who are in frequent contact with the downstream industry contribute to further diffusion of the solar PV and is identified as key customers in the market (Chasanidou et al., 2021). However, Xue et al. (2021) points out that despite being in the same system, the communication among all actors is poor.

6.1.2 Institutions

The institutions in Norway are not geared towards an expansion of PV, as can be seen by the lack of supporting institutions and policies. The government offer limited financial incentives to diffuse solar PV. There are some smaller schemes in play like subsidies for initial cost by Enova (public support scheme) which cover up to 32 000 Norwegian kroners (NOK) for private household installation of solar PV. When the price is expected to range between 100, 000-300, 000NOK, it becomes apparent that the initial cost for customers is a barrier (Enova, 20220). Moreover, NVE do not have any form for financial investment support schemes for private companies in the solar PV industry. Their toolkit consists of "plusskundeordning", which allows prosumers to sell excess energy production back to the grid via their energy suppliers. They can feed 100KWh into the grid free of charge per year. Additionally, additionally they do not pay grid utilization fees and can hence make a small profit from their solar PV installation. Neither are there any requirements for concession for smaller solar PV installations producing less than 1gigawatt-hour (GWh) annually (NVE, 2015a). The second tool is "Elsertifikat", which promotes green energy initiatives like hydro, solar, wind and bio energy. The green energy producers are awarded these certificates and receive on per megawatt-hour (MWh) they produce. It generates profit for the producers via the certificate market, where prices are tied to the demand. The buyers consist of energy suppliers and certain customers who are legally bound to buy them. Hence, the green energy production is partly financed through the consumers, as the suppliers disperse and include the cost of the certificates into the electricity bill. The third tool is "Opprinnelsesgaranti" which is a label scheme to assure the consumer of the sustainable origin of the consumed energy. 1 MWh equals one guarantee label (Henden & Ericson, 2019).

Norway have not defined any specific goals regarding the implementation of solar PV, and the policy framework suffer as a consequence (Holm, 2016). The most prominent form of regulation NVE has, is the distribution and granting of concessions. Any solar PV installation primarily feeding into the grid must obtain a concession in order to establish and operate said installation. The exception is for low voltage installations (less than 1KVh). The concession process can be tedious and time-consuming due to the sheer volume of applications, in combination with NVE's limited resources, and the thoroughness of the application process (NVE, 2022).

Furthermore, the grid owners are required by law (Tilknytningsplikten) to grant energy producers access to the grid. There are, however, possible for grid owners to apply for exemption if the producer project is not societally or operationally rational NVE, 2015b). Moreover, the Norwegian power grid has limited capacity and PV companies report a feeling of neglection in this process, often leading to projects being postponed or limited in scale (Riisøen, 2023).

In sum, the institution has insufficient schemes to legitimize the market for potential entrants to the system. NVE offer a limited toolkit to encourage the diffusion of solar PV in Norway (Chasanidou et al., 2021), but solely addressing that as the key obstacle would be an oversimplification of the weak market formation. However, it is evident that the weak institutional framework and financial incentives, together with the high initial cost pose a barrier to the diffusion of solar PV in Norway. The absence of consistent and favorable regulations and policies consequently weakens the legitimacy of the Norwegian solar PV market (Chasanidou et al., 2021).

Norway's abundance of rivers and running water have defined the energy production in the country for decades, and the percentage of hydropower's contribution to the total energy production in 2021 was 91.5% (Aanensen, 2022). In the same year, solar energy accounted for merely 0.15% of the 157,1 terawatt-hour (TWh) produced that year (NTB, 2022). Consequently, Norway do not have a strong incentive to pursue solar PV, as they already have a viable sustainable energy production option established. Furthermore, reports indicate high satisfaction with the current electricity system, and 95% of Norwegians have a positive perception of hydropower (Xue et al., 2021). In combination, viable options and satisfaction with the current system stunt the market development. As the table below shows, the production of hydropower (0.4 NOK/KWh) and land-based wind power (0.4 NOK/KWh) generates a significantly lower electricity price compared to solar PV, hence minimizing the financial incentive to pursue solar PV (NVE, 2023).

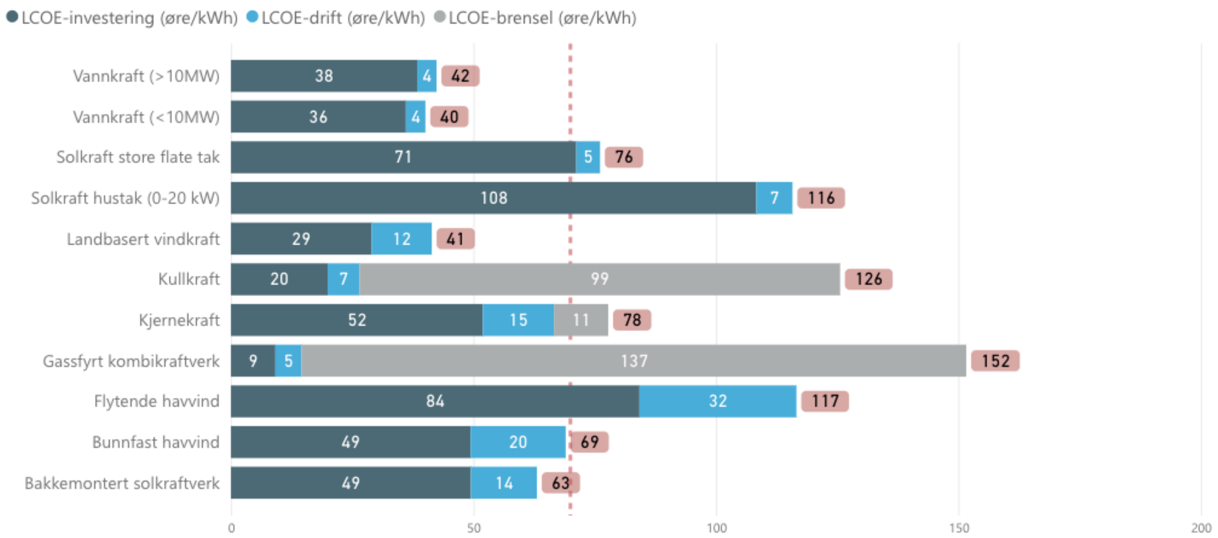

Figure 5: The levelized cost of electricity (NVE)

Subsequently, the weak regulatory & policy framework, plus the satisfaction with the current system, deter investment, as these barriers create high uncertainty and risk in potential projects, and hence limit available investment capital pouring into the market.

6.1.3 Network

The Norwegian solar PV industry have an established communication platform in the form of a cluster, "Solenergiklyngen". It is an industry association constituted of employees in the solar PV and energy system industries. Additionally, over 150 energy industry firms and cross-industrial partner firms are affiliated with the cluster (Solenergiklyngen, 2023). It is part of the cluster program financed by Innovasjon Norge. The aim of the cluster is to continuously innovate, exchange knowledge, develop new projects and create a meeting place for the industry (Solenergiklyngen, 2023). Effective communication between various actors like energy companies, consumers, financial institutions, skilled workers, and more is detrimental to the diffusion of solar PV (Chasanidou et al., 2021). However, Xue et al. (2021) report of an insufficient level of communication among various stakeholders. The consequences of ineffective communication can in worst case scenario lead to project failures. Hence, the lack of communication between stakeholders can be seen as a market formation barrier.

Furthermore, limited awareness among consumers and potential prosumers about the positive effects of installing solar PV is another identified barrier. However, the Norwegian society is accepting of the industry, and a survey by Kantar revealed that 89% of the population positively viewed solar PV as an energy source. Despite the public acceptance, the lack of awareness and effective communication about costs and availability limits the attention to solar PV's potential role in the future energy portfolio. Moreover, solar PV receives less political and media attention compared to other sources of renewable energy, which consequently further exacerbates the awareness and hence the legitimacy (Chasanidou et al., 2021).

Pilot projects is key to expanding the knowledge pool and better understand the dynamics of solar PV in the Norwegian context. Further development of knowledge regarding performance, project costs and gains from potential projects can potentially promote wider diffusion as it may eliminates some of the uncertainty in the market (Xue et al., 2021). Solgrid is currently conducting a large-scale pilot project in Stor-Elvdal municipality, where they were awarded a concession for the first ground installed solar park. The project, named "*Furuseth Solkraftverk"* might help shed light on the feasibility of large-scale solar parks in Norway (Solgrid, 2023). Unfortunately, there is a lack of pilot projects to learn from, which constitutes a barrier for the market diffusion (Xue et al., 2021).

6.2 Summary of Identified Market Barriers

The analysis has identified the barriers to be 1. High competition from hydropower. 2. Discouraging policies and regulation. 3. High initial cost. 4. Limited access to investment capital. 5. Uncertainty related to risk. 6. A lack of pilot projects, 7. Limited communication between stakeholders and actors 8. A lack of incentives and subsidies 9. Limited awareness. 10. Limited grid capacity. In section *8. Discussion*, we will propose potential solutions to overcome the identified barriers.

7. Case Study – Ullevaal Stadion

In our case study, we conducted interviews with an informant heavily involved with a solar PV project at Ullevaal Stadion. For those unfamiliar with Ullevaal Stadion, it is the national arena for the women's and men's national football teams. The stadium is owned by the Norwegian Football Federation (NFF), but is managed by their daughter company Ullevaal Eiendom AS, which is responsible for managing the facilities. Ullevaal Eiendom is a private company, whereas NFF is semi-public.

NFF aspires to be a beacon a more sustainable football industry and hence decided to utilize their enormous roofing of 14, 000 square meters (m^2) to install solar panels. The utilized area will be closer to 2000 m^2 and produce roughly 222, 000 KWh annually. As the owner of the national arena, NFF leases out spaces to offices, stores and other tenants. These tenants will be the receivers of the generated power and will hence receive a mix of energy from the planned solar PV project and the original energy supplier Elvia. NFF has engaged VENI Metering to measure the power output, buy it, and distribute and re-sell it to the tenants. There are no plans of sending the power into the grid, and the tenants will receive the power directly from the solar panels own integrated systems.

Compared to other projects, like the Furuseth Solkraftverk, which will have an annual production of 6.4 GWh, it is a rather smaller project (Solgrid, 2023). However, if you compared it to other installations for internal use, where the average installation on house rooftops generates between 650-1000 KWh per year, it then appears like a rather large installation (NVE, 2019).

The informant reviled that they got inspiration to install solar panels from a similar pilot project at Skagerak Arena, where the Norwegian top tier football club Odds Ballklubb, rents out its roof to Skagerak Kraft. That project scale is twice the size and covers 4300 m^2. The annual production capacity is 660 000 KWh (Skagerak Kraft, 2021). Similarly to Ullevaal Stadion, there is no feed-in to the grid. The installation at Skagerek Arena has its own micro grid, and storage battery. The energy usage tenfold on match days, and as the men's first and second team, and the women's team plays their matches there, the access to battery storage is vital. The aim of the project is to prove solar PV as a feasible option and reduce the stress on the power grid. The project functioned as a template for the planned installation at Ullevaal Stadion.

7.1 Process

Initially, the process started out with an inspection of the property, followed up by a project application to the local government. Due to its size and purposes, it did not require a concession from NVE. However, the project application process was described as tedious by the informant, and they engage an external firm, Avery, to assist with the application process. Once the application was completed and accepted, Ullevaal Eiendom AS engaged the Norwegian solar PV firm Over Easy to deliver the solar panels. Over Easy utilize a slightly different design than other firms, where the panels are installed vertically, and hence enable it to be combined with other green initiatives like green roofing. Furthermore, the panels are mobile and can easily be rearranged, which allows for experimentation regarding positioning to maximize capture. The theory is that the sun’s position is relatively low throughout long periods of the year, and the informant said they theorized this design would take advantage of the sun’s positioning.

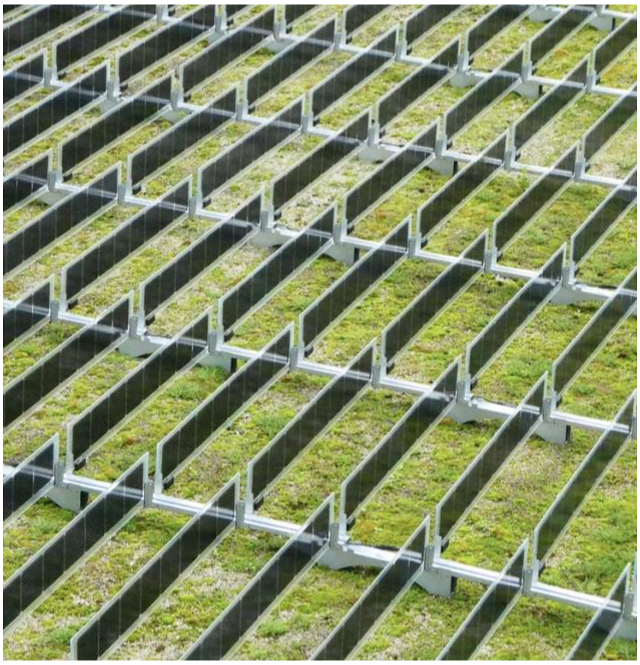

Figure 6: Green Roof Solar (Over Easy)

The installation will be conducted by Fusen, companied by the construction manager, the property manager and sport manager. The project is scheduled to be finalized spring 2024.

7.2 Partnerships, Economy, and Incentives

Installations of this scale necessitates efficient communication among actors, and it is formalized in the sense of partnerships. NFF and Ullevaal Eiendom AS facilitate the partnership and bring in external actors to contribute with their expertise. Avery contributes with bureaucratic and legal expertise, Fusen, VENI Metering, and Over Easy comes in with technical expertise. The three internal managers possess the local knowledge and hence aid in the installation and design of the project. Although not all actors communicate among each other, NFF and Ullevaal Eiendom AS operates as a facilitator to redirect relevant information between the different actors and facilitate communication platforms between various actor if necessary.

The informant estimated the overall project cost close to 6.5 million NOK. It is a steep initial investment, and the search for external funding were priority number one. NFF reeks the benefit of being a sports organization and receive governmental funding regularly. Additionally, it makes them eligible for grants from the Ministry of Culture and Equality (KUD). KUD operates several support schemes for sport and cultural events and organizations. Through KUD, NFF secured a 2.4 million NOK grant from the support scheme for sustainability projects. One of the requirements attached to the grant was a demand for a minimum of three green initiatives. Hence, NFF included the integration of smart ventilation and smart heating, which both are considerably less expensive and smaller in scale, but nonetheless conserves energy. Hence, they allocated 1 million NOK to the solar PV project and funneled the remaining 1.4 million NOK into the upgrade of the ventilation and heating systems.

The reported incentives for the installation of solar PV range from economical to reputation building. With the rising and fluctuating electricity prices, it is expected that the payback time will shorten, as to what were expected when the idea first appeared. Although the price fluctuates, it is expected to remain relatively high compared to pre-covid-19 levels. Furthermore, there is a stable demand at the stadium from the tenants. Hence, there is already a reliable and stable customer circuit and articulated need in place. Apart from the economic incentives, NFF strive to become one of the leading nations within sustainability in the Union of European Football Association (UEFA). Utilizing the roofing is just one of many sustainable initiatives from NFF. Installing solar PV adds to the reputation, not only in Europe, but in Norway too.

7.3 Project Challenges

Two challenges were specifically pointed 1. Tedious and expensive application processes and 2. Limited sources of public funding. The application for the project permit was described by the informant as long hauling, difficult and expensive. The cost was in relation to third-party involvement and hired expertise. A confusing legal framework requires extensive detailing and expertise in the planning phase. The sluggish bureaucratic processing was also identified as a source of frustration, as it led to the postponing of the estimated completion date. Originally, they planned for installation fall 2023, but changed the estimated completion to spring 2024. the Moreover, public funds were available for this project, but the informant pointed out the options for governmental support was scarce, and due to their status as a sport organization have access to normally inaccessible sources.

7.4 PPP as a Potential Project Model

Although NFF is not a solar PV company, and hence do not encounter the same challenges as a solar PV firm would have done in a similar or larger project, there are some key insights to be taken from the study. The project at Ullevaal Stadion did indeed encounter challenges in the process and it is in the thesis' interest to hypothesize how the PPP model could have addressed these challenges.

1. Tedious and expensive application processes (Related to 7. Limited communication between stakeholders and actors) Two of PPP's strengths are knowledge & expertise sharing, and risk allocation. In the case of a PPP, the public actor would have taken the legal risk and handled the application process. The public actor tends to possess expertise in the legal framework and the process would not only have been faster, but also significantly cheaper due to the now obsolete role of a third-party acquisition.

2. Limited sources of public funding (Related to 3. High initial cost and 8. A lack of incentives and subsidies) - A PPP would instantly grant access to public funding, hence render the grant application obsolete. How much and when would depend on the contract terms. The project would most likely be arranged as a co-venture, securing both actors payback for their investments, rather than the typical BOT variant. A PPP naturally comes with its own challenges and risks, and those will be addressed in section *8. Discussion.*

8. DISCUSSION

The TIS structural analysis have identified the key barriers to solar PV's market formation function and the case study highlighted a couple of those barriers and how they materialized in an actual solar PV project. In the discussion we will address to what extent PPP can address the market barriers and contribute to the acceleration of the solar PV diffusion in Norway, and hence answer the research question:

RQ1: "To what extent can PPP accelerate the diffusion of solar PV in Norway

8.1 Identified Key Barriers

The analysis identified the barriers to be 1. High competition from hydropower. 2. Discouraging policies and regulation. 3. High initial cost. 4. Limited access to investment capital. 5. Uncertainty related to risk. 6. A lack of pilot projects. 7. Limited communication between stakeholders and actors 8. A lack of incentives and subsidies 9. Limited awareness 10. Limited grid capacity. The case study further emphasized two obstacles in an actual project 11. Tedious and expensive application processes and 12. Limited sources of public funding. The two latter ones are of extra interest, as they have explicitly been identified by an actor in a solar PV project. The current market formation does not address these barriers sufficiently, and it is therefore of great significance to constitute and propose potential measures to overcome the identified barriers. The question of interest is how well the PPP model can weaken or remove these barriers, and therefore, we proceed to present concrete PPP responses to said barriers.

8.2 Public-Private Partnership's Response to The Market Barriers

The analysis and case study have highlighted the blocking mechanisms applying to the formation of a sustainable Norwegian PV market capable of diffusing. Xue et al. (2021), have proposed a few ways to address the barriers through the implementation of PPPP (Public-Private-People Partnerships), we take these into consideration, but modify them to apply in a PPP fashion, as that is more fitting to the research question.

1. Co-Investment with PPP – This solution is centered around establishing models for PPPs where public subsidies go directly into funding instead. This reduces the risk of initial cost for the private actor. The private actor can hence focus on the operational, managerial and

construction aspects without the concerns of financial insecurity. It would occur through the formal establishment of a partnership between a public and a private actor. This model broadens the knowledge pool and grants access to a cross-sectional resources and finances by combining resources and expertise, which enhances the ability to handle and allocate risk to deal with potential challenges. This implementation of PPP addresses 3. High initial cost, as the project instantaneously have access to public funding through the new scheme. 4. Limited access to investment capital is addressed by engaging in a partnership where the private actors have access to the private market capital. 5. Uncertainty related to risk is dealt with through frequent communication and the rational allocation of risk. Barrier 8. A lack of incentives and subsidies and 12. Limited sources of public funding is tackled through the co-investment scheme, where public funding is injected into the project from the start.

2. Information sharing platforms with PPP – To overcome the issues of unawareness and lack of communication, it is proposed to establish a communication platform. The platform will provide extensive knowledge from both private and public sector. Information like costs, benefits of solar PV, energy output, incentives and environmental benefits will be widely available on these platforms. The different actors play a unique role. The public actor offer knowledge about financial support, incentives, and policies. The private actor addresses the cost and benefits, while consumers articulate needs and provide feedback/questions. In person meetings and activities among stakeholders would still supplement the platform. Additionally, frequent communication and market analyses are integral parts of the PPP model, as PPPs often are established to respond to a societal need and create value thereafter. The frequent communication between the partners and stakeholders in the partnership creates a learning environment defined by effective and concise communication which enables information and knowledge sharing to overcome barriers 5. Uncertainty related to risk by making information and knowledge widely available, 7. Limited communication between stakeholders and actors through frequent communication and 9. Limited awareness through the assessment and communication of consumer needs. Additionally, the platform facilitates easy access to information about solar PV for the consumers. Lastly, 11. Tedious and expensive application processes would be addressed through the partnership by expertise sharing and by the platform's information about processes tied to solar PV projects.

3. Creation of new incentive policies with PPP – This solution encompasses the implementation of new polices. The most significant task of the policies is to ensure

legitimacy and reduce uncertainty and risk in PV projects. This could include risk guarantees which limits the investor's potential losses, or in the form of feed-in tariffs. Successfully implemented, it could potentially increase confidence in the market. The incentives would be shaped to meet customer demands and enabling the private actors to meet them and this is achieved by communication needs through a partnership. The PPP model offers a platform to communicate these needs and enable actors to discuss their sectorial barriers. The public actor's proximity to the regulatory organ is also a strength in this model, as they can effectively communicate the private sector's perceived barriers and inducement to the right institutions. This measure effectively addresses barrier 2. Discouraging policies and regulation through the implementation of financially encouraging policies and 5. Uncertainty related to risk via legitimizing the market, showcasing trust in its growth and offer financial guarantees.

This leaves barriers 1. High competition from hydropower, 6. A lack of pilot projects, and 10. Limited grid capacity unaddressed. Xue et al. (2021) argues that the combination of 1. Co-Investment with PPP and 2. Information sharing platforms with PPP naturally address the remaining three barriers. These two combined will grant access to new sources of funding, which consequently enable more pilot projects to be conducted and gain knowledge from. The project information will be widely available on the information sharing platforms, and hence create acceptance among actors and legitimize the market diffusion. Simultaneously as the market diffuse, there will be economic and logistical incentives to expand and adapt the power grid for solar power. The expansion of the market may force the Norwegian government to adapt solar PV into its future sustainable energy portfolio.

Although these proposals address the barriers, further studies would be required as this is all hypothetical. Policy pilot projects, analyses and learning from international solar PV markets would be essential measures in the process of implementation said proposals.

8. 3 Why Public-Private Partnership

Like any model, PPP has its positives and negatives. It is not special or unique in that sense, there are however many good reasons to opt for PPP over more traditional models. PPP has the potential to create dialogue between actors and facilitate a platform where capabilities of each actor can come into fruition in a joint project (KPMG, 2003).

There are shortcomings of solely public projects or private projects that can be bridged by a PPP. Some of these has been addressed already but will be presented again in an orderly summary fashion. A common risk for both purely private or public project is the fact that they carry all the responsibility of risk alone.

The PPP model offers a solution to many of these shortcomings (Sanner et al., 2010). And the below table highlights the shortcomings of both sectors, accompanied by the PPP literature's idea of how PPP responds to them

Shortcomings of Public Actors	PPPs' Solution
Limited Funding	-A PPP gives the public actor access to capital from the private market and hence obtain funding to complete projects and accommodate user needs. The cost can also be dispersed over a longer time period, and the initial costs are significantly lower.
Limited Expertise	-Especially in lower levels of the governmental organs, like on the municipal level, the lack of expertise can exacerbate the quality and price of a project. The opportunity to partner up with a specialized private actor bridges the knowledge gap.
Slow Bureaucracy	-The private sector tends to process paperwork and obtain financial capital faster than the public sector. Adopting that strategy speeds up the construction start and potentially the construction process, as the private actor has a financial incentive to complete the construction swiftly. First after completion do the private actor receive financial gains.
Financial Consequences of Construction Delay	-In a solely public project, construction delay or altering construction plans are covered by the public, often by taxpayers' money. This unfortunate and highly unpopular scenario can be evaded by transferring that risk to the private partner.

No Access to Private Capital	-The public sector cannot tap into private funding the same way as the private actor. Establishing a PPP grants access to new economic resources.
Maintenance Backlog	-All infrastructure requires attention and maintenance to a certain degree. Due to strict public budgets, this job is often neglected. With a PPP the private partner ensures the standard and quality of the infrastructure throughout the lifespan of the normally decade-spanning contract.
Shortcomings of Private Actors	PPPs' Solution
Higher Interest on Financial Loans	-The interest of private actor's loans is significantly higher than the loans a public actor get. Combining forces in a PPP improves the loan conditions drastically for the private actor.
Limited Access to Public Projects	-Private actors do not normally get access to projects considered to belong in the public sphere. Entering a PPP means the private actor gets a unique chance to gain knowledge from a different sector and potentially find ways to make them more cost-efficient.
Financial Uncertainty and Unreliable Partnerships	-Public-Private partnerships are more stable than private-private ones, as the latter has two parties prone to bankruptcy. That dynamic render those partnerships, to a higher degree, financially unstable.
Risk of Bankruptcy	-The risk of private bankruptcy does not evaporate in a PPP, but the project has a higher chance of seeing completion as the public actor will see the project through. The public partner is also a reliable financial partner, which never fails to pay its bills.
No Equal Risk Allocation	-In a private project, or a public for that matter, the actor is forced to claim all the risk related to the project, even if they do not currently possess

	the capabilities to handle all of them. The PPP model offers a solution where the different types of risk is allocated with the most capable actor.
Less Concerned with Regulations and Standards	-The private sector tends to be less concerned with regulations and standards related to construction, management, and operations. A PPP brings in that expertise and the public actor follows up on said regulations and standards.

Table 4: PPP's response to the shortcomings of purely public projects or private projects

8.4 Evaluation of Public-Private Partnership and Solar PV Diffusion

PPP's relative novelty and limited experience within the Norwegian context constitute a need for more research and exploration. One of the costliest obstacles seems to be the lack of a standardized framework in a PPP agreement. Moreover, the political charged polarity hinders the exploration of its true potential. A standarized framewrok could overcome this polarity and ensure swift and transparent processing in PPP. A political compromise is required, where all parties agree on a way to implement a standardized framework, without obstructing its potential, but at the same time minimize negative effects. This could potentially include standard procedures of tendering, contracting, financing and transferring. A clear understanding of what a PPP project implies has the potential to increase trust and omit the vaugeness and subtleness of a loosely defined model. A thourough assessment of the PPP literature, indicates that PPP in Norway, mainly is a model for road and bulding construction, and there is limited experience with PPP in other sectors, especially the energy sector. Noteworthy, not a single PPP project has been related to the energy sector. As forementioned 90% percent of the Norwegian energy production stems from public sector (Leithe, 2016) and Norway has traditionally been an energy producing state, with hydropower, oil and gas as their biggest assets (Statistisk Sentralbyrå, 2023). There is a wide selection of barriers to the solar PV market, ranging from political to economic ones. It seems natural that a state wants to remain in control over established industries connected to socially and economically critical infrastructure. The transfer function of PPP could potentially address this issue and ensure public control in what is considered their domain. However, the situation might be different for niche industries like PV.

Oil and gas will eventually be phased out in accordance with the UN sustainable development goals (SDG), and as hydropower is not 100% reliable and are affected greatly by climatic factors such as precipitation and seasons, it seems logical to diversify the energy sector to include several forms of renewable energy to ensure reliable energy production in the future. On-shore and off-shore wind is already being developed as a substitute in Norway (Haddeland et al., 2022). However, PV has not been explored to the same extent, despite being developed abroad successfully (Zhang & He, 2013). It would be disadvantageous not to explore the potential of PV in Norway.

8.5 Risk of Public-Private Partnership

PPP is not the only model capable of accelerating the solar PV market diffusion, but due to its relative novelty and undiscovered potential, it deserves further examination of its potential to solve complex societal and environmental challenges. The novelty and lack of complete understanding of its strength and weaknesses can potentially deter actors from using the model due to limited knowledge, and hence ultimately lead them to choose a more familiar model. The politicized nature of PPP also makes it somewhat controversial in the Norwegian context. The political left tends to be more skeptical than the political right. The political question revolves around whether it is an extension of privatization or not (Sanner et al., 2010) & (Bakke, 2011). Further exploration and interaction with the model could potentially lead to a type of PPP which the entire political spectrum would condone. Furthermore, the tendering process poses a potential risk, as it may be a drain for public funding (Thomassen et al., 2016). This would have to be addressed properly to minimize waste and gain societal acceptance for the model, as constituencies usually perceive unnecessary public spending unfavorably. The last risk is tied to the longevity of PPP projects. In the current solar PV policy and regulatory climate, there are vague incentives to pursue solar PV projects. The uncertainty of the market could potentially make both public and private actors hesitant to commit to decades long agreements, in a market characterized by high uncertainty.

9. Concluding Remarks

The thesis embarked on an investigation to reveal to what extent the PPP model could accelerate the market diffusion of solar PV in Norway. The PPP model have been thoroughly assessed through document analyses, explaining its strengths and weaknesses. Through a contextually constructed TIS structural analysis, focusing on the market formation function, the structural analysis provided keen insight into the array of market barriers in the Norwegian solar PV market. The Ullevaal Stadion case study installed an understanding of solar PV market and the experiences of the involved actor. Additionally, it showcased and underlined that some of the identified barriers indeed were present in the actual project. Furthermore, the thesis presented the PPP model as a potential response to the identified barriers.

The thesis has contributed to the betterment of the understanding of PPP's functionality by applying it to the specific context of diffusing the Norwegian solar PV market. Furthermore, it proposes three concrete PPP responses to the identified market barriers, the responses are based upon Xue et al.'s (2021) responses to a similar problem, but the responses are tailored to address PPP's rather than PPPP's. The Ullevaal Case study provided a unique opportunity to confirm the relevance of some of the identified barriers from the TIS structural analysis. The barriers identified can be classified as economic, regulatory, and structural.

The thesis proved Norway's feasibility to cultivate solar energy in a larger scale than we currently do and that there is an established industry ready to diffuse the market if they get the get-go from the regulatory and financial institutions.

The thesis is an open invitation to further research on PPP's ability to address complex societal problems. PPP is a relatively new concept in Norway and further research may help establish a standard framework and improve the collective understanding of it. There is currently limited research on how PPP can contribute to the green shift in Norway and this thesis makes contributions to these research gaps.

The conducted study may have potential limits. Firstly, the limited informants may undermine the data quality if the study, but this has been carefully reflected and triangulated through other data sources. Moreover, additional constant access to the informant in the case study ensures a constant flow of quality information. Secondly, the selected case may not represent the structural barriers for solar PV development in Norway and thus informs limitations on the role of PPP. This indicates future studies can further expand case studies to comprehensively understand how different actors can work together to diffuse solar PV projects in Norway. Thirdly, the study specifically investigates the market function barriers in TIS, and other contextual functions affecting the market function barriers might be overlooked in that process. Conclusively, the thesis is mainly concerned with PPP's ability to address early market formations while offers limited insights on the future on the upscaling issues.

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