University of Stavanger

Title:

Under the Norwegian sun: a pragmatic analysis of prospects for solar energy communities

Master Thesis

Department Of Media and Social Sciences

Study Program: Energy, Environment and Society

Candidate Number: 268071

Spring semester 2023

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Abstract

Norway has ambitious clean electrification targets that require expansion of its renewable energy sources. A leader in hydropower, its energy flexibility positions it to add solar and wind energy capacity towards even larger decarbonised electricity grids. While wind energy is progressing with some contestation, Norway has remained a laggard on solar energy unlike other Nordic countries with similar solar irradiation. Yet solar energy at community scale can overcome many of the challenges associated with limiting renewable energy diffusion, such as nature conservation and safeguards against land use change. This thesis examines why solar energy communities are emerging slowly in Norway and seeks to identify pathways for their emergence and diffusion. It draws on document analysis of peer-reviewed and grey literature, expert interviews, and online news articles.

This approach offers the basis to argue that energy communities are limited to various forms due to various reasons. These include lack of regulatory frameworks and strong support schemes, reluctance of grid companies to engage with end-users and the threat of disperse generation units to grid stability, the ownership structure of natural resources and the skepticism in collective energy activities among others. During this research some of the barriers identified earlier in the process became drivers later in the process. The main drivers identified include deeper electrification efforts, high electricity prices and people’s interest in energy activities. These limitations and pathways to overcome them are discussed in relation to scholarship on sustainability transitions, especially concerning the dynamics of diffusion. The thesis offers an overview of prospects and challenges for solar energy community evolution in Norway and the justice implications that emerge along the way.

Acknowledgements

Completing a thesis has been one of the most challenging experiences in my life. Long days in front of a computer, often neglecting what is around me can describe how my reality looked like the past six months. An overwhelming and at the same exhilarating experience. In this part, I want to write an informal and very personal thank you note to all the people who supported me, were patient and lifted me up during this process. First, my partner, Ioannis, who was there for me all the time. Second my best friend, Liana for sending me all these beautiful songs and all my other friends. Third my parents, my brother and my dog. Although from a distance, they were there for me. And Sid, my supervisor, for all the guidance and his constructive feedback. Then I would like to thank all the informants. Finally, a thank you note to myself, for the perseverance that I demonstrated along this journey.

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List of abbreviations and acronyms

APS: Announced Pledges Scenario

CEC: Citizen energy community

DERs: Distributed energy resources

DES: Distributed energy systems

DSOs: Distribution system operators

EC: Energy Communities

FD: Finansdepartementet (Ministry of Finance)

kWh: kilowatt hour

MW: Megawatt

NVE: Norges vassdrags of energidirektorat (Norwegian Water Resources and Energy Directorate)

OED: Olje- og energidepartementet (Ministry of Petroleum and Energy)

RE: Renewable Energy

REC: Renewable Energy Community

RED II:Renewable energy directive 2018/2001

RES: Renewable energy sources

RME: Reguleringsmyndigheten for energi (The Regulatory Authority for Energy)

TSO: Transmission system operator

TWh: Terawatt hour

1 Introduction

Dramatic increase in CO_2 concentration in the atmosphere and associated impacts on climate change have prompted nations to call for action to achieve a sustainable pathway. Energy issues are considered one of the biggest challenges of the present, while the United Nations has highlighted the need for sustainable energy in its 2030 Agenda. This document recognizes the necessity to ensure affordable and clean energy for all (SDG7) and to create sustainable cities and communities (SDG11) as a way to build resilience against climate change (Mussard, 2017). Renewable energy sources will play a crucial role in this transition towards a more sustainable future. Among these sources, solar power has been characterized as the most affordable source of renewable electricity generation in most countries globally (IEA, 2020). Despite the latest cost increases in the production of solar photovoltaic (PV) technology, solar power still remains the most affordable option along with wind power, while predictions indicate rapid growth in all scenarios (STEPS, APS, NZE) [1] (IEA, 2022). Therefore, the deployment of solar power can be considered a potential way to meet future energy demand and reach environmental targets.

Development of solar energy systems relies on the adoption rate of the technology; hence consumers are the most important components. Increased adoption among consumers can further strengthen deployment levels, thus questions such as what influences their willingness to participate and what kind of activities would enable a particular technology adoption require attention (Lazdins et al., 2021). Distributed energy systems enable consumers from being passive actors in the current energy systems to become active in energy activities. This can further provide accommodation for the creation of Energy Communities, which in turn can contribute to the deployment of a decentralized system based on renewable energy sources. The creation of Energy communities is recognized as an effective strategy with various positive outcomes since it allows consumers to collectively pursue

[1] STEPS (Stated Policy Scenario), APS (Announced Pledges Scenario) , NZE (Net Zero Emissions by 2050 Scenario). Source: IEA (2022)

energy production activities and can contribute to a sustainable and sufficient energy system. Furthermore, they create a more inclusive environment, where citizens can consume, produce, store and share electricity among them. In this way, citizens can become more engaged and conscious about their energy system (Tarpani et al., 2022).

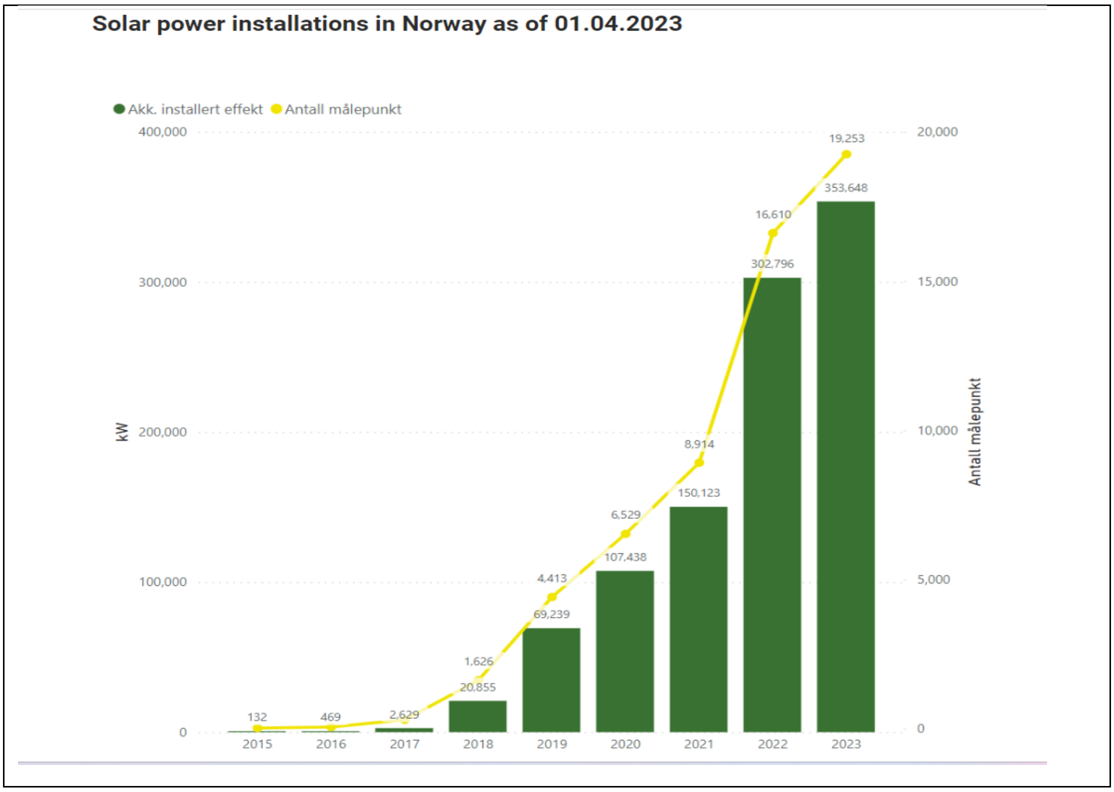

Figure 1 Solar power installation in Norway as of 01.04.2023. Accumulated installed power (green color), number of measurement points (yellow color). Source: Elhub (2023)

Norway has experienced slow but steady growth in installed solar power capacity, especially from 2015 and onwards, reaching over 350 MW in 2023 (Elhub, 2023). Although the share of solar power in the electricity mix is minuscule, estimates from the Energy Commission's (Energikommisjonens) 2023 report indicate that it is realistic to develop 5 to 10 TWh of solar capacity by 2030, while predictions from NVE show up to 7 TWh by 2040. According to the report, "we are entering a new era that requires a comprehensive restructuring of the energy system" (OED, 2023a, p.9) , thus changes seem essential to accommodate solar power development. In line with these new events, the government has highlighted the need to enhance local energy production, and new regulations are adopted that allow housing associations and commercial properties to participate in local energy activities (Ulvin & Gregersen, 2023).

1.1 Solar Energy: The Norwegian context

The Norwegian energy system is highly dependent on the strong hydropower industry present in the country that provides more than 90% of the electricity supply in a clean and affordable way, while the second source of electricity is provided by wind (8%), leaving a small room for solar power development (IEA, 2021, p.85). This has led to a delay in the deployment of solar energy systems within the country. When shifting the attention to Nordic countries, one can observe that Norway's solar energy deployment is on a lower scale in comparison with Sweden and Denmark, despite the similarity in weather conditions and solar irradiation levels (Hanson et al., 2021). Despite annual electricity surplus from the hydropower industry, Norway's ongoing effort at full electrification of the transport and the industrial sectors calls for greater amounts of electricity generation going forward.

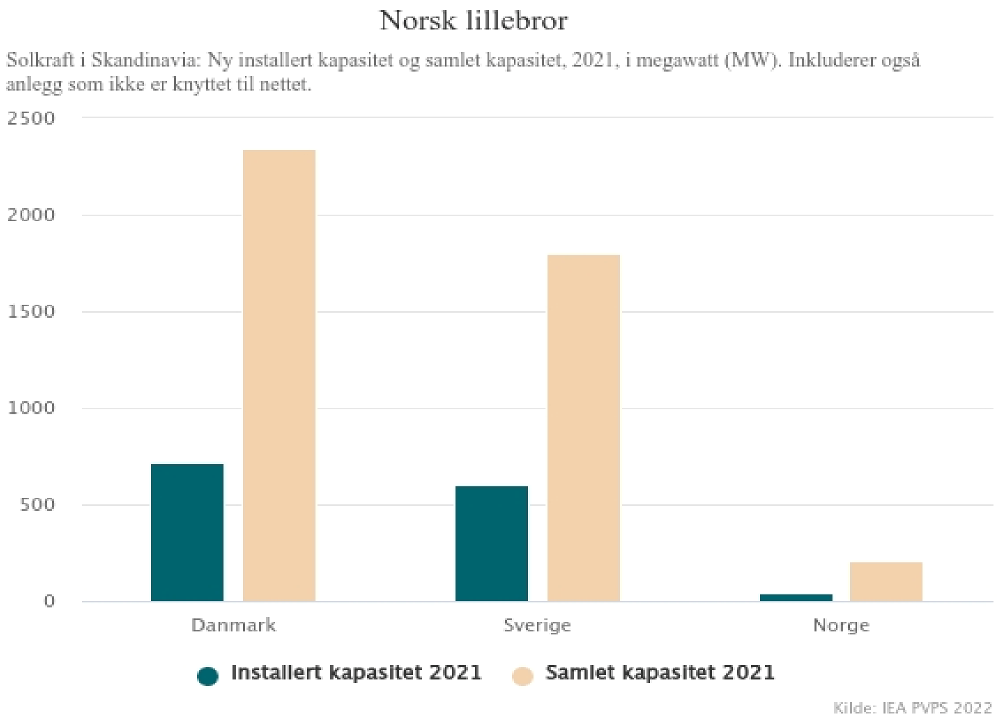

Figure 2: Norwegian little brother. Solar power in Scandinavia: New installed capacity (depicted by the green color) and total capacity (depicted by the beige color), 2021, in megawatts (MW). Also includes facilities that are not connected to the grid. Source: Øvrebø (2022)

One of the main barriers that hinders the deployment of solar energy applications is the lack of awareness about the potential of PV in the country. Whereas other sources of renewable energy, such as hydropower and wind, receive more attention in media and governmental reports, PV is less visible, raising issues of legitimacy (Hanson et al., 2021). Furthermore, low deployment rate is due to the misconception that solar systems' performance is different than other countries located in Europe (Formolli et al., 2021). Although solar energy systems have been installed in warmer temperatures with high solar irradiance levels, their implementation on cold climatic conditions can be challenged due to their impacts (Mussard, 2017). However, low irradiation levels can increase the efficiency of solar applications, while other characteristics, such as high latitude coupled with low angle solar rays can be beneficial in yielding energy from vertical surfaces. Moreover, when integrated in the built environment, they provide numerous advantages, since they utilize unexploited surfaces, such as roofs, reducing electricity losses during transmission and achieve a greater level of resilience against extreme climatic phenomena.

Hence, high efficiency can counteract short daylight periods where cold temperatures are more present. Although the absence of sun is a challenge, especially in Northern parts of the country, high albedo provides an advantage to PV technology, since it can complement efficiency levels (Mussard, 2017).

Among other barriers identified is the lack of strong policies to incentivize investments in solar power. Upscaling requires mobilization of financial resources to achieve the full potential of solar capacity. Thus, changes in policies seem essential to enhance market formation (Hanson et al., 2021). Furthermore, the existing legislative frameworks prove to be insufficient in the Norwegian context and hinder municipalities' efforts to facilitate solar energy integration in the built environment due to poor planning and lack of effective tools. On the one hand, these issues create challenges on achieving legitimation, while on the other, they prevent municipalities from actively pursuing an increase in solar installations either through direct financial support or by indirectly disseminating information among citizens to capture their attention with the aim to initiate further investments (Formolli et al., 2021).

1.2 The concept of Energy Communities

The concept of Energy Communities (ECs) is relatively new. Such initiatives allow changes in the structure and the governance of existing energy systems. Considered as "new energy management system", energy community can contribute to a reduction in carbon footprint, can enhance deployment of a decentralized system and can promote renewable energy sources (RES), such as solar and wind (Tarpani et al., 2022). ECs include various forms of energy projects where citizens actively participate in a collective way in the production, consumption and potentially also management of energy. These projects involve different levels of citizen participation and distributed benefits, while they may be location bound or refer to a community of interest (Caramizaru & Uihlein, 2020). In these communities, citizens can "take ownership" of the energy transition and engage in energy production activities, while new technologies, such as solar PVs combined with energy storage, allow citizens to actively participate in the energy market in new ways, challenging the traditional structure of the entire value chain (Magnusson & Palm, 2019).

Energy community is a rather obscure concept that leads to confusion regarding actors, activities, and outcomes that take place within the community. Different terminologies have emerged throughout the years, such as sustainable energy communities and energy cooperatives among others, that present different angles of resembling phenomena (Iliopoulos, 2021). According to European legislation, there are two main definitions of energy communities, citizen energy communities (CEC) and renewable energy communities (REC). The first was introduced in the Internal Electricity Market Directive 2019/944, while the latter was included in the revised Renewable Energy Directive 2018/2001 (RED II).

According to the Renewable Energy Directive 2018/2001 (RED II), an Energy Community includes legal entities that can voluntarily participate without discrimination. These legal entities which consist of shareholders or members are location-bound and control the system. In particular, shareholders or members can be individuals, small and medium size enterprises(SMEs) and local authorities, including municipalities with the aim to contribute to environmental, social and economic aspects, rather than to merely focus on financial profits (Tarpani et al., 2022). For the first time, the European Union (EU) through the publication of these documents created an enabling environment where citizens can actively participate in energy projects and share the benefits (Caramizaru & Uihlein, 2020)

Both renewable energy communities and citizen energy communities have similar characteristics regarding the modes of governance, ownership, and purpose (Tarpani et al., 2022). However, they differ in various ways. Regarding geographical scope, activities in REC are location-bound, while in CEC the community does not have to be located in the immediate proximity of energy projects. REC can perform activities that cover all sources of renewable energy, while CEC can also operate activities that are based on fossil fuels. Furthermore, while membership in REC includes individuals, local authorities and SMEs whose engagement in the community is not their primary economic activity, in CEC large-scale companies can also participate.

The latter and medium companies though cannot exercise power or influence during decision-making processes (Caramizaru & Uihlein, 2020). In this paper, the focus will be on renewable energy communities.

1.3 Problem statement

Renewable energy communities can be considered drivers towards a low-carbon pathway and can contribute to the empowerment of energy consumers. According to the recast RED II, the connection between stakeholders and the location has resulted in an increase in social acceptance of renewable energy projects and local investments, while it further facilitates citizen participation in management tasks by creating a more inclusive environment. These are essential in states' decarbonization efforts and can boost renewable energy capacity (Iliopoulos, 2021). Estimates indicate that more than 250 million citizens will become prosumers by 2050 with the capacity to produce up to 45% of renewable energy (Tarpani et al., 2022). By introducing the two directives as part of the 4th Energy Package, the EU established a legal framework for both REC and CEC that enables citizen engagement in collective energy activities. In this way, end users can collaborate in energy consumption, generation, sharing and storage, while they can also sell excess energy and receive remuneration (McElhinney et al., 2022)

Despite the two directives being transposed in policy frameworks in various EU Member States, in Norway the Renewable Energy Directive may take up years to be implemented, since the country is not a member of the EU. In practice, however, Norway does cohere closely with energy policy evolution in the EU, albeit with a lag. Although countries such as Germany and Denmark have a long tradition with energy community initiatives, other countries are lagging (Spasova & Braungardt, 2021). According to a study conducted by Thema Consulting Group for NVE, there are no energy communities in Norway along the lines defined in RED II by the EU (McElhinney et al., 2022). The absence of RECs may hinder the expansion of a decentralized energy system that is based on renewable energy sources, while nonparticipation of consumers may influence adoption rate, social acceptance and investments on PV technology. According to the Solar Energy Cluster (SolEnergiklyngen) in Norway, Energy Communities are important to realize the full potential of local energy production, sharing and storage, while they also contribute to security of supply. The necessity of energy communities is further underlined by the Storting's (Norwegian Parliament's) unanimous vote that calls upon the government to "remove regulatory barriers that prevent local energy production, local energy storage and the exchange of energy between buildings" (Solenergiklyngen, 2023).

Norway is an interesting case to study since it differs from other countries, with a high number of community energy initiatives with regard to the structure of the power system and the country not being an EU member state. The power system relies on renewable energy (mainly hydro, wind and some solar), thus there is no need for decarbonization. Furthermore, since the country is not part of the EU, it means that directives that promote renewable energy communities do not automatically apply, and instead take time to be transposed. Since in Norway there are no energy communities as those defined by RED II, this thesis refers to buildings with more than one individual metering point – such as housing associations and condominiums – that have solar installations to be solar energy communities in the Norwegian context. Solar energy was selected among various renewable energy sources, as it is the most popular option among prosumers given its modular nature which lends itself to different plant sizes to match space and budget availability and logistical considerations. In particular, more than 99% of prosumers have solar systems (SSB, 2022, p. 13).

However, electrification efforts within the transport and industrial sector will require greater amounts of electricity that may lead to a significant restructuring of the current energy system. Solar power has been identified as a renewable source with a high potential to contribute to electrification efforts given its competitive cost and modular nature, while its contribution will bring changes to the current centralized energy system and will create favourable conditions for other actors to participate in energy activities. Moreover, solar systems – and PV in particular – are regarded as a strong alternative generation option for energy communities due to low costs and increased efficiency (Lazdins et al., 2021). Other advantages that make them suitable for community energy initiatives is that they do not require land, while in Norway there is huge potential for solar power in roofs (Gholami & Røstvik, 2021). Although there has been research in solar power in Norway, renewable energy communities with a focus on solar technology have received limited attention. This thesis contributes to the greater research required on this topic of timely interest.

1.4 Research questions and objectives

Using Norway as a case enables me to focus on a study that involves continuous socio-technical changes. The objectives of this study are: 1) to better understand how a socio-technical transition evolves and the impacts that it creates along the way, and 2) to contribute to the growing literature on socio-technical transitions with an energy justice lens. Correspondingly, the focus of this thesis is to explore how solar energy communities emerge, and to investigate the barriers, drivers and prospects of solar communities, while providing insight into justice implications. Hence the main question is:

1) How do solar energy communities emerge in the Norwegian context?

This is followed by these sub-questions:

2) What are the barriers, drivers and prospects of solar energy communities?
3) What are the justice implications?

The questions are addressed through literature review, primary data and analysis of secondary material, both peer-reviewed and grey literature. I address the first two questions through the theoretical framework of Multi-Level Perspective (MLP), while the third question is addressed through an energy justice lens.

1.5 Overview of the research study

The thesis consists of seven chapters and proceeds as such: the first chapter establishes the background of this research, introduces the research questions and addresses the aim of this study. In chapter 2, as the research topic is complex and involves socio-technical challenges, I will provide the bigger picture that the topic is embedded in. Chapter 3 introduces the theoretical frameworks that are utilized to structure this research, followed by chapter 4, that provides the methodology and data collection methods and limitations of the study. Chapter 5 offers greater details on the Norwegian context. Subsequently, chapter 6 presents the empirical analysis. This is then discussed in chapter 7, followed by Chapter 8 which concludes the thesis.

2 Literature review

Since the topic is embedded within a larger picture, I will provide definitions of key terms that are essential to understand the topic.

2.1 Linking the electricity sector and the energy transition

The electricity sector is important in achieving climate targets, such as decarbonization (Inderberg, 2020). However, decarbonization efforts in the electricity system may require higher amounts of RES, while the variability of these sources may affect the system’s sufficient operation. Hence, a greater number of management tools are essential to address the intermittency and enhance the flexibility of the system, through demand flexibility services, adequate grid capacity and storage, among others. This may alter the traditional structure of the electricity system, which is characterized by a centralized model, where the primary goal in the past was to provide cheap electricity and ensure availability of energy supply in case of increased demand (Defeuilley, 2019).

Since the late 1990s, countries such as Germany and the UK among others, have pursued decarbonization initiatives in the form of either incentive mechanisms that aim at increasing the penetration of renewable energy sources in the electricity mix, or in the form of instruments that foster energy efficiency measures and control consumption patterns. The deployment of these initiatives throughout the years seeks to tackle climate change and mitigate carbon emissions, contributing overall to the energy transition (Defeuilley, 2019). In particular, during the German Energiewende (energy transition), the feed-in legislation was introduced to incentivize local production of electricity. Through that scheme, locally produced electricity could be distributed at the central grid and purchased at a fixed rate (Shkembi, 2021). The feed-in support scheme "created an initial protective space for renewable electricity and a growing coalition supporting change in the selection environment " (Lauber & Jacobsson, 2016, p.150). Although Germany's early investments in renewable energy (RE) technologies led to higher taxes for consumers due to high technology costs, they contributed to cost abatement related to the production of technologies worldwide (Agora, 2017).

Initiatives and investments in RE technologies paved the way for the development of renewables around the world. In 2022, renewables made up nearly 30% of the generation mix, while predictions indicate a growth rate of over 9% between 2023-2025, reaching over one-third of the global generation mix. This curve is supported by governments' promises to increase investments in renewables (IEA, 2023). Although the energy transition is in an early phase, it has a significant impact on the energy sector and could disrupt its traditional structure. New activities, such as increased generation of renewables, demand-side tools and utilization of local energy resources, can lead to diversification and decentralization of the electricity system. Exploiting local energy resources is often considered as the optimal pathway towards a low-carbon future (Defeuilley, 2019). However, exponential growth rates in renewables in the generation mix will bring up integration challenges in the energy system. A primary challenge for the electricity sector is how to accommodate increased share of variable renewable energy sources (RES). Power system flexibility is seen as a vital element to manage the intermittent and unpredictable nature of variable RES. Coordination between countries, markets and various stages of the electricity system is essential for successful system integration (De Vries & Verzijlbergh, 2018). Furthermore, advancements in storage capacity, demand-side flexibility and adequate dispatchable renewables, like hydropower, play a crucial role in balancing variable renewables (IEA, 2023). If local energy solutions address these financial and technical barriers, they could act as alternatives to large-scale, centralized systems (Defeuilley, 2019), or complement them effectively.

The pace of the energy transition will be determined by the existing structure of the electricity sector, organizational model, preferred technology and/or by public policies and institutional settings. These components may lead to acceleration or deceleration of the energy transition in each country. The transition will affect the current structure of the electricity sector. Nevertheless, given the favorable environment and the fragility of the current system, a new setting is developing (Defeuilley, 2019).

2.2 Defining power system flexibility

As power systems are experiencing changes worldwide, due to an increased share of variable low-cost renewables, the development of distributed energy resources (DERs), digitalization and rising efforts for electrification, power system flexibility has emerged as a key priority at the global level. Power system flexibility is defined as "the ability of a power system to reliably and cost-effectively manage the variability and uncertainty of demand and supply across all relevant timescales, from ensuring instantaneous stability of the power system to supporting long-term security of supply" (IEA, 2019, p.4). Conventional power plants, electricity networks and hydropower have historically provided flexibility services. Additional to these, new assets, such as renewable energy sources, energy storage and DERs enhance system flexibility and allow for more reliable, resilient and affordable power systems (IEA, 2019).

High penetration of solar PV and wind will affect the net load, the load after extracting renewable sources from the electricity demand, while electrification efforts in the transport and industry sector will lead to higher variability of electricity demand and fluctuation of peak loads. This growth in the total energy generation mix will lead to a reshaping of the power system and will increase the needs for power system flexibility to ensure grid stability and security of electricity supply. In this setting, technologies, such as hydropower and geothermal will be of great importance. According to estimates from IEA (2022) in all scenarios, including APS, STEPS and NZE, there is exponential growth in power system flexibility needs, while in the latter, the estimates indicate a fourfold growth by 2050 (p.215). To manage these changes while maintaining security of supply, new approaches seem necessary. In line with this, there is a need for more responsive electricity generation, more connected and flexible consumers and a more robust and digitalized grid. There are four ways to develop flexibility in power systems, namely generation plants, grids, demand-side and energy storage (IEA, 2022).

2.2.1 Flexibility options: Demand-side measures and storage as solutions

To balance the intermittency of RES, demand-side flexibility options are viewed as a potential solution. Demand-side flexibility is related to “the ability of electrical consumption to change/shift/adjust/curtail the electricity consumption in response to an external request, e.g. electricity price, financial incentives and technical requirements” (Golmohamadi, 2022, p.3). There are numerous benefits that stem from demand-side flexibility options. These include lower electricity bills for consumers, coupled with a reduction in electricity prices. Furthermore, higher penetration of flexibility options can lead to a more reliable electricity system and distribution grid (Golmohamadi, 2022). However, to make the most of demand-side response, there is a need for greater investments in digital infrastructure, while policies need to accommodate suppliers in providing financial incentives that remunerate demand response to consumers (IEA, 2022).

Energy storage is considered as another alternative that can contribute to system flexibility and allow for higher penetration of RES in the grid. While in fuel-based power plants, the electricity generation relies on the quantity of fuel you insert into the plant, in renewables, unpredictable factors such as solar irradiation affect the generation output. Hence, energy storage options can store this excess production and release it back to the grid when there is demand, adding important energy flexibility. There are various energy storage systems (pumped hydro, green hydrogen, electric vehicles, batteries) whose suitability for a given context relies on different characteristics, such as cost, performance, technological maturity and size. Integration of storage options in the electricity system comes with many benefits, since it provides additional services, such as load shifting, increase in performance, auxiliary power among others (Jafari et al., 2022). Moreover, modularity of battery systems allows for higher scalability and integration in many locations, while both utility-scale and behind-the-meter battery storage systems reached deployment above 27 GW by 2021 (IEA, 2022, p. 311). This increase in storage capacity is supported by technological advancements and higher production capacity which leads to continuous cost reductions (Heitel et al., 2021).

Although there are challenges related to the cost and supply of critical minerals essential to produce batteries, the estimates indicate a growth by 2030. Since batteries are mostly used for short-term storage, they fit well with solar PV applications, while behind-the-meter systems are usually connected with rooftop solar. Predictions show that there will be an increase of such storage option in regions with high shares of solar PV systems (IEA, 2022). Since self-consumption is seen as the optimal activity in countries with high electricity prices and with little or no strong support scheme, such as feed-in tariffs, batteries will play a significant role, due to their ability to balance the electricity produced and the household's electricity consumption needs. Already, in countries like Germany with high electricity prices, almost one out of two rooftop PV systems is paired with a battery (Heitel et al., 2021).

2.2.2 Variability of RES and grid implications

The integration of renewables into the existing grid may affect the efficiency and performance levels. The traditional grid consists of transmission and distribution systems that operate at different voltage values. The transmission grid transfers the electricity produced from central locations to load centers, while the distribution grid delivers electricity from load centres to end-users. Transmission and distribution grids, in systems characterized by high shares of renewables, will have to deal with challenges in the planning and operation of the current power system. In the planning stage, the high presence of renewables may threaten the system's reliability and performance and affect the network topology , while in the operational stage the integration of variable renewables will require tools to adapt to rapid generation shifts, whereas the need for storage facilities would influence the unit commitment (a procedure that defines the generation units to meet the demand with the aim to reduce operating costs, while taking into account various constraints). Both intermittency and storage could change the economic dispatch, which specifies the optimal financial distribution of generated outputs to meet the demand load. Hence, while renewables come with no associated fuel costs, higher maintenance and operation cost still must be met (Vittal, 2010).

Other challenges that arise with the integration of RES in the grid are related to expansion of renewables in greater spatial arrangements and the timeframe of planning, licencing and constructing a new transmission line, which varies from 5-10 years. Thus, grid enhancement and transmission network expansion seems necessary to accommodate the growth of variable renewables (Impram et al., 2020). However, in Lund et al. (2015), disperse renewables are associated with "smoothing effects"(p.799) as they can lead to reduction of rapid shifts in energy production. For example, distributed wind power production can minimize variability of wind power, while studies show that the same applies for solar power (Lund et al., 2015). As mentioned above, new transmission systems can take up to a decade or even longer to build, thus successful development demands long-term design and implementation to meet future supply and demand and act as enablers in a transition towards a low-carbon pathway. If not thoroughly planned, the transmission networks can become bottlenecks in integrating RES and result in delays for new renewable projects due to limited capacity or prevent transmission of renewable generation to end-users, such as in the case of Mongolia (IEA, 2022).

To overcome some of these challenges, new investments are essential for strengthening the grid. Although until now, responsible for funding was mostly the public sector, the need for expansion to meet future demand and supply, while maintaining reliability and affordability, requires investments from the private sector. Moreover, coordination and delegation of responsibilities between regulatory authorities, network operators and investors are necessary to ensure an effective planning and implementation of new or existing projects (IEA, 2022).

2.3 New actors in the energy system: prosumers

Recent targets from the European Commission aim at 55% of emission reduction by 2030 compared to 1990 levels and 32% share of renewables. The integration and engagement of end-users in a transition to a more sustainable future is considered essential to successfully reach these targets. Prosumers will play a significant role in enabling flexibility of the future energy system that is characterized by high share of variable renewables (Gržanić et al., 2022).

The word prosumer is a combination of the words *producer* and *consumer*. The first is conventionally at the start of a supply chain network, while the latter at the end. However, to minimize transmission and distribution losses and costs paid for the infrastructure present in a centralized electricity system, end-users are investing in installing generation technologies to produce their own electricity and even send excess electricity back to the grid (Khalilpour, 2019). Thus, the term prosumer indicates end-users who both produce and consume and "who supply surplus electricity production back to the electricity grid" (SSB, 2022, p.5)

The expansion of DERs has triggered changes in production, distribution and consumption of energy, while it facilitates a more decentralized and open electricity network. In this new setting, energy operators are not only responsible for selling electricity but also for accommodating surplus electricity delivered by prosumers (Soto et al., 2021). There has been an increase in the number of prosumers across the world, while developments in prosuming are influenced by country and time. Technologies, such as solar PV systems enable end-users to generate power for self-consumption and export their excess production back to the grid (Inderberg et al., 2018). The increase in prosumers can challenge the traditional energy system and may influence its design, operation, and management with a bottom-up feed-in of electricity to the grid. Among other potential benefits in pursuing prosuming activities are that prosumers may become more aware of their energy behavior and take an active role in the energy system (Winther et al., 2018).

2.4 Distributed energy resources as an enabler of two-way power flows

In the energy sector, notions such as community energy network and microgrid are considered as alternatives that can drive change within a traditional electricity system that is characterized by a central network (Khalilpour, 2019). The traditional model of energy distribution, where large-scale power plants produced and distributed electricity through a centralized grid has changed over the years. Emerging technologies related to solar and wind power have led to a diversification of the grid and has enabled “two-way power flows” (Bassam, 2021, p.7). Decentralized energy systems, also known as distributed energy systems (DES), entail distributed generation and microgeneration technologies, such as solar PVs and are located in close proximity to where electricity is produced and consumed, preventing transmission losses and enhancing security of supply (Kojonsaari & Palm, 2021).

Increased demand for electricity in nations' continuous full electrification efforts and high electricity prices have led many end-users to invest in other sources to secure their electricity supply, thus DERs have proliferated throughout the years. The development of DERs can contribute to a reduction in energy prices, can enhance energy efficiency and independence, while renewable distributed energy technologies can lead to mitigation of environmental externalities. Despite the benefits that DERs can offer to end-users, their deployment brings about certain challenges. One is the limited hosting capacity of the distribution grid that allows connection between DERs and the central grid. The second issue is related to the intermittent nature of renewable sources that present challenges to grid operators, who are responsible for balancing the grid during peak hours, when there is high demand for electricity, while avoiding power outages. Another challenge is the storage capacity when it comes to electricity produced in a sustainable way (Bassam, 2021).

A distributed energy system, which encompasses different distributed energy resources, can create new prospects in urban settings for end-users, such as sharing of locally produced electricity. The transition of the current energy system, from often large-scale power plants to small-scale energy generation, challenges the way the system operates and the ownership status. In this new decentralized system, citizens are encouraged to engage in energy activities, while increased ownership and control over energy projects can lead to high empowerment. Thus, the deployment of such a system can contribute to the development of energy communities. However, although the two concepts are similar, they differ in ownership structure. While in DES the ownership model is vague and can include traditional energy utilities, energy communities are owned or controlled by its members (Kojonsaari & Palm, 2021).

One way to facilitate decentralized electricity generation and distribution is through microgrids. Although microgrids were firstly focused on remote areas, the need to meet challenges on the urban grid, have resulted in a change in focus. Microgrids can be connected to the central grid and can either operate alongside the main grid or in isolation which is known as "island mode". Several benefits arise from the emergence of microgrids. They can increase resilience and flexibility of the system, they can enhance the penetration of renewable energy sources and they can secure electricity supply. However, the connection of microgrids to the central grid is rather challenging, since it requires customer engagement, control, and protection (Kojonsaari & Palm, 2021).

Decentralization is considered as a more suitable way to meet the needs of an energy transition. In Norway, three policies have played a crucial role in enabling future decentralization of the energy system. The first one was the national smart-meter deployment from 2014 onwards, which picked up pace during 2017 and 2018. The implementation of smart meters was mandatory in all households, with 97% completed by January 2019. Within the country, smart meter can enable a two-way communication, can provide data about consumption/production patterns, can facilitate electricity distribution, and were seen as a necessary precondition for the creation of a smart grid and for the improvement of demand-side management. The second is the regulatory framework regarding prosumers. Prosuming is considered as a driver towards a more decentralized electricity system. In Norway, production and distribution of electricity back to the grid required registration as a power plant and prosuming activities were not allowed. After 2010, an extemption was introduced that allowed private prosuming for learning purposes with the aim to develop a regulatory framework. Two hearings followed, in 2014 and 2015 respectively, where the main topic was the creation of a prosumer scheme. (Inderberg, 2020). This paved the way for the introduction of the first formal prosumer regulation in 2017 (Winther et al., 2018).

3 Theory

Since main objectives in this paper are to explore how solar energy communities emerge and identify barriers, drivers and prospects related to solar communities, the MLP will be a valuable framework to understand the complexities in a transition, which in our case is in the form of deeper electrification. Moreover, it will be helpful in distinguishing the barriers and drivers, prospects and the emergence of solar energy communities drawing on events at all three levels. Thus, this study will view solar communities as emerging niches that try to infiltrate in the electricity regime. To explore the justice implications that stem along the transition, I will draw on the four energy justice dimensions.

3.1 Multi-level perspective as a theoretical framework

The multi-level perspective (MLP), which draws on earlier work from Rip & Kemp (1998) was developed and introduced by Geels as an explanatory tool for historic transitions, while it further expanded to new socio-technical systems, which entail topics such as mobility, entertainment while it is also employed for policy recommendation and policy analysis. The conceptual understanding of transitions to new regimes is based on innovation and science and technology studies (Smith et al., 2010, Kern, 2012). According to Geels (2011) the MLP is a "middle range theory that conceptualizes overall dynamic patterns in sociotechnical transitions" (p.26). The MLP serves as an analytical and heuristic tool to understand the complicated dynamics embedded within a sociotechnical change. Technological transitions do not solely entail changes in technology, but also changes in other elements, such as "user practices, regulation, industrial networks, infrastructure and symbolic meaning" (Geels, 2002, p.1258). In this line, in Rip & Kemp (1998), the authors use the notion of *seamless web,* developed by Hughes, to describe the collective engagement of these different elements in technological developments and argue that technological developments go hand-in-hand with societal developments. Similarly in Kern (2012), system change is determined by events in the co-evolution between society and technology.

Changes emerge as a result of the interplay between three levels, namely landscape, socio-technical regime (ST-regime) and niche level. Dynamics at the niche level coupled with tensions in the regime and developments in the landscape level determine the rate of diffusion of innovations. Thus, transition is driven by multiple events on all three levels (Geels, 2011). However, transitions are difficult to realize, as existing systems are known for their stability and lock-in. This is especially relevant for infrastructural systems, such as the electricity system, where investments in new technology and associated infrastructural change, expertise and social networks create a challenging environment for a new system to emerge (Verbong & Geels, 2010)

The landscape level acts as an external structure and consists of heterogeneous elements such as “oil prices, economic growth, environmental problems”. In this level, changes encounter strong difficulties and occur on a slower pace compared to the ST-regime (Geels, 2002, p. 1260). In Rip & Kemp (1998), the landscape is viewed as an entity that “we are part of, that sustains us” (p.334). Actors in niches and the regime level have little or no influence on the landscape (Geels, 2011). However, gradually certain emerging regimes can influence landscape developments, which in turn provides further stability to regimes. One example is the aeromobility and communications regime on economic globalization (Smith et al., 2010). Developments on this level can be either reinforcing or disruptive for the regime. The first can lead to stabilization of the regime, while the latter can lead to tensions (Geels & Schot, 2007).

The ST-regime is located within a socio-technical landscape and accounts for the stability of the sociotechnical system (Geels, 2011). The ST-regime entails three features, namely material and technical components, different group of actors and formal, normative and cognitive rules that direct activities among actors (Verbong & Geels, 2010). These components co-structure each other (Geels & Kemp, 2007). The regime rules, being routines, shared views and lifestyles, regulations and legal contracts, are both enacted and reproduced by actors, and they act as tools that shape the actors (Geels, 2011). By reproducing the rules, actors are not passive but rather actively engage with them. While rules are present in both regime and niche level, in regime they are “stable and well-articulated” while for niche novelties they are “unstable and in the making” (Geels & Schot, 2007, p.402). Actors in this level interact and create networks, where activities become coordinated. Stability of the regime and prevalence of technologies or practices relies on socially structured roles, routines and similar mindsets, while adaptation of lifestyle to a certain system, policies, institutional settings, investment in existing infrastructure and presence of special-interest groups provide greater resilience (Geels & Kemp, 2007). The alignment between heterogeneous components in the regime, where activities are guided by a set of rules, can lead to path dependency and opposition to change (Geels et al., 2017). Hence, in this level, changes occur gradually and may accumulate over time into more stable pathways. However, these changes do not imply only shifts in technology, but also in politics, science and culture. While different sub-regimes can create further stability through coordinated activities, they can also create conflicts (Geels, 2011).

Niches is the level where radical innovations emerge. This level provides an "incubation room" and act as a shield for emerging novelties. Niches play a pivotal role, since they provide the "seeds for change" (Geels, 2002, p.1261). In this level, the selection environment is less competitive than the one in the regime level. Funded projects for learning purposes and an environment of early adoption and experimentation can provide support to niche developments (Smith et al., 2010). Furthermore, niche novelties are social or technical innovations that can arise in specific contexts or due to support from regulatory frameworks (Geels, 2011). Niches have to overcome various challenges to infiltrate the regime level, while many face expansion and viability issues over time, threatening their successful development. Actors in this level value the environmental and social aspect of niches, while they are more willing to put aside their differences compared to incumbent regime actors. While fringe actors are important, wider diffusion of niches require participation of regime actors, while sharing similar expectations is essential for further niche deployment. Hence, although they can act as tools for transformation, they are not *blueprints,* while their potential development is determined by multiple factors on the regime level (Smith et al., 2010, p. 441). Although novelties are crucial for the society, their introduction alone will not bring significant changes. For that to occur adoption is required, which implies active engagement and behavioural, organizational and societal change (Rip & Kemp, 1998).

Developments in the landscape level affect the stability of the regime, which is unable to accommodate those developments and lead actors to conflicts, opening a "window of opportunity" for novelties emerging in niches to infiltrate the regime level (Geels, 2002). In this context, transitions are viewed as non-linear processes, where different actors compete for specific technologies and policies to prevail.

Thus, these coalitions may lead to a reorientation of the transition pathway (Geels et al., 2016). Moreover, they are disruptive and contested since they challenge traditional business practices and incumbent actors often oppose to the realization of new solutions (Geels et. al, 2017).

According to Geels & Schot, (2007) there are four transition pathways, namely transformation, reconfiguration, technological substitution and de-alignment/re-alignment pathways. Although the simultaneous convergence of events occurring in all three levels was an important aspect in early studies of MLP, the authors introduced the concept of timing and nature and argue how they influence the transition pathways. Different timing between developments in all three levels can lead to different outcomes. If niche innovations are not mature enough to infiltrate in the regime, the *window of opportunity* may close.

In the transformation pathway, developments in the landscape create pressure on the regime level, where actors face challenges to respond to these new changes and a *window of opportunity* opens for innovations (Geels et al., 2016). However, the pressure is moderate, thus regime actors can address that by reorienting their activities, while niche novelties are not mature enough to break through the regime. In this process change, incumbents are also prone to radical novelties and may change their activities towards new opportunities, refuting the view that regime actors are "locked in" to the existing regime. The pace of the reorientation differs and relies on the influence from the external structure and potential market prospects, varying from *defensive hedging to reorientation.* (Geels et al., 2016, p.898). New regimes may develop out of old ones through increasing changes and reorientations, whereas radical novelties will be limited to niches (Verbong & Geels, 2010)

In the reconfiguration pathway, niche novelties align and lead to a restructuring of the system. Thus, this pathway is characterized by a symbiotic relationship between regime and niche novelties. The latter emerge in niches and are later integrated in the regime as "add-on" or replacement elements. The difference between the transformation and this pathway is that niches influence the regime structure and call for adjustments, while in the first niche innovations do not affect the regime architecture. Gradually, this may lead to technical and societal changes, such as user practices and perspectives (Geels & Schot, 2007). Although there is no major shift rather than integration on the existing regime, alignment of novelties may have cascading effects leading to more changes (Geels et al., 2016).

In the technological substitution pathway, novelties are constrained in the niche level due to stability of the regime. However, an external shock occurs on the landscape challenges regime actors, who are unable to address them, thus creating an opportunity for niches to infiltrate (Geels & Schot, 2007). Momentum and stability are essential for niches to use this opportunity. The innovation covers gradually a larger market, replacing the old regime leading to substitution pathway, while there is direct competition between actors on the regime and niche levels (Verbong & Geels, 2010). Moreover, niche novelties either adapt to the existing rules and institutions or the latter try to accommodate niche innovations. The first presents a "fit-and-conform-pathway", while the latter a "stretch-and-transform" pattern (Geels et al., 2016, p. 898).

In the de-alignment and re-alignment pathway, sudden change occurs in the landscape that creates tensions among incumbent regime actors. The actors question the viability of the existing regime, leading to a weakening and collapse. Geels & Schot (2007) use the word "vacuum" to describe the situation that emerges after this. In this pathway, uncertainty that arises following the destabilization of the regime leads to the emergence of multiple niche innovations (Verbong & Geels, 2010). However, niche innovations are not mature enough and lack of set rules lead to competition with each other, until one prevails and leads to re-alignment of a new socio-technical regime (Geels & Schot, 2007).

Transitions are non-linear processes and there may be a reorientation of the direction, since they are influenced by actors forming different coalitions and advocating for specific technologies and policies to prevail (Geels et al., 2016). Moreover, pathways are influenced by social processes. Hence, in a case more than one pathway can be found, and over time different transition pathways can take place. A transformation pathway precedes in most cases, where low pressure is put on incumbent regime actors, followed by a reconfiguration and de-alignment/re-alignment pathway, where cumulative pressure may have a more disruptive influence (Verbong & Geels, 2010).

Several criticisms have emerged throughout the years regarding the MPL as a theoretical framework. One of them is that MPL neglects agency and the role of power/politics in transitions. However, as Geels (2011) argues, agency is present throughout the MLP, since alignment and rules are enacted and reproduced by groups of actors.

3.2 Energy justice lens

Low-carbon transitions are often associated with inherently positive outcomes for the society since they reduce carbon emissions. However, studies have shown that they can also lead to the emergence of new inequalities and vulnerabilities, while they often neglect and are unable to address existing factors that enable injustice in energy markets and the society at large (Sovacool et al., 2019a). Hence, a transition towards a low-carbon energy system needs to take into consideration energy justice principles to ensure that regulatory frameworks and plans provide fair and equal access to clean and affordable resources and technologies (McCauley et al. 2019). Failure to accommodate the participation of all citizens in the energy transition can result in low representation in policy decisions and can create conflict and irritation, leading to further exclusion and injustices (Sovacool et al., 2019a).

As presented in Sovacool et al. (2016) energy justice refers to a global energy system that distributes the benefits and expenses of energy services in an equitable manner and aims at inclusive representation and transparency during decision-making processes. It entails three main aspects: distribution of externalities and benefits of the energy system in the society and fair procedures, characterized by an even representation in the decision making. Moreover, the authors view the energy system not solely as “black box”, but also as a mechanism of potential exclusion and uneven decision-making processes.

The energy justice framework involves four different spheres: distributive, procedural, cosmopolitan and recognition justice. Distributive justice focuses on the allocation of benefits and costs among members in the society (Sovacool et al., 2019a). The global energy system is disproportionate when it comes to the location of technologies and the accessibility of their outputs (McCauley et al., 2019). In detail, distributive justice seeks to understand how "social goods and ills" are distributed among members of the society, by distinguishing the goods and ills allocated, the groups that they going to be distributed and the most suitable way of allocation (Sovacool et al., 2019a, p.588). Distributive justice issues can further be spatial and temporal (Sovacool et al., 2019b). In low-carbon transitions, the concept of distributive justice can be particularly important and lead to a fair allocation of costs and benefits among participants within the energy system (Sovacool et al., 2019a).

Procedural justice seeks to identify the level of fairness on decision-making processes (Sovacool et al., 2019a). In procedural justice, the focus is on interrelated justice issues that entails recognition (who is recognized), participation (who gets to participate) and power (how is power distributed in decision making) (Sovacool et al. 2016, p.2). Recognition justice, also known as injustice of misrecognition, aims at identifying vulnerable groups, whose position in the society may deteriorate in light of processes, such as a transition towards low-carbon future. Moreover, the focus is how to ensure a fair representation of their perspectives, while aiming to understand the different particularities and securing equal opportunities for all (Sovacool et al., 2019a, Sovacool et al., 2019b). Fraser identifies three aspects of misrecognition, namely cultural domination, non-recognition and disrespect (Fraser (1999) in McCauley, 2019). Finally, cosmopolitan justice proposes that all humans are equally worth despite their different characteristics, i.e gender and ethnic identity (Sovacool et al., 2019a). Furthermore, it suggests that all justice principles should expand and apply to all human beings, surpassing border limitations. All these groups comprise a single community that share same moral beliefs. Although it pays attention to differences, it concludes that an individual is a member of global community (Sovacool et al., 2019b).

4 Methodology and methods

In this chapter, I will discuss the qualitative case study as a methodological approach. This study is based on eight semi-structured interviews conducted between 2 March and 19 of April 2023. My informants consisted of three academic researchers, a consultant in solar projects, a researcher specialized in solar technology, a prosumer, a municipality representative and a high-level solar business executive. By conducting semi-structured interviews, my aim was to gain an insight on the barriers, drivers and prospects on solar energy communities and the energy sector at large. Thus, through the interview guide I aimed to investigate barriers and drivers related to both the solar power and energy communities. Although the interviews give value in this study, the sample is limited, thus findings are not generalizable on their own. However, when paired with secondary data from grey and peer-reviewed literature, they gain some generalizability.

4.1 Logic of inquiry: inductive and abductive logic of inquiry

Research strategies can act as a guiding tool for a researcher on how to answer research questions. According to Blaikie (2009), the inductive logic aims to develop limited generalizations of observed or measured features of individual and social phenomena. Inductive inference starts with a case, continues with an observation and concludes with generalizations and establishment of patterns of regularities related to a broader set of actors or between phenomena (Blaikie and Priest, 2019, Dey, 2004). In this research, the interview guide aims to generate descriptions from actors about the development in solar sector and their perspectives on potential deployment of energy communities. Hence, part of this research employs an inductive logic to establish patterns of regularities that can explain certain phenomena.

Abductive logic of inquiry seeks to provide an understanding of a phenomenon rather than an explanation and concentrates more on reasons rather than causes. The primary focus of this research strategy is to identify actors' perspectives and understandings of their world that constitutes the important topic for the researcher

(Blaikie, 2009). The abductive logic pursues a “bottom up” approach by providing descriptions and understandings of actors’ perspectives than relying merely on researcher’s views (Blaikie & Priest, 2019). Moreover, according to Dey (2004), abductive inference provides an interpretation of specific phenomena and concepts rather than producing generalizable outcomes. Finally, abduction is seen as a way to “recontextualize, i.e., to observe, interpret and explain something within the frame of a new context (Danermark, 2002, p.91). The aim of this research is, through interviews, to provide a novel understanding of a known phenomenon, such as the development of solar power sector and further focus on its relationship with energy communities in a Norwegian context.

4.2 Selection of solar communities in Norway as a case study

I use a case study as a primary methodological approach to investigate the emergence of solar energy communities, identify the barriers, drivers and prospects, and potential justice implications. Different definitions of case study exist, while case studies vary in purpose and orientation, one of them being a research approach that develops a detailed, multi-faceted understanding of complex phenomena in their real-world contexts (Crowe et al., 2011). Furthermore, according to Yin (2009) a case study is “an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context” (p.47).

There are single and multiple case studies, while findings from multiple cases are often viewed as more compelling and allow for a comparative approach. The rationale behind the selection of a case study varies and depends on the researcher’s purpose and the availability of cases that are relevant to the research. One of the reasons can be the uniqueness of the case (Seale, 2017). The selection of my case rests not only on scientific interest, but also on the uniqueness of the case in the sense that solar energy is an emerging sector in an electricity system dominated by hydro, while the necessity of energy communities is underlined in the Norwegian context during public debates, challenging the current regulatory frameworks and initiating the design and planning of new policies that accommodate local power production.

One benefit when employing case study as a research method is that it allows us to gain a detailed insight of an individual, setting or phenomenon. However, if the case is atypical, the results may not be generalisable. Another issue is that case studies may require vast number of resources and time and they can provide possible cause-and-effect relationships without necessarily proving them beyond doubt (Seale, 2017). Although the limitation regarding time was considered when planning the timeframe of conducting the interviews, which initially was during 1-31 March 2023, due to the limited availability of informants the interviews were extended until 19 April 2023.

The issue of time was also critical in capturing all the events. Since Norway is in a transitional phase, rapid changes occur in regulations. Although I tried to capture and incorporate these changes in the paper, at times it was challenging. To avoid the second limitation, I will try not to draw conclusions based on a partially informed perspective given uncertainties related to the implementation of evolving regulations, but rather present and discuss the findings according to my informants' views on the topic and further triangulate them with secondary data examined in academic literature and reports. Notably, having conducted fieldwork at this critical juncture does offer a rare window into stakeholders' views even as a legislative basis to enable solar energy communities was being brought into place nationally.

4.3 Qualitative interviews

Interviews are considered as "conversations with a purpose" (Burgess in Seale, 2017, p.218) and according to Yin (2009) are crucial sources of case study data. Interviews are a form of communication that aims to generate data with individuals or groups of people. They range from structured to open-ended (Seale, 2017). Interviews constituted a significant part on this research and approximately 15 hours were spent to conduct nine interviews. Since the topic is broad and continuously evolving, this paper employed semi-structured open-ended interviews. According to Seale (2017) when asking open-ended questions, you are more likely to achieve better access on interviewees perspectives and understandings of phenomena. Moreover, compared to more structured interviews, semi-structured interviews allow the interviewer to become more visible and active participant in the process of generating knowledge (Brinkmann, 2018).

Two of the interviews were conducted in person, while the remaining seven were conducted virtually due to interviewees' location of residence. According to O'Leary (2017) interviewing online allows you to overcome geographical limitations. However, there are certain trade-offs that require consideration, such as technical difficulties related to the use of the specific platform or connection issues. When conducting one interview, I experienced an issue related to the audio system of my computer. Although this caused a ten-minute delay in commencing the interview, good communication with the interviewee allowed us to overcome this challenge. Another issue is that the setting influences the responses of the interviewees, while the use of remote meeting applications creates a distance between interviewer and interviewees. For example, Skype is referred to as "presenting an emotional barrier" due to technological hindrances (Seale, 2017, p. 230). However, during the interviews, I did not experience such issues. In total nine interviews were conducted between 2 March and 19 April 2023.

Table 1: A list of interviewed informants categorized by type and interview date (all interviews were conducted in 2023)

Informant ID	Type	Interview date
Informant 1	Consultant in solar projects	2nd March
Informant 2	High level solar business executive	9th March
Informant 3	Prosumer	10th March
Informant 4	Academia	15th March
Informant 5	Municipality Representative	16th March

Informant 6	Researcher specialized in solar technology	22nd March
Informant 7	Academia	24th March
Informant 8	Academia	19th April

Although I used an interview guide, interviewees were encouraged to talk freely about any relevant subject during the process, while more questions emerged when interviewing certain individuals. The interview guide included some general questions about: (1) solar sector in Norway compared to other neighbouring countries and barriers that hinder its development, (2) estimated increase in solar power capacity and implication in the current structure of the energy system, (3) solar systems, potential applications and its suitability in community owned projects, (4) solar diffusion as enabler of energy communities, and (5) barriers that hinder energy communities and potential challenges to address before initiating such collective energy projects. The selection of interviewees was based on their expertise and relevance to the research, while their recruitment was either purposeful or by snowball sampling.

Due to the sparse number of energy communities established in Norway, I managed to only conduct two interviews with actors more closely related to energy communities. As mentioned above, other actors were related to the solar sector.

When concluding the interview sessions, interviewees recommended other relevant actors as potential subject matter experts along with new sources of data in the form of news articles, academic papers and reports. Thus, since interviewees provided support during the process, they can be considered as informants and not merely as interviewees (Yin, 2009). Moreover, towards the end of the interviews of the first informants, I asked for recommendations for other possible subject experts. The informants were not only kind to recommend others, but also allowed to mention their names when contacting other potential informants through snowballing.

4.3.1 Coding and analysing interviews

In qualitative analysis data turn into findings, while the biggest challenge is to make sense of large amounts of data. As Patton (2002) puts it “sitting down to make sense out of pages of interviews and whole files of field notes can be overwhelming” (p.440). Through the interviews, I gathered a considerable amount of data. Before delving into coding and analysis, I transcribed the interviews in their entirety and transformed the audio files into text files. To create themes and codes, I used Quirkos, which is a qualitative data analysis software.

First, I started by identifying patterns in the utterances of my informants and developing initial themes and codes. Initial codes were “challenges in solar development”, “challenges for energy communities”, “solar impact on current energy infrastructure”, “Nordic region/Norway” followed by sub-codes such as “regulatory challenges”, “technical limitations”, “electricity prices”, “perception of public goods” among others. Quirkos helped me visualize these patterns, as it allows you to create bubbles embedded within other bubbles with different colours, while if one utterance was identified by multiple informants the size of the bubble grew, indicating that a number of people had mentioned the same thing. When choosing one of the codes, I could access the direct quote and the informant ID, while I could also download the coded data in an excel sheet, where I could further work with the data.

4.4 Ethical considerations

The main ethical consideration was related to the informants. As Patton (2002) states because interviews involve personal and interpersonal relationships, qualitative research may have a higher degree of interference than other inquiries, such as surveys or other qualitative methods. Thus, he provides a checklist of ethical issues to bear in mind during design, data collection and analysis. The first element is to obtain an informed consent. Before starting collecting data through interviews, I applied to the Norwegian Centre for Research Data (NSD) to get approval. When contacting potential informants, I attached the consent form, that included simple and understandable statements about the scope and the aim of the project, who would have access to the data and how data would be treated.

Before every interview, all informants provided consent to record the sessions, while during one interview the informant asked for reconfirmation that their statement would not be associated with identifiable information before proceeding to the statement. During the transcription identifiable information were removed and stored in a separate file, where access could be obtained only with a password, while numbers were given to informants when uploading their interviews in Quirkos. Access to that file required two-factor authentication that provides further security of the data.

Only on one occasion, after the interview ended, the informant did not provide the consent form, despite follow-up to check if it had slipped her mind. Thus, no data will be utilized in this paper from that informant.

4.5 Limitations and challenges during the data collection

The main challenge when pursuing a qualitative case study is to present the data collected in an unbiased manner. Thus, it is important to follow a systematic approach to avoid drawing conclusions based on biased perspectives. Another important aspect is that case studies require vast resources and time, which pose a limitation to me as a Master student, since there are time restrictions for collecting and submitting your final research (Yin, 2009). Moreover, the reflexive nature of the qualitative research implies that the researcher inevitably puts in something personal during the research and further in the results (Blaikie, 2009). According to Yin (2009) there are three principles to avoid or mitigate these challenges: (a) using multiple sources of evidence, (b) creating a database and (c) maintaining chain of evidence (p.163). This study employs multiple sources of evidence, such as primary data from semi-structured interviews and secondary data from academic literature, both peer-reviewed articles and grey literature, along with online news articles.

Moreover, a separate database was developed, where sources were placed in a chronological order, to maintain a chain of evidence.During the recruitment of the potential informants, I encountered other limitations that involved limited or no availability of interviewees and/or lack of responses when I tried to reach them. Part of this limitation may stem from my usage of English rather than Norwegian which I lacked adequate fluency in, something I was reflexively aware of as part of my positionality as a researcher. Four more interviewees were contacted; however, no further activity occurred.

5 Context

5.1 The Norwegian power system

The electricity sector is important in achieving climate targets, such as decarbonization. The Norwegian electricity system is entirely based on renewables, with hydropower being the dominant source. The system entails transnational interconnectors that secure energy supply and facilitate electricity exports, while storage in the form of reservoirs provides flexibility. Hence, the system is already decarbonized. However, since Norway is part of the EEA, they have to comply with regulations implemented to the sector in the European context (Inderberg, 2020).

Throughout the years, the electricity sector in Norway has driven industrialization and achieved economic prosperity within the country. Natural conditions for energy production, such as the high presence of hydropower resources, have influenced the shaping of the electricity sector (OED, 2023a, p. 38). The development of the sector can be divided into three phases. During the first period, from 1906-1945, a regulatory framework was introduced with the aim to secure national control over hydropower resources. At the same time, licenses were granted to public enterprises without time restriction, while licenses granted to private investors were valid for approximately 60 years. The second phase, between 1945-1990, is characterized by expansion efforts and high electricity consumption among dwellings and the industry. By 1960, almost the entire population had access to electricity. The third phase, from 1990 onwards is characterized by the liberalization of the market and the introduction of a new competitive electricity market (NVE & Norad, 2017). In 1990, the Energy Act was introduced with the aim to "ensure that the production, sale and distribution of energy takes place in a socially rational way". Although liberalization and deregulation of the market was a general trend among countries, where the key aspect was the privatization of power and network utilities, in Norway this aspect was negligible (OED, 2023a, p. 38).

The main stakeholders involved industries, municipality owned cooperatives and the government through the Norwegian Water Resources and Energy Directorate (NVE). However, state ownership through public entities has increased over the years and especially after the expiration of the licenses granted to private holders, reaching around 90% of the production (NVE & Norad, 2017). NVE was established in 1921 and was responsible for power generation and transmission. Following the liberalization of the market, the ownership was handed to public companies. Since the introduction of the Energy Act (Energiloven), energy authorities, NVE or the Ministry of Petroleum and Energy (OED) in case of appeal are responsible for licensing activities. Thus, licensing process also falls under "central state control", where energy authorities have a considerable power over decision-making. However, other national and regional authorities have the right to be heard or act as consultants (Gulbrandsen et al., 2021).

5.2 Grid under regulated monopoly

The Norwegian electricity grid entails three scales, namely transmission grid, regional grid and distribution grid (NVE, 2018). The first is governmentally owned and operated through Statnett, the Norwegian transmission system operator (TSO), while the regional and distribution grids are operated by nearly 130 grid utilities, known as distribution system operators (DSOs), which are mostly municipality owned (Inderberg et al., 2018). The majority of consumers are connected to the regional and distribution grids (NVE, 2018).

As mentioned above, the electricity system in Norway is based on renewable sources with electricity surplus that is exported to other European countries, substituting for fossil-fuel. Hence, there is no need for decarbonizing the electricity sector. Despite this, full electrification efforts that will require greater amounts of electricity generation, the need for diversification in the energy mix, technological advancements and pressure from the EU can challenge the current infrastructure (Gulbrandsen et al.2021, Inderberg, 2020).

5.3 Prosumers and prosuming regulation in Norway

According to NVE there were no officially registered prosumers in Norway prior to 2011. Until 2010, anyone who produced and distributed electricity back to the grid had to register as a power plant, while prosuming activities were not allowed (Inderberg, 2020). In March 2010, NVE allowed for the first time prosuming activites through a general exemption. Through this exemption, prosumers were no longer required to register as power plants, which led to a significant reduction during application procedures among other benefits. However, connection between a prosumer and the grid was under the control of the grid utility, which was not mandated to allow connection. The first regulatory framework to define prosumers entered in 2017, where prosumers were defined as end-users who can produce or consume electricity behind the point of grid connection and where the electricity does not exceed 100 kWh. With the introduction of this new regulation, DSOs were mandated to connect prosumers to the grid (Inderberg et al., 2018).

The main prosumers in Norway, also known as plus customers (plusskunder), are households and businesses with solar panel or wind turbine installations. A connection and a rental agreement with a network company are necessary so that plus customers can sell their excess electricity production. There is no fixed rate for the electricity sold, while the price depends on the agreement made by the power supplier. Although plus customers have to pay for grid rent for electricity purchased by a power supplier, they do not have to pay for consumption of self-generated electricity, while additional remuneration is provided by the network supplier to prosumers for their contribution to the grid and are exempted from paying the grid tariff for delivering excess production (SSB, 2022).

During the period that the data were collected from 2019-2021 there was an increase in the number of prosumers, more than 150% reaching 6.100 (SSB, 2022). The latest data, from December 2022 indicate that the total number of plus customers have reached nearly 17.000, where the majority of them is households and a small number of business customers (NVE, 2023). According to data from Elhub, most of the prosumers reside in Viken county, followed by Adger, Rogaland, Vestfold and Telemark among other locations, while prosumers lived in larger dwellings, had higher incomes and owned a greater living area (SSB, 2022). Although the prosumer policy enabled end-users to pursue energy activities, the lack of shared metering between end-users residing in apartment buildings hindered collective energy projects. Thus, issues emerged regarding prosuming potential in housing associations (Inderberg, 2020).

Norway has established its own laws regarding energy communities and citizen participation in the energy system. The Energy Act has been revised to incorporate the third energy package and was implemented in 2019. In detail, article 3-1 states that a license is required for all installations that produce and distribute electricity, while it is under the authority of the Norwegian Energy Ministry to decide "how high voltage or what installed power an electrical system must have for the first paragraph to apply". Thus, energy communities would need to apply to pursue energy production activities (McElhinney et al., 2022, p.5).

Two additional and more detailed regulations are the Energy Act Regulation (Energilovforskriften) and the Energy Market Regulation (Energimarkedet-forskriften) to secure that production and distribution of energy are performed in a socially reasonable way and to secure market stability and effectiveness. Hence, from the above mentioned it can be derived that the Norwegian state has authority over almost all the regulations related to the energy system (McElhinney et al., 2022).

6 Findings and analysis

6.1 Barriers to the rapid diffusion of solar energy communities

Before delving into the presentation and analysis of barriers for solar energy solar, I provide a summary overview (Table 2).

Table 2: Summary of barriers for the deployment of solar energy communities and related implications. Source: Author's work.

Barriers to the development of niche	**Implications**
Hydropower dominance and associated low-cost electricity	No immediate need for diversification in the energy mix which hindered exploration and investments opportunities for alternative technologies
Dominant energy narrative and public ownership of natural resources	Perception of electricity as common good, trust between citizens and the electricity sector, disconnection between value and electricity and skepticism in collective energy activities
Organization structure of housing companies and concerns about monetary compensation	Hindrance for investments and operation of collective energy projects
Intermittency of renewables and grid companies' concerns regarding the operation of their activities	Threat for system balance, potential lack in grid capacity to accommodate the integration of RES, delays in handling

	requests for grid capacity and network connection
Traditional business model and network redistribution concerns	Lack of engagement with end-users and increased network costs for non-prosumers
Lack of regulatory frameworks	Hindrance on electricity sharing activities for properties with more than one individual metering point
Lack of coordination in implementation of policies in the EU and Norway	Delays in implementation of the directive that enables energy communities
Lack of strong support schemes	Low profitability of solar systems for energy communities that results in low investment interest

Hydropower dominance and historically low-cost electricity

Hydropower dominance and associated low-cost electricity were identified among the biggest barriers for the deployment of solar power and the entry of other actors in the market. Informants mentioned that in Norway the design of the electricity system is adjusted to hydropower production, that provides power in a clean and affordable manner. The electricity prices within the country have historically been lower when compared with other countries in the Western Europe (Inderberg et al., 2020). Reliance on hydropower created barriers for other renewables' entry in the system, while recent investments in wind have left a small room for solar development and have hindered participation of other actors in the market. According to informant 6, a researcher specialized in solar technology, the belief that there is enough hydropower coupled with the belief that electricity is always going to be cheap led to further stabilization of the system. As he shared during our conversation, “for my first decade in PV, the whole assumption was that we have enough power, and it doesn’t make sense to turn off nicely working hydro to make room for solar, why on earth should we do that?”.

Low-cost electricity has hindered diversification in the power mix since it favored continuous investments in hydropower. Moreover, since the electricity sector has been already decarbonized, there have been no discussions about other forms of energy activities and their potential contribution to the current system. Thus, as informant 1 expressed “so, when you don’t have a problem, you don’t look for solutions”. These accord with findings in other studies that focus on solar energy and housing associations in Norway, where they mention that profitability of solar installations relies on electricity prices, indicating that high electricity prices can lead to more cost-savings. However, historically low electricity prices have resulted in low interest for investments in solar systems in the Norwegian context. This is particularly relevant for housing associations, since the investment opportunities are less attractive compared to those of detached houses (Lindberg et al., 2022)

Furthermore, the number of actors in the hydropower sector has grown over the years forming a more dynamic presence, while extensive networking in relations and resources, have led to a more robust regime. In contrast, low presence of actors in the solar sector and small number of solar prosumers have formed a weaker sector with limited competition in the energy market. One of the reasons behind this low diffusion is that there is a lack of experts in the solar sector and the lack of knowledge when it comes to the performance of solar systems under Norwegian climate conditions. Informant 1, a consultant in solar projects, raised his concerns about the lack of workforce and the need to build further expertise, “but we need more people to be able to translate these different languages [between architects, engineers, consultants and people] and we don’t have that”, while the latter was also supported by informant 2, an executive of solar firm, “you need more skilled people to install solar”, who also urged that the government should introduce new educational programs to train more people.

Moreover, low dissemination of information about solar systems in the country poses a barrier towards their diffusion. As informant 3, a prosumer, mentioned “I think there is so little too about solar among people, so they think solar? There is no sun here, it’s raining all the time”. Informant 1 further stated that misconception about low efficiency of solar systems coupled with high initial investment costs make people question the feasibility of solar installations, while informant 8, a researcher in energy communities, advocated for the need of higher dissemination of information that have to be provided in a different manner, tailored to the community level:

“There needs to be better information, the information has to be given at a level for grassroot initiatives, so that requires that you provide information in a different way, like they would have different questions and they will have different understanding than the energy actors that are already there”.

To sum up, hydropower dominance and low-cost electricity have hindered exploration for alternative technologies, such as solar systems, while low number of actors present in the solar sectors coupled with low dissemination of information about solar projects have resulted in less interest in investments.

Dominant energy narrative, ownership structure of natural resources and the perception of common good

In Norway, the dominant energy narrative views natural resources and cost-efficiency as key priorities for the operation of the power system. This idea of cost-efficiency is further supported by reliable and affordable power supply, even in difficult climate conditions, while the ownership structure of the system, where the majority of natural resources are owned by public authorities, such as municipalities, means that the distribution of financial profits derived from those will also apply to citizens (Standal & Feenstra, 2022). The latter has nurtured a relationship of trust between the electricity sector and the customers. Informants highlighted the high level of trust. During our conversation with informant 3, he expressed his trust to the energy companies, since they are to a great extend publicly owned, while the revenues benefit the municipality and thus the citizens “so in my head [grid company operating in a specific area] is already part of a kind of a democratic system”.

When compared with other countries, where there is strong presence of collective energy initiatives, such as Germany, informants talked about the different context in the Norwegian society. Informant 4, a researcher, shared her experience when interviewing people in Norway “Norwegians speak about electricity as if it was our rivers, our common nature, so it’s kind of common property”, while the sense of electricity as a collective good was also supported by informant 5, a municipality representative. Moreover, they mentioned that there is lack of political incentive in the sense that in Germany people opposed to fossil fuel dominance and investments in solar were seen as alternatives to that, while in Norway this political incentive is not present.

Furthermore, the low electricity prices coupled with high availability of resources for power production have resulted in disconnection between value and power. Informant 5 talked about citizens’ high reliance in affordable and readily available electricity and how that hindered investments in solar projects, while informant 3 and 6 mentioned that the experience in high electricity prices, especially the last two year, have resulted in more people realizing that electricity is valuable. These findings are in line with research on end-users, such as in Winther & De Lesdain (2013), where they found that Norwegian citizens perceive electricity as green and clean and do not connect it with financial concerns, while they are not preoccupied with the idea to reduce their electricity consumption.

Scepticism towards collective energy initiatives

Another barrier that emerged due to the energy mix in Norway and ownership structure of the natural resources is the scepticism in collective energy activities. Informant 3 was sceptical about the concept of energy communities in Norway. He talked about how in a different energy mix, he would consider pursuing energy activities with his neighbours, but given the current context, it seemed impossible for him to ask the neighbour “but if I go to my neighbour, he would say: what the **? I use hydro, renewable, it’s renewable, what’s the problem?” and advocated that a different narrative is necessary to incentivize people in Norway to engage in collective energy projects. Furthermore, informant 5 talked about the design of the cities and how that can affect the engagement rate of different actors in energy activities. She spoke about how in smaller cities with no densely populated areas, investing in a solar would be more of an individual choice, since the households would be far from each other "you don't have the same social effects of imitating your neighbours as you would in a more densely populated place."

Organizational structure of collective properties and future tensions

The organizational structure of collective properties may also hinder engagement in community projects. As informant 4 argued, ideally community ownership, where people decide equally on projects could be beneficial, however, according to her experience "in practice is bound to be conflict, is bound to not having enough resources to fix things", which will create tensions in the future. Moreover, she raised the issue of monetary compensation for people who are responsible for the organization of such collective activities. The form of organization of collective properties was also identified as a barrier in Lindberg et al. (2022) since a collective project require the majority vote from residents to be implemented. This is sometimes difficult to achieve as residents have different characteristics.

The grid companies as gatekeepers

As stated above estimates from NVE indicate a growth in solar power development by 2040. This will affect the current system and will come with certain challenges. Grid implications were identified as a major challenge for the growing solar sector and the entry of new actors. Informants raised the issue of complexities for grid companies, due to growth in solar and disperse generation units. Informant 3 mentioned that aspirations of increase in hydro, solar and wind power, due to increased electricity demand, may cause lack in grid capacity that can accommodate these new streams of power production. Although DSOs operate as regulated monopolies, thus not being used to competition, they are still not *interest free*, meaning that they own and operate the distribution grid with the responsibility to provide electricity to customers and maintain system balances. In addition, their activities are subject to media control, hence they try to avoid grid imbalances (Inderberg et al., 2020, p.6).

Similar concerns were also present in the report from THEMA Consulting group on behalf of Renewable Norway (Fornybar Norge), a nationwide interest organization for the renewable energy industry in Norway. In the report they mentioned that higher number of decentralized production units and new flow patterns, create challenges to the existing grid infrastructure and underlined that effective coordination between TSO and DSOs in operational phases is considered essential to address these challenges (THEMA, 2021). Furthermore, informant 4 shared the experience when interviewing some grid companies, stating that they could adapt their activities to a limited number of households being connected and delivering excess electricity production to the grid, whereas a high number was considered as a threat to the stability of the current grid and could lead to potential increase in their workload. Moreover, she continued how grid companies are so accustomed to their business-as-usual model, which makes them hesitant to include more actors in the market. As she stated "but it can be their way to say that we want to do it as we always have done, with few actors involved in a way, it's very efficient you know, the old grid. They were so used to where to buy the power and what to do and their routines were so set".

Informant 5 shared the experience of the DSO that operates in the region where she lived. The DSO tried to benefit from distributed systems, but the unpredictability during the operation of those systems created challenges, both technical and financial, when it came to balancing the grid. As she mentioned "suddenly they have to go from a system, where they relate to a few producing generation units to kind of potentially thousands that have no predictability…and that is very hard and very costly to run a system". Along this line, informant 1 highlighted how intermittency of solar power and the associated limitations during the night or when the sun is absent can jeopardize the stability of the system. Furthermore, delays in processing requests regarding the cost of connection and the grid availability act as bottlenecks for the development of solar projects. Informant 6 emphasized how lack of communication between grid operators and solar project developers can cause huge delays in project initiation. In his words:

"they [grid companies] are becoming increasingly out of tune with the development and if you look at the process times…it's easy to define funding but you have no clear [answer] whether you will be able to find space on the grid and what it's going to cost to get connected to the grid, and those answers take an insane amount of time".

Both Statnett and DSOs have experienced a recent increase in inquiries from customers about network connection and the network capacity, which have led to the exploration of new ways that enable shorter handling processes (THEMA, 2021).

Limited engagement with end-users and concerns about network rent redistribution

Network companies' reluctance to enable new actors in the market or more distributed power systems has affected the pace of solar rollout within the country. According to informant 7, a researcher, grid companies are quite traditional and operate as monopolies, thus they are not used to openly communicate or engage end-users into their current business model. Moreover, the sense of responsibility to provide secure electricity supply, which lies upon them, and the lack of remuneration for accepting disperse solar production in the grid created economic challenges. The latter was also raised as an important issue in the proposal from the Regulatory Authority for Energy (RME) on behalf of the NVE. The proposal suggested a change to allow online customers located in the same building to invest and share renewable electricity with a limit of 500 kW per property. However, in the same document they highlight the need to draw upon clear geographical delimitations regarding the properties. They proposed that these changes in regulations should be limited to one property and be in accordance with property boundaries as suggested by the Mapping Authority (Kartverk), so that grid companies could avoid implications in the case adjacent buildings could be considered as one property (RME, 2021).

Moreover, they claimed that this could lead to a better redistribution of the network rent, an issue that emerges due to properties being exempt for paying the grid component for consumption of self-generated electricity, that leads to an increase in network costs for the rest of the customers (RME, 2021). This issue was also raised by informants. In particular, informant 1 mentioned a scenario where he invests in a solar system and the implications that this will bring to grid companies “the things that happen by having a PV system [is], I will use less transmission lines, I will use less power from hydropower and so on. So, who will lose from this PV system?”. Furthermore, informant 8 mentioned that high number of decentralized units will lead to loss of income for grid companies, and as they operate under regulated monopoly, they will not cover it themselves “which then is an income loss for the grid companies, which other consumers have to take that loss…they have to distribute this cost to everyone else”. In the case that energy communities proliferate, there will be further cost increases which will affect consumers that will not/cannot participate in these collective energy activities, creating justice implications.

Grid development as necessary precondition for a diversified energy mix

Furthermore, upgrading and expansion of the grid are highlighted as a necessary precondition for increased integration of solar into the electricity mix. However, informant 5 expressed her concerns about the lack of informed discussion in public debates regarding the upgrading of the grid and how that can lead to a deceleration in grid development.

In Norway, following the introduction of the 3rd Energy Package, Statnett is a member of the European Network of Transmission System Operators for Energy (ENTSO-E) and collaborates with the TSOs present in the Nordic and European region in topics such as future network development. However, development plans in those regions are not binding in nature and each country decides individually about their investments (RME, 2022a). Nevertheless, in the Nordic grid development scenario, which presents the development of the Nordic electricity grid by 2030 and 2040, the need for more power and investments in the current grid infrastructure is highlighted as key priority to achieve climate neutral goals either through strengthening the current lines with additional ones or through increased flexibility. Moreover, the latter is seen as essential to accommodate the increase in volatile power flows, prices and capacity issues to secure efficient operation of the power grid (ENERGINET et al., 2021).

Lack of regulatory frameworks as hindrance for solar energy communities

Lack of regulatory frameworks that enable sharing of electricity between meters in the same property or between properties is identified as the biggest challenge for solar communities in Norway. As stated above, the plus customer scheme until now allows only individual households to pursue and benefit form prosuming activities, while power production exceeding 100 kW is subject to additional charges. Informants underlined the lack of sharing between meters as a big obstacle, especially for those residing in housing associations (borettslag). Although there is great potential for housing associations and commercial buildings to yield electricity from solar due to large rooftop surfaces, the lack of policy acts as a hindrance. As informant 4 puts it "so, it's a big issue that people are not able to share and effectively excluding energy communities. If you can't have the same meter for different type of, you know, entities, then you can't have a joint installation", while informant 1 expressed his concerns about the new regulation that will finally allow housing associations and other types of properties that include more units to invest and benefit from a joint installation "we have this project open with them [housing association] but they are waiting for this new regulation to come, how they are going to shape it".

These findings are in line with those in Lindberg et al. (2022), where the authors indicate that the main challenge for housing associations and other properties with more than one metering point is the lack of opportunity to consume self-generated electricity, unless they pay the network component, the electricity tax and the value-added tax (VAT). Hence, these type of properties can install solar installations, but the utilization of power from those resources is limited to communal areas. Since consumption in communal areas is minuscule, the benefits will be low and insufficient to trigger investments. Although a solution is available to address these limitations in Elhub, the virtual measurement, an IT system introduced by Statnett in 2019, only two housing associations have been granted the license to implement it for learning purposes.

In the same proposal presented above from RME, they mention how the number of solar systems present in detached households or properties with one individual metering point have increased throughout the years and suggest that the same opportunities and benefits should expand and apply to other types of collective properties. Thus, they recommended a change to allow online customers located in the same building to invest and share renewable energy with a limit of 500 kW per property. As stated above, the proposal highlights the need to draw clear demarcation of properties, meaning that sharing between different buildings is not allowed (RME, 2021).

Lack of coordination in implementation of policies between the EU and Norway

Moreover, the lack of coordination between policies implemented in the EU and Norway creates further challenges for the implementation of renewable energy communities within the country, since Norway is not part of the EU, meaning that the directives are not automatically transposed in the Norwegian legislation. When talking about the directive that enables RECs and its lack of implementation in Norway, informant 5 mentioned that delays on implementation have a negative impact in the regional and local level. Delays prevent policy actors in those levels to understand and tailor the directives in a specific area, thus affecting their successful implementation. Moreover, she mentioned that there is lack of workforce to implement those directives. According to her:

“We just come and, you know, someone gives a paper that makes no sense to us and we have to find a way to make it happen without any plans of procedures or routines or mandates and there’s no clear kind of responsibilities and roles are not clarified in Norway, so most people would assume that the renewable directive would automatically implement itself by Enova giving more kind of grants and subsidies but that’s not how it works”.

Insufficient support scheme to trigger investments in collective energy activities

Lack of strong support scheme is considered another barrier for investments in solar projects. As informant 7 expressed, financial support schemes from Enova have been quite modest, while financial incentives present in other countries, such as the feed-in tariff have not been implemented to trigger high number of investments in solar PVs. Enova, a state enterprise, has provided the main support scheme, where partial remuneration is given to prosumers for their investments. The support, which covers 35% of documented total cost, increased in early 2022 from NOK 26,250 reaching up to a maximum of NOK 47,500 (MN, 2023). However, due to regulations, access to this support scheme was limited to household owners of detached or semi-detached households and some commercial actor. The latter coupled with a long payback time for a solar installation within the country, due to low remuneration for excess production and low self-consumption during winter when energy is more needed, have hindered many households who are unable to meet the initial investment costs (Standal & Feenstra, 2022). Although housing associations can apply to this support scheme, same as commercial buildings, it is more challenging for them since they do not share the same resources.

Moreover, according to informant 4 the support scheme was focused on new technology and not scaling on a level where all people can engage "Enova [has been focused to] support the next type of technologies and those forerunners are not the poor people, those are the middle class or upwards or engage, maybe in, through work with these kind of technologies". Along similar lines, informant 8 also claimed that the support scheme is enabling people with higher incomes and bigger houses "I think that the incentive schemes, like Enova's, is geared towards villas and private consumers and not the community initiative". Although it is difficult to verify these claims, data from SSB (2022), during 2019-2021, indicates that prosumers in Norway are those who lived in larger dwellings, had higher incomes and owned a greater living area.

6.2 Drivers for deployment of solar energy communities

Before the presentation and analysis of drivers, I summarize them in tabular form (Table 3).

Table 3: Drivers for the deployment of solar energy communities and outcomes. Source: Author's work.

Drivers for the deployment of niche	**Outcomes**
High electricity prices since the end of 2021	Increased interest for investments in solar installations to reduce energy costs
Regulatory changes driven by the need to increase local energy generation and high interest among people to pursue energy activities	Create favourable conditions for the emergence of solar energy communities
Emerging financial support schemes at the municipality level	Strong investment incentives for solar projects
Introduction of new business models from solar installing firms	Mitigation of transaction costs that leads to lower threshold for investments in solar energy communities

High electricity prices as enabler for investments in solar projects

Increase in electricity prices was identified as the major driver for the development of solar projects and the entry of new actors in the market. In Norway, the power price is determined by several factors, such as the filling in the water reservoirs, the share of renewables in the energy mix, the temperature that affects the demand for power consumption and the trading capacity with other areas. The electricity price has increased, especially from the last half of 2021, due to dry weather conditions and low level of import capacity on NO1- SE3[2], while high electricity prices in the European area resulted in higher prices in Norway as well. This created a divide between the power prices present in the north and the south (RME, 2022a).

During the same period Norway experienced the highest annual average spot price, which reached 60 EUR/MWh, while average spot prices in the north were 35

[2] The Nordic grid entails several corridors. NO1 (Southern Norway)-SE3 (Southern Sweden) is one of the four Norwegian-Swedish corridors. Source: ENERGINET et al. ST(2021)

EUR/MWh and in the south 75 EUR/MWh (RME, 2022b, p.6). The following year, the increase in electricity prices was even higher, reaching a 6% increase from 2021 and 32% higher than the average prices over the last five year, while higher electricity prices were also present in the north of the country by the end of 2022. To mitigate the impacts of high electricity prices, the government introduced the electricity subsidy in December 2021, that provided partial reimbursement to households (Holstad, 2023). Figure 3 visualizes these trends for recent years.

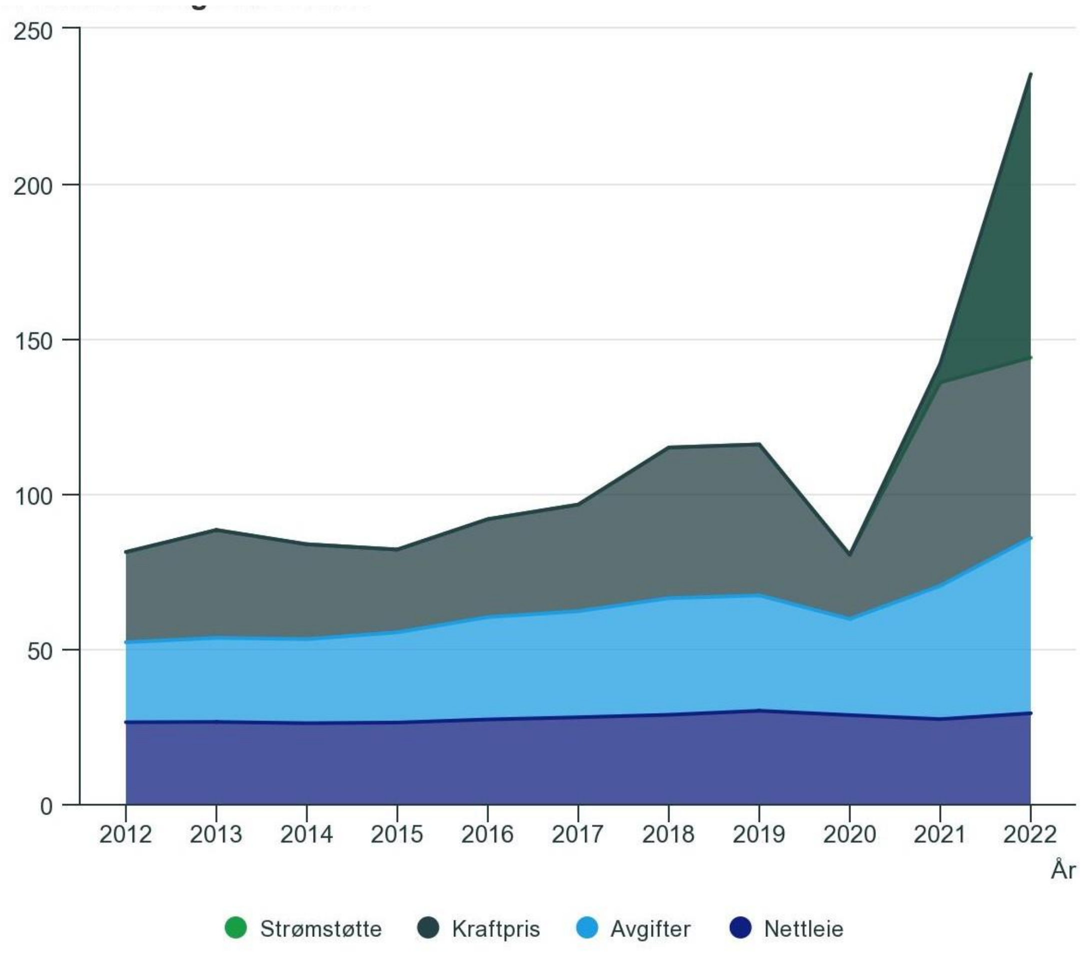

Figure 3: Electricity price, network rental, taxes and electricity support for households. Ore/kWh. Electricity price (dark grey), network rent (dark blue), taxes (light blue), electricity support (green). Source: Holstad (2023)

There is a correlation between the increase in electricity prices and higher number of people investing in solar systems in an attempt to reduce their electricity costs. Informant 1, who specializes in solar projects, discussed how demand from people has increased especially the last two years in the sector “the number of inquiries that they receive exploded. All the companies are booked six months [from now,(the interview was conducted early March)] from citizens", while the same demand was also present in housing associations. He continued "and the board [from the housing association] comes to us, this push from citizens…citizens are interested and willing and pushing towards citizen participation in solar communities". Moreover, informant 7 mentioned that high electricity prices have resulted in loss of trust in grid companies or the electricity sector in general, triggering more actors to actively participate in the electricity sector. This growth in demand for solar installations is also acknowledged by Enova, which saw an increase of more than 130% in applications for financial support (Granbo, 2022).

The need for local renewable energy production and increased interest among people for energy activities as drivers for regulatory changes

The government, driven by the need to increase renewable energy, local electricity production and people's interest in energy production activities, announced that the limit of solar installations would be up to 1,000 kW and confirmed that the plus customer scheme would allow the entry of other types of housing and commercial properties. As stated by the Oil and Energy Minister, Terje Aasland "it is important for the government to increase the production of renewable energy. There is increasing interest in local energy production, and especially through the use of solar cells. I am happy that now we can make better arrangements for this" (OED & FD, 2023).

The recent press release from the government confirms that the regulatory changes regarding sharing of self-generated electricity between customers in the same property will be introduced on 1 October 2023, to provide room for network companies to adjust their activities and point out that the grid companies should adopt new measures to accommodate the changes in the sharing scheme (OED, 2023b). In the document regarding these changes, they further specify in the section 3-12 "Obligation to register the sharing of production" that the notion of same property entails the same municipality, farm, utility number (OED, 2023c).

These new regulations were welcomed by organizations, such as the Co-operative Housing Federation of Norway (NBBL) since they allow housing co-operatives to install and benefit from solar systems on their roof. However, they expressed their desire for an increase regarding the 1 MW limit and expansion of the regulation to allow sharing for more than one individual property (NBBL, 2023). In contrast, other actors expressed their disappointment on the new regulations. In particular, a manager of two large warehouse buildings in Trondelag mentioned that, although the two buildings share the same owner and operational activities are similar, they are not allowed to share electricity between them, despite the close proximity, since they are under different utility numbers. Thus, they have to deliver the excess electricity back to the grid and purchase it at a higher price (Thobroe & Lindsetmo, 2023).

Emerging financial support schemes at the municipality level

A new support scheme has emerged since last year. The municipality of Oslo offers a new subsidy to housing associations, condominiums and commercial buildings who want to invest in solar PV. The amount of the support scheme can be up to 35% of the total cost of the installation, while it can be utilized for other purposes, such as during the purchase process or for advice. The application period started in early fall 2022 and will continue until the end of December 2023 (Klima og energifondet, 2022). Informant 1 supported this new scheme, which according to his perspective, makes a solar project more profitable "with this support from Oslo kommune [Norwegian word for municipality], this levelized cost of electricity is always going to be less than the spot price of the grid, which means that it will always be profitable", while informant 5 mentioned that the municipality where she is employed is looking to introduce a similar support scheme and expressed her desire for successful implementation. However, informant 8 argued that the support scheme will not be sufficient to trigger deployment on a national level if not adopted by all municipalities, while she advocated for its introduction in larger cities.

Solar installing firms introduce new business models to reduce the investment threshold: purchase, leasing and long-term down payments

Although in Spasova & Braungardt (2021) their findings indicate that higher disposable income among citizens can lead to further investments in renewable energy projects and can enable the creation of energy communities, in Norway the high up-front costs of solar systems have hindered their adoption. High up-front cost coupled with long payback time periods can create reliability issues among customers. Thus, low-risk investment opportunities and established models from companies that provide solutions are necessary to address these challenges and facilitate diffusion of solar PVs (Strupeit & Palm, 2016).

New business models have emerged throughout the years to engage more customers to invest in solar projects in Norway. One of them is leasing. Through leasing, a non-ownership business model, the customers can avoid the initial investment for the installation of solar panels. In this model, the company charges a fixed payment every month (Agrawal et al., 2019). Otovo, an installation company based in Norway with operations on an international level, provides not only the direct purchase option but also leasing. Shortly after being established, and with minimal promotional campaign, the company received 800 applications from prosumers. This models resembles the “free solar” business model established in UK, where companies provided solar installation to households at no cost, through leasing (Inderberg et al., 2018). Under leasing, Otovo is responsible for the operation of the solar system for 20 years, while in the purchase option they provide warranties of up to 10 years, which is higher than the average warranties provided by the industry. Moreover, they provide the opportunity of future purchase of the system (Otovo, 2023). Business models based on ownerless structure can enable new actors with limited financial assets to invest in a certain technology, while long-term warranties in the purchase option can shift the responsibilities from consumers to companies (Strupeit & Palm, 2016).

Leasing was identified as a potential driver that enables citizens to overcome the high financial threshold and engage in more solar projects. Informant 6 supported this business model “I do appreciate some of the companies trying to develop new business models, like leasing, like other things and I think we’ll see more of that, because I think that is probably one of the ways we to get the same for the system”.

However, informant 1 was sceptical about the ownerless structure of this business model and advocated that alternatives, such as loans, may be better a better solution for citizens to invest in solar systems “I know that some banks, like [bank name], they have some loans, really good loan with good [interest] rate. So, when there is such a solution, why should you lease?” The latter is also supported in Strupeit & Palm (2016), where they mention that although result-oriented product-service business model reduces financial barriers, there are certain trade-offs that require consideration, such as the internal costs of a firm that still need to be met by customers. Hence, they argue that owning a PV, partially financed by a loan, may be more profitable.

Another business model that may facilitate further investments in solar systems is down payments that require monthly payments over a longer period. Informant 2 mentioned a company operating in a certain area and how their business model can tackle financial impediments “ they have five years down payment with no interest rate, so you can split the payment during five years in 60 months, which makes it a bit easier, it takes down the barriers to invest for private customers”. These findings are in line with Inderberg et al. (2020), where they found that solar installing companies and business models, such as leasing or direct purchase, can facilitate the process of installing a solar system, by reducing transaction costs and providing information.

6.3 Norwegian electricity system: what does the future hold? Combination of hydro, solar and wind, decentralization, increased flexibility and the need for storage

Electrification and associated increase in consumption, higher presence of variable renewables in the electricity mix and the entry of new actors in the energy market will lead to a much more dynamic energy system. Most informants stated that the future of the Norwegian energy system will be based on the combination of hydropower, solar and wind power, both onshore and offshore. As informant 5 puts it: “it’s hard to imagine an energy system that doesn’t eventually include all generation options”. The majority of informants argued that there will be higher presence of solar. In particular, informant 1 mentioned that the main trend in

Norway will be the installation of solar systems in urban areas, since the license application for utility-scale solar until now is challenging, while informant 6 argued that if barriers that hinder solar development will be removed, this will be especially beneficial for prosumers “I really think that where we remove the obstacles that makes especially power from solar much more used…[we] will have hundreds of thousands of flexible prosumers actively contributing to the green transition”.

Norway’s energy system presents a big advantage, since hydro can be used to complement solar power, by providing storage capacity and flexibility. Informant 1 talked about how the intermittency of solar can be monitored when combined with hydro “the good thing with the hydropower is that it has a really fast response, if you can’t get power from solar, you can use hydropower to cover it”, while informant 2 mentioned how magazines can be used for storage purposes and further argued that this can be an advantage for Norway when compared with other countries “I think, [it’s] much easier for Norway than a lot of other countries, like the UK, where they struggle already with a lot of renewables that they don’t have much baseload power, as they used to have”. These findings accord with the grid development perspective present on ENERGINET et al. (2021), where reservoir hydropower will play a key role as a source of flexibility in the Nordic region until other flexibility options become mature enough, since hydropower has the ability to quickly adapt to production needs at low cost, while it can be further utilized for storage purposes.

Moreover, the findings indicate that there will be more pockets of decentralization. As informant 7 stated “in terms of being central/decentral, it’s going to be a much more complex system regardless…it’s going to be more decentralized”. Informants also supported that battery technology will play a crucial role in decentralization. Although they mentioned that batteries are still quite expensive, they argued that cost reductions due to technological advancements will lead to wider proliferation. Batteries can be also used in combination with solar systems to cover electricity needs during the night or when irradiation levels are low.

In a recent survey conducted by YouGov on behalf of Eaton Norge, a power management company, more than 50% of Norwegian consumers expressed their desire for Enova to provide financial support that covers some of the costs for battery installation, advocating that battery technology can lead to cost-savings for households, while the National Association of Homeowners (Huseiernes Landsforbund) argue that this will further benefit the grid operations (Kunøe, 2023).

However, informants expressed their concerns about grid implications due to higher presence of decentral production units and increased integration of variable renewables and how these can lead to lack of grid capacity. Hence, informant 5 questioned the aspirations about increase in renewable power production "and I don't know if it makes sense to develop that kind of capacity in Norway if there's no grid to take it".

7 Discussion

7.1 Transition in a multi-level perspective: solar energy communities as niches in relation to the electricity regime

According to Geels et. al (2017), transitions occur through the interplay and alignment of developments at three levels, the landscape, the regime and the niche level. Thus, it is necessary to identify these events to understand how a transition comes about. Changes in the landscape level create tensions on the regime and open a "window of opportunity" for niche innovation to emerge and permeate in the regime (Geels, 2002). In this part, I will discuss the emergence of solar communities in a multi-level perspective. Solar energy communities are viewed as niches that try to permeate the electricity regime, while high electricity prices, electrification and increased consumption are seen as developments in the landscape level that trigger pressure on the regime. Before proceeding, I will restate the main research question:

RQ 1: *"How do solar energy communities emerge"?*

The landscape

As Verbong and Geels (2010) argue early landscape pressures on the existing electricity regime can be the neo-liberal ideologies, such as privatization, deregulation and liberalization. Further pressure derives from alarming issues, such as climate change and associated impacts, resource scarcity and security of supply that challenges the feasibility of the electricity sector. In the Norwegian context, liberalization in the 1990s and more recently, transition towards a more sustainable future in the form of increased electrification, which implies higher consumption, can be considered as landscape developments that create pressure on the regime. Norway has committed under the Paris Agreement, together with other Member States from the EU, to reduce carbon emissions by 55% compared to 1990 level (OED, 2023a). This means that Norway does not act on its own but is rather part of a bigger context with common goals.

Estimates from Statnett's network development plan indicate that there will be an increase in consumption by 2040, reaching 220 TWh compared to 140 TWh due to electrification efforts (Statnett, 2021). In this line and driven by climate change, the Energy Commission report, introduced in 2023, indicates that Norway may experience a situation of power deficit in the immediate future, while it recognizes the necessity for more renewable power to meet climate targets and increase in electricity consumption. Moreover, it highlights that regulatory changes will be a key aspect for the entry of decentralized production, further suggesting that municipalities should have the authority to grand licences for solar installations up to a certain size. Finally, contributors in the report urge that "we are not acting fast enough" (OED, 2023a, p.9). These developments further call for changes in the regime.

Another element that can affect the stability of the power system is the electricity price. In Norway, the electricity prices have historically been lower when compared with other countries in the EU. However, since the last half of 2021 the country has experienced a dramatic increase in electricity prices, mainly due to dry weather conditions, low import capacity and increase in prices in the European area. This increase in power costs, seen as an external shock, led to loss in trust between people and network companies, while it further led people to generally question the effectiveness of the electricity regime, which is mainly based on hydropower production. Furthermore, this reinforced the belief that energy diversification is a key component in mitigating the vulnerability of a weather-dependent power system (OEDa, 2023).

The regime

The ST-regime, known for its stability, entails rules, routines, shared beliefs, regulations and legal contracts that act as tools that shape the actors within this level (Geels, 2011). Adaptation of lifestyle to a certain system, sunk investments in existing infrastructure and interest-groups provides further resilience to the regime and support the dominance of certain technologies (Geels & Kemp, 2007). In Norway, the electricity regime, which relies mainly on hydropower production, consists of network companies, operating under regulated monopoly, regulatory authorities, such as NVE and public enterprises, such as Enova. High presence of natural resources, mainly hydro, has historically shaped the electricity sector. Abundant hydropower has provided electricity in a reliable and cost-effective manner. Low electricity prices have resulted in stabilization of the regime, since they favoured continuous investments for hydro production, leaving small room for investments in alternative technologies. Public ownership of hydropower resources and associated revenues that benefit the municipalities and subsequently the citizens, have nurtured a relationship of trust between the people and the power sector, while people often view natural resources as common good. As the Energy Commission report puts it “hydropower formed the basis of modern Norway and is an important part of our national identity and culture” (OED, 2023a, p.109). Thus, the lifestyle and routines, which entail energy behaviour and consumption patterns, are adjusted to the wide presence of hydropower resources.

Grid infrastructure, tailored to centralized electricity production, is another element that stabilizes the regime. Network companies’ reluctance to engage more people in the electricity system stems from their traditional business-as-usual model. Since network companies operate under grid monopoly, they are not used to communicate with other actors, such as prosumers. Moreover, their activities regarding power purchase were adjusted to a certain value chain. At the same time, proliferation of decentralised units of power generation, which enable two-way power flows, mainly based on solar and wind, have challenged the entire value chain and call for changes on the electricity system. Interest groups at this level, namely network companies and the lobby from hydropower sectors, try to protect their interests and oppose to change. Grid companies are not interest-free, meaning that if more and more people pursue prosuming activities, this will lead to reduction of revenues, which has to be met by increasing the network rent for other end-users. Network companies, whose main responsibility is to provide electricity supply, while maintaining security of supply, often view disperse renewable power production units as a threat to the stability of the power system that can lead to disruption of their activities and can cause lack in grid capacity.

The regulatory authority within the country defines which activities are allowed and to what extent. NVE and RME have always considered the structure of the grid infrastructure and the activities of network companies when suggesting or introducing new regulatory frameworks. Before the introduction of the plus customer scheme, it was under the decision of grid firms, whether prosumers could pursue prosuming activities or not. Only in 2017, grid companies were mandated to connect prosumers to the grid, so they could produce, store and deliver excess electricity back to the grid and receive remuneration. Moreover, in the report from RME, where they suggest that the plus customer scheme should expand and benefit to properties with more than one individual metering point, they highlighted the need to draw clear demarcation of properties, to avoid grid implication in the case adjacent buildings could be viewed as one. In this line, the new regulatory changes that will allow sharing self-generated electricity for housing associations and commercial buildings will enter into practice only in October, so that network companies have time to adjust their activities and adopt new measures that will facilitate the sharing possibilities.

The niche

Niche is the level where radical novelties emerge. This level acts as an incubation room that aims to protect emerging innovations, which are the key elements for change (Geels, 2002). Niches face various challenges to enter the regime level and experience expansion and viability issues that hinder their proliferation (Smith et al., 2010). In the Norwegian context, solar energy communities, in the form of properties with more than one individual meter, such as housing associations, condominiums and commercial building among others, have experienced multiple challenges over time. The main challenge was the lack of regulatory frameworks that enabled sharing of electricity between meters in the same property. Properties with more than one individual meter could install solar systems, but the electricity produced from these could only be used for common areas, where consumption is negligible. This coupled with high up-front costs reduced the overall profitability of such installations.

Lack of support schemes is another element that hindered the proliferation of solar energy communities. Enova subsidies were available mainly for plus customers, which are those residing in detached or semi-detached houses. Although solar energy communities could apply, same as commercial buildings, they were unable to compete on a level playing field, due to lack of resources, both financial and advisory. However, the emergence of new business models, such as purchase options with long-term warranties, down payments over a longer period and leasing, reduced the financial threshold for solar energy communities. Solar installing companies, such as Otovo, offered low-investment opportunities that further facilitated the diffusion of solar systems. In the same line, banks introduced low-interest loans that would make solar systems more profitable and attractive alternative.

Developments in the landscape level, namely transition in the form of electrification, future projections about increase in consumption patterns and the imminent threat of power deficits coupled with the shock of electricity prices, especially since the last two years, have created pressure on the regime level and recently opened *a window of opportunity* for solar energy communities to emerge.

The regime level had to respond to these pressures to maintain the stability. This pressure led to the exploration of alternative sources to meet future demands, while the potential for local energy production received more attention. This initiated further changes in regulations, such as the recent expansion of the plus customer scheme to properties with multiple metering points, and in network expansion efforts, in the form of higher investments to strengthen the current infrastructure to enable the integration of more renewables in the grid and the entry of other actors in the market. Although, the subsidy from Enova did not benefit solar energy communities, it served as a protective space for the expansion of solar systems.

Moreover, recent events, such as the proposal to facilitate licensing practices for solar and wind installations to enhance local renewable energy production, further supports the emergence of solar energy communities. The proposal advocates that solar and wind installation, of up to a certain installed capacity, can be exempted from licencing requirements. This will enhance local energy generation, since there are expansion opportunities to already exploited environments, such as industrial areas. Furthermore, they argue that this change will offer greater authoritative power to municipalities, which can tailor regulations to a specific context (OED, 2023d).

In the niche level, new business models developed by solar firms and introduction of other subsidies, such as the one from Oslo municipality coupled with high interest from citizens who live in collective properties to install solar systems, have nurtured the development of solar energy communities. The latter are now mature enough to benefit from that opportunity and break through the regime level.

From the above, we understand that transitions do not occur easily and are dependent on multiple events on three levels. As Inderberg (2020) argues transition of the electricity sector is not seen a unified development, but rather a concept that entails transitions in multiple domains, in “production and consumption patterns, grid activities, digitalization of the electricity sector, the electrification of new sectors, and, usually, decarbonization” (p.173).

7.2 Barriers, drivers and prospects for solar energy communities

Norway has committed to ambitious climate agreements. Electrification of the transport and industry sector are important to successfully meet these targets. As presented in the Energy Commission report, Norway is in a transitional phase where new demands emerge and call for changes in the power system (OED, 2023a, p. 43). Hence, some of the barriers for solar energy communities identified at an early stage in this paper have turned into drivers later in the process. Below I will present the barriers, drivers and prospects for solar communities. To answer the last part of the question, regarding the prospects, I will employ the typology of transition pathways, as developed in Geels & Schot (2007) and presented in Smith el al. (2010) and Verbong & Geels (2010).

RQ sub-question 1*: "What are the barriers, drivers and prospects of solar energy communities"?*

Hydropower presence that provided low-cost and reliable electricity supply over the years was identified as an early barrier that hindered the diffusion of alternative renewable energy sources, such as solar and wind, and the entry of new actors in the market. The narrative of cost-efficiency as key for the operation of the electricity system, triggered further investments in the hydropower sector over other resources. Moreover, the ownership structure of natural resources, with high public ownership through municipalities, nurtured a relationship of trust between citizens and the electricity sector. Findings indicate that Norwegians view hydropower resources as common property and were not concerned about their consumption behaviour. Hydropower dominance and public ownership of resources has led people to neglect the idea of collective energy initiatives.

Grid companies and their activities, based on a centralized energy system, has also been a barrier for the deployment of solar energy communities. Network companies, which operate under regulated monopoly, have been reluctant to engage prosumers in their activities, while they often view renewable generation units as a threat to the stability of the grid. Moreover, a major concern was how to balance the network component in case prosuming activities proliferate.

However, the need for more energy production to meet the future demands have led to reconsideration of priorities, to maintain system stability and avoid future bottlenecks and lack in grid capacity. Thus, Stanett has presented a development plan, where they prioritize strengthening of the current infrastructure, either though expansion or the introduction of more flexibility tools. In the same line, grid companies driven by increase in inquiries about network capacity and connection to the grid, aim to explore new measures that will facilitate handling processes. Although this thesis views grid companies as barriers, in Inderberg et al. (2020), the authors argue that the grid companies maintain a passive position towards prosumers, while the attitude is dependent on the area that they operate in, thus their practices may be limiting or enabling. This challenges the conventional view that grid companies do actively hinder prosuming activities.

Lack of regulatory frameworks that enable sharing of electricity between meters in the same property or between properties was identified earlier in this paper as the biggest challenge for solar energy communities in Norway. In Lazdins et al. (2021), the authors argue that from a policy perspective, regulatory frameworks have a significant influence in the development of energy communities, through support schemes, guidelines between consumers and grid operators and the creation of favourable conditions that allow them to enter the energy market. Furthermore, they mention that sharing policy is more important than pricing policy when it comes to excess production of renewable energy. However, driven by increased interest in local energy production and citizens' interest in energy activities, new regulation has recently emerged and will come into effect early October 2023, that will finally allow properties with more than one individual metering points to engage in energy production, consumption and distribution, paving the way for solar energy communities to emerge.

Lack of strong financial support schemes coupled with low remuneration for delivery of excess electricity production also hinder the development of solar energy communities. The support scheme from Enova was mostly adapted to detached and semi-detached households' needs, leaving modest room for other types of properties to compete and claim the same benefits. According to Caramizaru & Uihlein (2020), strong financial support schemes – such as the feed-in-tariff, tax reductions and grants – play a crucial role in the proliferation of energy communities. In particular, in Germany, the feed-in tariff led to an increase in community-owned wind projects, indicating that there is correlation between the development rate of energy communities and support schemes.

The organizational structure of housing associations, condominiums and other types of similar properties is another barrier that may hinder the proliferation of solar energy communities. A majority vote is necessary to invest in solar installations. However, often is rather difficult for people from different backgrounds and characteristics to agree on these topics. Another issue that stems from the organizational structure is the monetary compensation for people who will be responsible for the smooth coordination of activities regarding the solar project. The latter is particularly relevant for the emerging solar energy communities and according to Kojonsaari & Palm (2021), limited resources and reliance on voluntary work are some of the challenges that need to be addressed before the implementation of energy communities.

The main driver for solar communities is the high electricity prices. High electricity prices towards the end of 2021 have led people to question the energy sector and triggered investments in solar technologies as an alternative to reduce their energy costs. Moreover, they have reinforced the idea that diversification of the energy mix in the electricity sector is key component to meet future demand, achieve environmental targets and gain resilience from the imminent threat of power deficits. Another driver is the emergence of new business models that aim to address the challenge of high-upfront investment costs and facilitate the diffusion of solar system. Purchase option with long-term warranties, leasing, down payments over an extended period of time, loans with low interests are some of the business models that lower the financial threshold for citizens to invest and engage in more solar projects.

One more driver is the introduction of the support scheme for solar installations from Oslo municipality that is tailored on the specific needs of housing associations, condominiums and commercial properties. This coupled with new regulations that will provide more authoritative power over licencing processes on municipalities will be important and may influence the proliferation of solar energy communities. As Spasove & Braundgardt (2021) argue, municipalities play a significant role in enhancing energy renewable community initiatives, since the latter are location-bound.

Since the first components of the first research sub-question have been addressed, now it is time to move to the last, that entails the prospects. For this, I will employ the typology of transition pathways. The findings do not indicate that a substitution or a de-alignment and re-alignment pathway is possible, thus the focus will be on the transformation and reconfiguration pathways.

Early in the project solar energy communities were in a transformation pathway. The plus customer scheme, introduced in 2017, functioned as a shield for the exploration of prosuming activities and enhanced the investment opportunities for solar projects. Although this scheme was not expanded to properties with more than one individual meter, they still led to a reorientation of activities among network companies, which were now mandated to connect prosumers to the grid. This challenged their reliance on the traditional value chain. Solar energy communities were limited to the niche level and did not affect the basic structure of the regime, but developments still led to a reorientation to a more sustainable direction.

The external shock from the electricity prices, deeper electrification efforts, the threat of power deficits and the vulnerability of a weather-dependent power system require changes on the electricity regime. Higher presence of variable solar in the electricity mix and new regulations that enable the entry or more actors in the market, have influenced the regime structure and call for further adjustments. Due to these developments, the TSO and DSOs operating within the country have announced their plan for strengthening the current grid infrastructure and for developing new measures that will enable shorter handling processes for requests regarding grid capacity and network connection. According to Statnett's network development plan, the green transition implies that more and more customers will require network connection, while security of supply will be threatened if not followed by higher production and network capacity (Statnett, 2021).

Furthermore, high interest among citizens for pursuing energy activities have resulted in a bottom-up management approach, characterized by increased control and ownership of energy activities by citizens. Recent developments put more emphasis on solar power energy generation and recognizes and prioritizes the potential of local energy production. This paves the way for solar energy communities to enter the regime as *add on* elements. Gradually this may have cascading effects leading to more changes, such as increased decentralization and the emergence of other technologies, such as batteries. From the findings, we already observed that more and more people are interested in alternative solutions. Although solar energy communities may affect the architecture of the regime, it does not seem to lead to the replacement of the old regime. Findings indicate that the future energy system will be based on a combination of hydro, wind and solar power, while hydro will still remain the dominant source and will provide flexibility and storage opportunities. This implies a symbiotic relationship.

7.3 Transition and justice implications

In this part, I address the second research sub-question. From the findings and analysis, this paper identified injustices in three energy justice dimensions: the procedural, distribution and recognition justice, which will be presented in more detail below. To answer this research sub-question, I draw on the energy justice dimensions as presented in Sovacool et., al (2019a), Sovacool et al. (2019b) and McCauley et al. (2019).

Regarding procedural justice, the findings showed that authoritative power over decision-making in the energy system over the years, through NVE, and associated regulatory frameworks, tailored to centralized power production, have often followed network companies interests over prosumers interests. Before the introduction of the plus customer scheme, prosumers acted on regulatory vacuum and it was under the decision of network companies to provide connection to the grid. Even after the introduction of the plus customer scheme, different properties' needs were not recognized equally.

Properties with more than one individual metering point, could not pursue sharing of electricity. In Norway, nearly more than 30% of people reside in building types with more than one metering point (SSB, 2023). Thus, these people could not pursue prosuming activities and share the benefits as people who lived in detached or semi-detached houses. Although they could still install solar systems, they could use the electricity produced only in communal areas, where electricity consumption is negligible. In Winther et al., (2018) most of the interviewees recognized self-consumption as the most profitable activity. The lack of self-consumption in properties with multiple metering points coupled with the limitation on electricity usage in communal areas, have hindered investments in solar systems. The new regulation that will come into effect in October 2023 will finally allow sharing of electricity in properties with multiple metering points and remove this challenge. However, even with the new regulation, properties under different utility number are still not allowed to exchange electricity, although the buildings may be in close proximity. Thus, they have to deliver the excess production and purchase it at a higher price, making the investments of solar systems less attractive.

Procedural injustice is also identified in the Enova support scheme for solar installation. The support scheme was again tailored to the needs of people living in detached and semi-detached households and commercial building, neglecting other types, such as housing associations and condominiums. Although the latter could apply, same as commercial buildings, the competition level and the lack of resources often hindered such initiatives. Moreover, the lack of support scheme coupled with regulatory frameworks reduced the profitability of solar systems for housing associations, thus making them a less attractive investment opportunity.

With regard to distributive justice, the findings show that injustice occurs regarding the network component. Injustice emerges due to properties being exempt for paying the grid component for consumption of self-generated electricity, which leads to an increase in network costs for the rest of the customers. If solar energy communities proliferate, they will lead to higher networks costs for those who are unable to invest in such initiatives. Thus, although people cannot invest in decentralized production units, they still have to face the implications, in the form of network component, that supports the grid infrastructure. This will be a major challenge in the future, since estimates indicate that there will be an increase in network component due to higher investments for network development infrastructure (Statnett, 2021).

Regarding recognition justice, findings suggest that focus on hydropower investment over alternative sources over time have led to a less diversified and vulnerable weather-dependent energy system. This coupled with electrification efforts and high electricity prices, especially the last two years, have created new vulnerable groups (i.e., end-users who have to pay higher network tariffs) and has affected those who are more in need.

8 Conclusion

This research set out to explore how solar energy communities emerge, identify the barriers, drivers and prospects for solar energy communities and potential associated justice implications. During the timeframe of the research study, rapid socio-technical changes occurred, that were often challenging for research, as there were limitations in time and resources to capture all these events. The study shows that transition in Norway, in the form of electrification, challenged the current electricity regime, calling for adjustments in the infrastructure and regulations, that allows the entry of more actors in the market, increasing citizen participation in the energy sector. Various barriers and drivers were identified along the way. The barriers were mainly present due to regulatory frameworks, hydropower dominance, reluctance of grid companies to engage with end-users and the threat of disperse generation units to grid stability, the ownership structure of natural resources, the scepticism in collective energy activities and the organizational structure of solar energy communities.

The drivers are the deeper electrification efforts, that implies increase in consumption, high electricity prices, interest in local energy and people’s interest in energy activities. Recent events indicate that solar energy communities will enter the reconfiguration pathway as add-ons that provide solutions to emergent challenges, such as the threat for power deficits, and call for change in the architecture of the electricity. However, the findings show that the future energy system will still rely on hydropower and will be combined to solar and wind power. This implies a symbiotic relationship.

However, this study identified several justice implication in this transitions to a more sustainable future. It also challenges the view that decentralized energy production units can support distributive justice. In the Norwegian case, prosumers do not pay for consumption of self-generated electricity or for delivering excess electricity, leading to an increase in network component for other consumers. This will be particularly important in the future since estimates indicate an increase in the grid component. Thus, the government need to pay attention when forming policies regarding prosuming activities.

Future research should focus on how to structure support schemes to enable all citizens to participate in energy activities and focus on robust policy formation, that does not rely only on technical aspects. Moreover, due to new events that enhance the emergence of solar energy communities, it will be interesting to see how and to what extend the organizational structure present in these will affect their proliferation.

Appendix: Interview guide

Theme 1

1. What are the trends in solar power development in the Nordic region and more specifically in Norway?

2. Who do you think is determining the pace in solar rollout in Norway?

3. What are the challenges that hinder deployment rate of solar systems?

4. How do you think the estimated increase in solar power capacity will impact the current structure of the energy system?

Theme 2

5. What are the key advantages that make solar energy well suited for community-based energy initiatives?

6. Do you expect that increased solar capacity will play an important role in creating an enabling environment for energy communities?

Theme 3

7. What are the challenges that hinder community owned solar projects?

8. What are some of the challenges that may need to be addressed before the implementation of energy communities ?

9. Do you believe Energy Communities can drive the deployment rate of solar systems?

10. How do you envision the future energy system in Norway?

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