Energy Communities Between Policy and Civic Engagement: Denmark, Netherlands, and Germany

By
Menta Mora

Submitted to
Central European University
Department of Economics and Business

In partial fulfilment of the requirements for the degree of
Master of Arts in Economic Policy in Global Markets

Supervisor: Dora Piroska

Vienna, Austria
2024

Abstract

The thesis focuses on mapping energy community (EC) formation trends and the main factors driving the process in the three EU Member States with the highest number of energy communities: Denmark, the Netherlands, and Germany. The scope of the analysis is the period from 1970 to 2023. The purpose is to show that tools de-risking energy community projects and minimising instability incentivise EC formation the most. After analysing the policy and financial frameworks targeting energy communities in each country, the thesis estimates the treatment effect of selected policy interventions using a difference-in-differences method with Manski's bounding to correct for non-parallelism in the pre-trends. The policy interventions chosen for performing the difference-in-differences are the introduction of feed-in tariffs in Denmark and Germany and the introduction of market premiums in the Netherlands. The estimated treatment effects for Denmark and the Netherlands follow the hypothesis that long-term compensation schemes are associated with higher treatment effects. The estimated impact of feed-in tariffs in Germany, which is lower than what the literature suggests, shows that fluctuations in the number of ECs can occur despite providing favourable conditions for them. The German example also poses the question of whether there is a ceiling for energy community formation.

Acknowledgements

I would like to thank my supervisor, Dr. Dora Piroska, for her support throughout the research project. Her expertise was instrumental in the completion of this thesis.

Table of Contents

1. Introduction

The potential role played by energy communities in accelerating renewable energy production and facilitating civic engagement and influence over energy usage has become increasingly discussed by both academics and the European Commission (Diestelmeier, 2021; European Commission, 2022; Klagge & Meister, 2018; Wierling et al., 2023). According to some scholars (Ruggerio et al., 2021; Stojilovska, 2021), energy communities can restructure the energy markets and foster a democratic approach to energy production, resulting in a more equal energy distribution among members of the communities. For these reasons, energy communities are not only essential for reaching carbon neutrality but also for decreasing energy poverty.

The birth and booming of citizen-led energy initiatives are associated with the anti-nuclear movements of the 1970s (Klagge, 2018). Their goal was to generate local ownership and increase the usage of renewable energy sources (RES), instead of relying on nuclear energy. As opposed to the neoclassical approach of markets, this community-based approach involves the element of energy justice, which, according to the analysis of Diestelmeier (2021), should be reflected in the legislation of the issue as well.

Energy markets are mainly dominated by incumbent actors, which creates a challenging environment for new, smaller producers. For this reason, there is a consensus among the researchers of the topic, that energy communities cannot become successful in their operations without significant institutional and financial support (Bauwens et al, 2016; Norden, 2018; Diestelmeier, 2021; Klagge, 2018). The aim of this thesis is to gain an in-depth understanding of how and what policy mix can best support energy community formation, and to also reflect on the potential role the financial infrastructure of a state plays in contributing to the increase of energy communities.

The thesis focuses on mapping energy community (EC) formation trends and the main factors driving the process in the three EU Member States with the highest number of energy communities: Denmark, the Netherlands, and Germany. The scope of the research is the period from 1970 to 2023 since the birth of ECs happened in the 1970s. The purpose is to show that tools de-risking energy community projects and minimising uncertainty incentivise EC formation the most. This will be done by estimating the treatment effect of the selected policy tools and reflecting on the timeframe and amount of the compensation offered by each. According to the hypothesis of the thesis, the schemes which cover a longer timeframe are associated with a higher treatment effect, due to ensuring more stability.

The research undertaken in this project consists of identifying the main policy tools and available financing to support ECs in the three studied states. After analysing the frameworks, the method of difference-in-differences will be used to estimate the treatment effect of the selected policies on energy community formation numbers each year, compared with agricultural cooperative formation. The comparison allows for separating the effect of policies targeting energy producers from other factors that influence participation in energy communities, such as the strength of civic society, willingness to participate in community initiatives, and ecological awareness. Since these factors affect both energy community formation and agricultural cooperative formation (Giagnocavo, 2020; Mey et al., 2023; Saz-Gil, 2021; Wierling et al., 2018), the comparison can give an estimate of how state-led policymaking affects ECs in the light of the civic society factors. Answering this question can also deepen the understanding of the role of the bottom-up and top-down mechanisms in creating energy communities. The discussion of the results will also consider the potential importance of a financial infrastructure in enabling the smooth formation of these communities.

For researching energy communities, there is a crucial need to create a publicly accessible and comprehensive database. Data on the exact number of energy communities in each country is inconclusive among studies, as a result of researchers having to rely on national company registries and other potential sources. Wierling et al. (2023) found Germany to be the EU Member State with the highest number of energy communities (4848), followed by the Netherlands (987) and Denmark (633). On the other hand, Koltuov (2023) found 847 energy communities in Germany, 676 in the Netherlands, and 527 in Denmark. The discrepancies between the papers result from different methodologies and criteria used for identifying energy communities.

The analysis in the current research project was completed by using the dataset built of energy communities and agricultural cooperatives in the given countries. The dataset built combined with the difference-in-differences estimates for Denmark, Netherlands, and Germany offers a comprehensive understanding of how different policy tools, namely market premiums and feed-in tariffs, impact ECs in these states.

It is crucial to highlight that various political and cultural factors can affect these communities; hence, the research does not offer generalisable answers but is specifically focused on the core of the EU. Furthermore, the quantitative analysis offered by the thesis is focused on estimating the impact of the selected state policies, without including the role of the financial infrastructures in the models.

2. Literature Review

To understand the reasons behind energy community formation and operation, despite the hindering factors, it is essential to acknowledge their importance and analyse the policy and financial support available to them. Energy markets are mostly dominated by a few incumbent actors, which creates a challenging environment for new producers who aim to enter and successfully remain on the market. Despite these difficulties, countries like Denmark, Netherlands, and Germany, among others, give home to an increasing number of energy communities. The research aims to gain a deeper understanding of how policies target the energy markets and civic producers in these countries and how they influence energy communities in light of other drivers of energy community formation, such as the strength of civic society and ecological awareness. For this reason, it is essential to unpack the main challenges these communities face. Since the countries with the highest number of energy communities in the EU are situated in the core of the EU, and consequently, the EU core is the subject of the analysis, the review also focuses on observations about EC operations in this region.

2.1. The Purpose and Operation of Energy Communities

The following section focuses firstly on the aims and secondly on the background of energy communities, including their legal form and ownership structure. These concepts are essential since the financing opportunities and challenges of everyday operations are directly connected to the goals of the ECs and the specific setup of the organisations.

According to some observers, energy communities have the potential to accelerate the green transition, as well as benefit local communities (Diestelmeier, 2021; European Commission; Klagge, 2018). Energy communities have non-profit-oriented organisational structures, which provide benefits to their participants and traditionally focus on generating positive externalities. In contrast with top-down hierarchical structures, this approach focuses on the community-based, decentralised organisation of the energy markets (Diestelmeier, 2021). By enabling new players to enter the market, energy communities help break the oligopoly of incumbent energy producers (Klagge, 2018). These citizen-led initiatives prioritise their local community, however, they can also realise cooperation between private and public actors (Diestelmeier, 2021).

Depending on the type of community, it can focus on generating energy and distributing it among its members or obtaining energy from an outside producer and mainly distributing it among the energy community members (European Commission, 2022). The communities have a longstanding history of using various technologies and providing a framework for continuous development and changing dynamics in the energy sector (Diestelmeier, 2021).

They most often operate under the legal form of a cooperative, limited partnership, non-profit organisation, or association; however, this can vary depending on their country (Nordic Energy Research, 2023a, 2023b, 2023c). They can be formed as a firm to which anyone with proximity to the energy community can join, or in some cases, they are formed from living communities (residents of the same building or street) (Diestelmeier, 2021).

Their ownership structure can vary based on the community, however, most commonly, either each member has one vote in decision-making matters (as in the traditional cooperative model), or members can obtain shares in the cooperative, which will provide them with ownership, and as a result, influence over the decisions (Rescoop.eu & Ecopower, 2023). According to EU regulations, at least 50% of the seats in the decision-making body of the renewable energy community must be held by civic individuals and not companies or institutions (Energy Community Secretariat, 2024). Depending on their specific structure, the starting capital can be obtained from member contributions to raise equity, their equity can be used to apply for additional loans, or they can receive grants for their energy projects (Rescoop.eu & Ecopower, 2023).

The EU urges its member states to ensure fair access to the energy grid to enable a smooth operation. In Denmark, the Netherlands, and Germany, energy communities are granted access to the electricity grid (Prota et al., 2018a; Wainer et al., 2022). Moreover, in Germany, they need to be connected to the grid shortly after they notify the grid owner of their aims to connect (Wainer et al., 2022).

2.2. Obstacles for Building Sustainable Energy Communities

The factors determining the successes and failures of energy communities are usually distributed into two categories (Diestelmeier, 2021; Mey et al., 2023). Diestelmier (2021) uses the categories of symbolic and structural factors, whereas Mey et al. (2023) focus on bottom-up drivers of energy community formation, sorting the ‘symbolic’ factors of Diestelmeier (2021) into the category of bottom-up determinants. This thesis will use the categorisation of bottom-up and top-down drivers of energy communities, based on whether the factors are rooted in the level of society or the state.

Bottom-up drivers of energy community deployment are the strength of civic society, level of engagement in community initiatives, and support for renewable energy. The second category is those determined by top-down processes, including economic policies affecting the energy markets and accessibility of the decision-makers. The following overview will focus on the hindering factors identified by researchers. The interaction of these factors will also be the centre of the analysis, following in the footsteps of Mignon and Rüdinger (2016), who argue that determinants of energy community formation need to be studied as a system since they are interdependent and the impact of one may influence the impact of another.

Conducting a systemic analysis, Mignon and Rüdinger (2016) present energy communities as organisations situated in an environment of complex institutional and social factors that overlap and are interdependent. Both theoretically and empirically they show that lowering one barrier can lower others, and the emergence of one obstacle can mean the emergence of many, due to the interdependence of these factors (Mignon & Rüdinger, 2016). After analysing ECs in France, Germany, and Sweden, the main barriers for energy communities they identified were the lack of professionalism, lack of legitimacy, lack of location, lack of experience, unstable policies, lack of capital, and lack of network. The study shows that the same factors affecting new corporations entering the energy market affect energy communities, however, the lack of financial infrastructure and lack of knowledge is hindering their operations more significantly. The present paper sorts the factors collected by Mignon and Rüdinger (2016) by viewing the legitimacy of energy communities, level of experience, professionalism in running such communities, and network as factors on the level of society, whereas the stability of policies is a factor determined by the state. Capital and location can be directly determined by both policies and the private resources of agents; hence, these are both rooted in the state and society.

Building on the analysis of Mignon and Rüdinger (2016), the case of Germany illustrates the interdependence of various factors well. Energy communities possessed legitimacy and were blooming, however, the policy decision to move toward a more market-based financing scheme and switch to market premiums from feed-in tariffs seriously hindered their operations and the founding of new cooperatives (Mey et al., 2023). This highlights, that despite societal acceptance and support being in favour of cooperatives, change in structural, and financial factors can still lead to backlash for them.

According to Diestelmeier (2021), the main factors determining the potential of energy communities to sustain their operation in EU Member States were the accessibility of policymakers and institutional design (Diestelmeier, 2021). Furthermore, willingness to participate in a community was also shown to be a crucial driving factor of ECs, specifically in relation to the 'collective action' or 'free rider' problems. However, as Diestelmeier (2021) argues, 'willingness' is often driven by individuals' socio-economic situation, since lack of free time and opportunity for community engagement can be barriers to joining. Hence, incentivising participation through structural regulations can involve those in lower socio-economic conditions who were willing to engage with the community but did not have the means to fully participate in it (Diestelmeier, 2021). By viewing this analysis through the framework of state-society relations, the example reinforces how the blooming of energy communities is heavily influenced by a complex interaction of the socioeconomic situation of individuals and cultural and historical factors determining whether these initiatives are viewed as legitimate alternatives to centralised energy production. Furthermore, the analysis of Diestelmeier (2021) on the importance of policies in engaging actors in energy community initiatives who otherwise would not have the opportunity reinforces the conclusion of Mignon and Rüdinger (2016) on the lack of financial infrastructure and know-how presenting significant hindrance for ECs. Energy communities with higher levels of energy produced, more paid positions, and in general, more benefits available directly to their members can be more attractive to potential members, and as a result, are more likely to sustain their operations.

Beyond the previously mentioned hindering factors, Wierling et al. (2018) highlight how regulatory uncertainty can also be a potential obstacle for new initiatives, as unpredictably changing regulations can disincentivise energy community formation, even if regulations at the time could be in favour of them. It is also important to highlight that several regulations affecting energy communities and the financial compensations available to them included a specific time length for which the compensation was guaranteed.

Whereas the observation of Wierling et al. (2018) concerns the stability of regulations, this thesis hypothesises that the stability offered by long-term compensations can also have a more positive impact on EC formation, than those with shorter timeframe. Hence, the length of guarantee for the compensation can also influence how the policies affect energy communities, namely, those promising financial compensation for a longer time can potentially incentivise community formation more, than those with a shorter compensation scheme. For this reason, the analysis presented here will also reflect on the issue of the timeframe of compensation.

It is not only policymaking which affects civic initiatives, but the social environment where policies are made also influences the effects of policies. As Mey et al. (2023) explain, in the long term, participatory aspects can increase the legitimacy of top-down policymaking. For instance, strong civic initiatives and accessibility of policymakers can create a sense of partnership between civic society members and policymakers, which, in turn, can increase the responsiveness of actors to policies. Public participation also plays a key role in managing conflicts which may arise in connection with the implementation of various technologies (Mey et al, 2023). The analysis highlights the importance of a high level of participation in public matters for ensuring the effectiveness of policies. This observation is crucial for understanding that the impact of the same or similar policies can still vary greatly depending on the social environment in which they occur.

The authors introduced above mainly focused on overall changes in EC numbers. Whereas certain systemic factors affecting these numbers were studied, a more targeted analysis of the specific impact of policies is still missing. This study aims to fill this gap by comparing Denmark, Netherlands, and Germany, and showing that tools de-risking energy community projects and minimising uncertainty incentivise EC formation the most. Examining energy community formation trends by using agricultural cooperatives as a control group enables the analysis to separate the effects of policies targeting the energy markets from other factors influencing the participation of civic actors in community-based production arrangements. Reflecting on the timeframe of the compensation each policy offers can also broaden the understanding of the role of stability in supporting energy communities.

3. Policy Framework

To unpack the current policy tools in Denmark, the Netherlands, and Germany, this section analyses the policy changes regarding energy production and, more specifically, civic energy production in each country. This is also crucial for understanding the main differences between the similar policies employed in different states.

According to Wierling et al. (2018), Denmark and Germany are the most frequently studied countries in research focusing on energy cooperatives. However, most papers focus on single-country studies, leaving a gap in exploring and comparing trends between various countries. Denmark was a pioneering country which started to establish energy communities in the 1970s, whereas Germany became the leader in the number of energy communities incentivised by the nuclear disaster of Fukushima and the anti-nuclear wave of public opinion following it (Wierling et al., 2018). The Netherlands is the country with the third highest number of energy communities, but interestingly, it is not mentioned as one of the main focuses of many studies on the topic. In the following sections, the specific policies targeting ECs in these three countries will be unpacked.

3.1. Denmark

Civic energy production in Denmark involves more than 150,000 households, which are all members of the local energy communities (Wierling et al., 2018). Renewable energy production in Denmark is mainly reliant on wind energy. To simplify the data collection process, Wierling et al. (2018) only accounted for wind energy-producing cooperatives in their research, excluding other forms of renewables from the analysis. Hence, more consecutive research involving other energy sources and different forms of energy communities beyond cooperatives remains necessary.

The data gathered by Wierling et al. (2018) shows two waves of foundation of cooperatives, one between 1985 and 1992, and the other between 1998 and 2002. The first one started following the new policy of the Danish parliament, introduced in 1985, which decided to exclude nuclear energy as a potential future energy source.

3.1.1. Feed-in Tariffs

One of the main cornerstones of Danish energy communities was the feed-in tariff programme introduced in 1992. This consisted of producers receiving 85% of energy production and distribution costs as a tariff. Furthermore, wind energy projects were also eligible for a reduction of the carbon tax and a refund of the energy tax (Wierling et al., 2018). The Energy Supply Act of 1999 also introduced a quota system with a minimum amount of renewable energy to be purchased by customers, furthermore, it also allowed them to choose their energy providers (Wierling et al., 2018).

The feed-in tariffs were phased out in 2004, with the decision announced in 2002 (Wierling et al., 2018). It is crucial to note that since feed-in tariffs were set depending on the cost of production and distribution of energy, they were not entirely fixed, however, this system still allowed for far less fluctuation in compensation, than premiums depending on more volatile market prices. The tariffs were guaranteed for 10 years for wind energy projects (International Renewable Energy Agency, 2013).

Another factor which influenced the number of energy communities and led to a reduction in their numbers was the decision of 1999 for wind turbines to receive 25% lower feed-in-tariffs (Bauwens et al., 2016). The policy was a result of many wind turbines being placed on land with suboptimal wind potential. Hence, they affected the landscape negatively without producing the amount of energy for which they had the potential. As a result of the new policy, several cooperatives dissolved and sold their wind turbines, which led to a reduction in their numbers (Bauwens et al., 2016).

3.1.2. Regulation of Wind Turbine Ownership

The liberalisation of wind turbine ownership reduced civic ownership of turbines after 2000 (Bauwens et al., 2016). Before 2000, 80% of Danish wind turbines were owned by cooperatives, single owners, and farmers. This was a consequence of the policy restricting ownership of turbines based on physical proximity to the turbine. As this law was abolished in 2000, the opportunity for commercial owners, foreign companies, and larger firms was open to own more turbines. Due to the decrease in local ownership, in 2009, the Danish government implemented a new regulation for investors in new turbines to offer a minimum of 20% of the ownership to local citizens (Bauwens et al., 2016).

3.1.3. Market Premiums

Currently, Danish cooperatives also receive a market premium which is offered on top of the market price for which a unit of electricity is sold. This option has been available for renewable energy producers since 2012 and made compulsory in 2014 (Bauwens et al., 2016; REScoop.eu). Under this system, on-shore wind projects receive a guaranteed premium of 0.25 DKK (approximately 3 euro cents), whereas off-shore projects can receive up to 0.1 DKK (approximately 1 euro cent) per kWh energy produced (Legal Sources on Renewable Energy, 2019a). However, the maximum amount of subsidy (market price plus premium) was also set, which means if market prices are particularly high, otherwise guaranteed bonuses will decrease. This maximum was set at 8-9 euro cents per kWh depending on the type of generator (Legal Sources on Renewable Energy, 2019a). Energy communities can also receive financing through competing and winning in public tenders (Wierling et al., 2018).

3.2. Netherlands

In the Netherlands, the energy community movement is highly connected to the anti-nuclear organisation, the Dutch Organisation for Renewable Energy (ODE) (Proka et al., 2018a). The current policy measures for building energy communities involve net metering, market premiums, and a tax-relief policy (Proka et al., 2018a; Proka et al., 2018b). In 1989, a new legislation granted grid access for energy communities, which led to an increase in their number. However, the exact impact of the policy alone cannot be determined, as increasing awareness of climate change started to appear simultaneously (Proka et al., 2018a).

3.2.1. Feed-in Tariffs

Feed-in tariffs (FiTs) were introduced in the Netherlands in 2003, however, due to a lack of effect on renewable energy production, they were quickly phased out in 2006 (Proka et al., 2018a). The tariffs were originally offered for ten years and consisted of 4.9 cents per kWh for onshore wind, and 6.8 cents for offshore wind, solar panels, and wave energy (van Sambeek & van Thuijl, 2003). The compensation scheme was significantly lower than the German feed-in tariffs and was only guaranteed for 10 years shorter, than the latter. These aspects could have played a role in the lack of impact associated with the Dutch feed-in tariffs.

3.2.2. Market Premiums

Currently, the state offers market premiums, which civic producers receive on top of the market price (REScoop.eu). This premium is available for wind power, solar panels, and hydropower (REScoop.eu). Wind energy projects can receive a premium of up to 5.4-8.5 euro cents depending on their size. For solar plants, the premium ranges between 9.0 and 10.6 euro cents (Legal Sources on Renewable Energy, 2019b). The compensation is paid for 15 years (Legal Sources on Renewable Energy, 2019b).

3.3. Germany

The German low-carbon energy transition called Energiewende, or energy turn, which was a decision to significantly decrease the greenhouse gas emission of the state, largely contributed to the booming of energy communities in Germany (Mey et al, 2023; Norden, 2013). As Mey et al. (2023) explain, the transitional pathway of Germany simultaneously incorporates bottom-up and top-down approaches to green energy generation and usage.

According to Norden (2013), 51% of German renewable energy production originates from citizen producers. The key policy tools identified for supporting energy communities were feed-in tariffs, financing and investment, the replicability of projects, and the planning of projects. The paper also identifies grants as a main factor driving the founding of energy communities. This is especially important, since several energy communities operate under the threshold of being an economy of scale, indicating their need for governmental support, both financially and legislatively (Norden, 2013).

3.3.1 Feed-in Tariffs

After 2000, feed-in tariffs were granted in Germany (Wierling et al., 2018). A fixed compensation was provided for renewable energy projects after every kilowatt-hour (kWh) of energy produced with the scheme guaranteed for 20 years (Netztransparenz.de). Small solar panels received 12.88 cents per kWh of energy they produced (Netztransparenz.de). Compared with the Danish system, this offers a more stable compensation system in terms of time, and the compensation is also higher in this case.

3.3.2. Auctions

The feed-in tariff system was reviewed in 2014 and largely replaced with an auction scheme (similar to that of Denmark). The auctions constituted three to four rounds where solar and wind energy producers could bid and compete to win the tender, however, for most of the time, civic energy producers were exempt from these and received market premiums instead (Norden, 2013). Mey et al. (2023) also conclude that as a consequence of the reduction of feed-in tariffs, installation of solar panels became less economically attractive, which resulted in a backlash of the citizen-produced renewable energy. Despite the backlash, Germany still gives home to the largest number of energy communities in the EU, which poses the question of whether this is a result of the strength of civic society and commitment to renewable energy, or the opportunity of EC projects to secure financing from alternative sources.

The impact of certain policies remains a puzzle in light of the case studies explained in this chapter. The feed-in tariffs were discussed as an effective policy measure in the case of Germany, whereas they were quickly dismantled in the Netherlands, due to lack of impact. In the case of Denmark, there is no specific policy tool highlighted by the literature which showed significantly higher impact than the rest of the policies. For these reasons, analysing the key policies and their impacts in these three countries can offer a more comprehensive approach to how the amount of compensation, the stability offered by the timeframe covered by these policies and the specific sociocultural context of each country can influence the results in different countries. Since most studies on the topic focus on analysing a single country (Wierling et al., 2018), a comparison of the three countries with the highest number of energy communities can offer a more nuanced view. This is of key importance, since for successful energy communities to develop, legislation must simultaneously incorporate lessons from international cases and reflect the individual needs and context of each country.

4. Financing Energy Communities

This section covers the main channels through which energy communities can secure financing for their operations. Since both market premiums and feed-in tariffs depend on the energy already produced by the initiatives, understanding how organisations can obtain capital for starting their operations is also necessary to unpack their specific financial needs. The analysis will focus on the financing available for ECs in Denmark, the Netherlands, and Germany between 1970 and 2023 since this is the scope of this research.

Contrary to most cooperatives, energy communities are not exclusively citizen-owned and financed but are a mixture of private, public, and civic financing. Hence, when analysing the financing of energy communities, third-party financing can also be a factor. Highlighting this is key in determining the possible success of ECs, as structuring their opportunities and financial plans can also play a factor in attracting financing from private investors who can be larger players than civic market actors. For larger investors, de-risking of investment can be a more efficient tool in lowering barriers (Norden, 2013). Hence, analysing the opportunities and risks beyond financing opportunities deepens the understanding of how energy communities can successfully start their operations.

4.1. Channels of Financing

The main channels to obtain financing for energy communities are equity financing, debt financing, and grants. Energy communities most often aim to secure financing through 50-100% equity so they can reduce the amount of debt financing they require (Rescoop.eu & Ecopower, 2023). This is due to the increasing requirements of banks attached to higher levels of debt financing. Grants, on the other hand, are non-repayable, which makes them advantageous, compared with accumulating high levels of debt. Another bonus of grants is they do not influence ownership and seats on the decision-making committee of the EC, as opposed to equity financing (Rescoop.eu & Ecopower, 2023).

Besides obtaining grants and bank loans, there are other options available for EC projects to secure funding. Crowdfunding can also be an option, including equity, debt, and donation crowdfunding (Arnould & Quiroz, 2022). In the case of equity crowdfunding, the investors receive ownership, in return for shares, whereas in the case of debt crowdfunding the energy community pays interest on the loans, but their ownership structure remains intact. Donation-based crowdfunding works similarly to grants, as these are also non-repayable and come with no conditionalities attached (Arnould & Quiroz, 2022).

Financial contributions from members can also provide equity for energy communities. Since equity financing relies on contributions from members or prospective members, it is the most self-sufficient and involves the lowest level of reliance on outside sources. As a result, this provides the community with the opportunity to make independent decisions regarding its structure and goals. On the other hand, if these contributions are made compulsory for members, it can raise barriers to membership and result in selectiveness based on financial status. Alternatively, CEs may only require those who wish to become involved in the ownership of the community project to contribute financially. This alternative structure diverges from the classical flat hierarchy of a cooperative and applies selective powers in decision-making.

Cooperative funds can provide equity financing for CEs (Rescoop.eu & Ecopower, 2023). This option usually requires the funding agency to be involved in decision-making and objective setting for the projects. Hence, they diminish the independence of the energy community. Other equity funds can be national or European as well. They use pooled resources to support energy community projects through investment and accelerate both the construction and operation of plants. Despite diminished independence, communities can prefer equity from cooperative funds, because this way they can avoid including commercial actors in their community (Rescoop.eu & Ecopower, 2023).

4.2. Financing Through Three Stages of the Project

Different financing strategies are required throughout the three main stages of the projects. The main stages of energy community projects are the following:

1. Making studies, assessing feasibility, obtaining licenses
2. Building the plant, installing the panels
3. Starting operations, maintaining the functionality of the plant

The preparatory stage is the most difficult to finance, since in the absence of any materialised element of the project, it is challenging to convince investors that the loan would be a performing one (Rescoop.eu & Ecopower, 2023). Especially for these cases rolling funds can be a viable solution (Rescoop.eu & Ecopower, 2023). These are funds collected for the project which are only treated as loans that must be repaid if the project is realised. In case the project fails before the stage of implementation, the funds are viewed as grants and the investors do not have to be compensated (Rescoop.eu & Ecopower, 2023).

Throughout the second stage of the projects, similar funds can be used to those secured for the first stage. Building the plant and setting up the technology necessary for production are still challenging to finance since it precedes the production of any sellable electricity (Rescoop.eu & Ecopower, 2023).

After reaching the third stage, the organisations can produce and sell electricity, which also means they can receive compensation from the government in the form of feed-in tariffs or market premiums.

4.3. Role of the Local Authorities in Securing Financing

Municipalities can play a significant role in supporting financing for CEs. For instance, when applying for a bank loan, guarantees from a municipality as part of the application can incentivise the bank to assess the loan request as less risky and demand lower interest rates from the EC (Rescoop.eu & Ecopower, 2023). Furthermore, municipalities can also cooperate with energy communities to accelerate the green transition in the local community and agree on a division of labour for the completion of the necessary tasks (Arnould & Quiroz, 2022). Through cooperation with a municipality, bureaucratic processes can become less challenging, as, for instance, obtaining necessary permits becomes more feasible. Finally, municipalities can provide grants for energy communities (Rescoop.eu & Ecopower, 2023).

In the EU, there is a two-level state consisting of EU directives and national governmental regulations. Despite the central role governments can play in providing financial support for energy communities, several EU member states still have not succeeded in establishing a clear framework for this (Rescoop.eu & Ecopower, 2023). The Renewable Energy Directive (European Union) specifies that every EU member state must provide a scheme which enables the founding and functioning of energy communities. This framework should also include a financial framework to accelerate the access of EC projects to sufficient financing.

4.4. Comparison of Financial Frameworks

The rolling grant, or grant-to-loan scheme was made available for German energy communities in 2018 (Rescoop.eu, 2023). Seventy percent of the costs during the planning and the obtaining of approvals can be gained from subsidies up to 200 000 EUR. Since 2018, the federal scheme has been available in the entire state, but it was modelled off the scheme of the state-owned development bank of Schleswig-Holsteinset, which provided financing during the preparatory stage of community energy projects. Hence, this opportunity existed before 2018 as well, but not on a state level. Furthermore, there are low-interest-rate loans available for ECs from promotional banks like Kreditanstalt für Wiederaufbau (KfW) or the Development Agency for Agribusiness and Rural Areas (Landwirtschaftliche Rentenbank). Additionally, financing for this stage is also available for up to 25 MW per applicant for generating electricity from wind energy on land. This is provided by an investment fund launched in 2023 (Rescoop.eu, 2023). Similarly to grant-to-loan tools, the funding only needs to be repaid if the project is successful (Rescoop.eu, 2023). The question also remains as to whether the successful structure of Germany can be replicated in other countries, as it is highly dependent on the federalist governmental structure and the banking sector of Germany (Norden, 2013).

In the Danish case, energy producers can apply to the Danish Energy Agency for grants which can be given either to disseminate information or to plan and realise the production and distribution of energy (Rescoop.eu).

Similarly to Denmark, the Netherlands does not provide specific financial tools for energy communities, excluding grants (Rescoop.eu, 2022. These grants are distributed based on a decentralised tender process, where regional boards make decisions on the allocation of funding (Rescoop.eu, 2022). The Western region of the country provides subsidies for community energy projects to hire legal experts. Furthermore, the Dutch government provides low-interest-rate loans for homeowners who plan to apply more energy-efficient solutions in their homes, but these are not tailored for community businesses (Rescoop.eu, 2022).

All in all, the funding available in Germany is more nuanced and is accessible through various tools, whereas the Netherlands and Denmark rely on offering minor grants to energy communities. The German system reflects more on the special needs of these communities by establishing special rolling grants to de-risk the preparatory process of the project implementation. However, following the preparatory process, the financial tools available are more market-based as the compensation scheme is focused on a market premium, and limits the opportunity for feed-in-tariffs. According to the assessment of Rescoop.eu (2022) both the Netherlands and Denmark lack a coherent and transparent financial system which could enable energy communities to tackle possible obstacles. For this reason, they remain mainly reliant on loans from commercial banks and funding from cooperative grants.

When analysing the impact of policies on energy communities, it must be considered that in the case of Germany, they occur in a state which provides a comprehensive financing scheme for community businesses, whereas Denmark and the Netherlands offer significantly fewer opportunities for energy communities to obtain financing. Hence, the final number of energy communities in Germany can potentially be higher, than in the rest of the countries, due to the state providing more financial support for community businesses. The quantitative models estimated in this thesis do not include the financial frameworks of each country, however, the results need to be viewed considering the financial opportunities offered by Germany, in contrast with Denmark and the Netherlands.

5. Data Analysis

The following chapter will focus first on the data collection process and methodology, then on the analysis of how policies introduced in the selected countries affected the number of energy communities formed each year and over time between 1970 and 2023. In the cases of Germany and Denmark, the impact of the introduction of feed-in tariffs will be estimated, whereas in the case of the Netherlands, the impact of market premiums.

The chapter explains how the dataset used for the analysis was built, as well as the reasons behind the policy case selection in each country. The analysis estimates the impact of the selected policies by using a difference-in-differences method, which measures how the difference between the number of energy communities and agricultural cooperatives formed each year changed after the policy intervention, in comparison with this value before the intervention. In the case of Germany, the discussion reflects on the potential role of the German financial framework in the incentivising of the EC foundation.

The analysis allows for estimating the policy impact by selecting a control group affected by several factors which also affect energy communities, hence, enabling the separation of the impact of the specific policies from the influence of other factors driving cooperative formation. The code for the data collection and the analysis is available in the GitHub repository on energy communities: https://github.com/mentamora2/Energy-Communities.git (Mora, 2024). The scope of the quantitative study is limited to factors determined by the state-society levels, as the financial frameworks and global factors are not included in the models.

5.1. Data Collection Process

Since there is no publicly available comprehensive dataset on energy communities in the EU, the research relied on downloading data from the national company registry website of each country. After selecting the legal and industrial criteria for energy communities, the date of registration for the identified companies was used as the time of foundation.

5.1.1. Denmark

Data on energy communities in Denmark was downloaded from the Business in Denmark website, where it was possible to filter for both the legal form and the industry. Based on Wierling et al. (2023) and the Nordic Energy Research (2023a), the search included cooperatives and partnerships for which “The real owner cannot be identified or found, the board is used as the real owner” was written under the ownership category, indicating the absence of profiting owners. The search identified a total of 1618 companies in the energy industry that met these criteria, out of which 668 were still in business. This is consistent with the findings of Wierling et al. (2023), who identified 633 energy communities.

5.1.2. Netherlands

For Dutch communities, the Bedrijvenmonitor, the Dutch company registry was used to search for cooperatives and associations in the energy sector. The results reflect the data provided by the Lokale Energie Monitor 2023 which includes a total of 705 companies. Unfortunately, due to the data protection measures of the company registry website, the more detailed documentation of each company could not be accessed.

5.1.3. Germany

Energy communities in Germany take the legal form of cooperatives and limited liability companies (Nordic Energy Research, 2023b). To identify energy communities, these legal forms were selected on the company registry website (Unternehmenregister) and, since the website does not allow for filtering based on industry, building on Wierling et al. (2023), the following search words were used to identify companies in the energy sector:

Energie (energy), *Bürgerenergie* (civic energy) *Energiegenossenschaft* (energy cooperative), *Wasserkraft* (hydropower), *Windkraft* (windpower), *Elektrizitätsversorgung* (Electricity supply), *Energieversorgung* (Energy supply), *Strom* (Electricity), *Solarstrom* (Solar electricity), *Sonnenstrom* (Sun electricity), *Kraftwerk* (Power plant), *Windenergie* (Wind energy), *Windpark* (Wind farm), *Solarpark* (Solar farm), PV (PV), *Photovoltaik* (Photovoltaic).

The historical records of the companies were downloaded, and the date of entry was taken as the date of foundation for the energy communities. The final dataset consists of 3585 companies. However, due to limited data availability from the early years, when several companies were found with missing information, the analysis is focused on companies that were started after 1970.

Since companies that were already dismantled do not always have their date of registration available in the database, the research cannot fully reflect the number of companies founded over the years which did not manage to stay in business. For this reason, the dataset only partially reflects the date and number of energy companies started between 1970 and 2023. The final inventory was compared to the data found by Koltunov et al. (2023) who collected 847 companies, and Wierling et al. (2023) who collected 4848 companies. The reason for diversion is that Koltunov et al. (2023) only considered cooperatives, whereas Wierling et al. (2023) included associations as well. Following the guidelines of Nordic Energy Research (2023b), the present study focused on limited liability companies and cooperatives.

In the final datasets, the number of energy communities founded in each year was calculated and stored in a variable named 'ec_count'. Missing observations for ec_count were replaced with 0 since this reflected the lack of companies founded that year.

5.2. Constructing the Models

The following section explains the selection of policy intervention points and the control group for the model. To study the impact of the selected policy interventions, the method of estimating difference-in-differences was used. For this, a point of policy intervention was identified for each country which was then used as the cut-off point in time to inspect changes after the intervention, compared with the pre-trends.

5.2.1. Selecting the Policy Intervention

For selecting the year of the intervention to be studied, it was taken into account how long each policy was in place, since legally registering a company can be a lengthy process, and a possible time lag between the start of a company's formation and the legal registration can occur. For this reason, a policy would have to be in place for approximately more than 3 years without another policy intervention occurring within that timeframe for the model to give accurate estimates.

Based on the review of policy frameworks in chapter 3, the main policy changes affecting energy communities in Denmark, the Netherlands, and Germany are shown in Figures 1, 2, and 3, respectively.

Denmark						
Policy	The decision to eliminate nuclear power	Feed-in-tariffs	Quota for minimum amount of renewables to purchase, 20% decrease in feed-in-tariffs	Ownership liberalisation for wind turbines	Announcing the phasing out of feed-in-tariffs	Market premiums
Year of introduction	1985	1992	1999	2000	2002	2012

Figure 1: The main policy interventions targeting civic energy production in Denmark

Netherlands			
Policy	Feed-in-tariffs	Decision to eliminate feed-in-tariffs	Market premiums
Year of introduction	2003	2006	2008

Figure 2: The main policy interventions targeting civic energy production in the Netherlands

Germany		
Policy	Feed-in-tariffs	Phasing out the feed-in-tariffs
Year of introduction	2000	2014

Figure 3: The main policy interventions targeting civic energy production in Germany

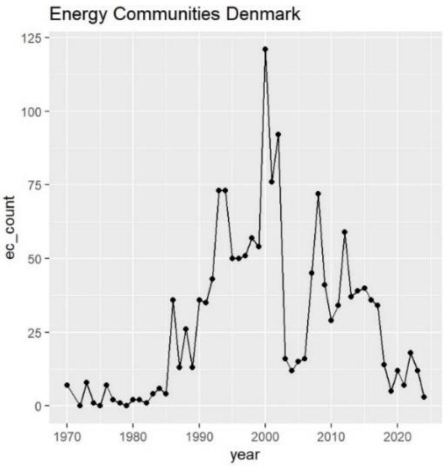

Figure 4: Number of energy communities formed in Denmark (1970-2024)

In the case of Denmark, the first wave of foundation is shown after 1985 (Figure 4), when the Danish parliament decided to eliminate the consideration of nuclear power as a potential energy source in the future (International Renewable Energy Agency, 2013). The next policy intervention was made in 1992 when the feed-in tariffs were introduced. In 1999, 2000, and 2002, five new policies were introduced, first the reduction of feed-in tariffs (1999), then their elimination (2002), a quota was set for the minimum amount of renewable energy to be purchased (1999), along with consumers being allowed to pick their energy providers (1999). Finally, the previously existing law which required physical proximity to wind turbines was abolished in 2000. This period is associated with a growth in the number of energy communities, however, due to the wide set of varying policies, it is not possible to judge what impact each one of these had, especially combined with a possible time lag between their introduction and their effects appearing in the data. In 2012, market premiums were introduced as the new financing tool for renewable energy producers, however, this was not associated with a large increase compared with the previous trends. For these reasons, the model will focus on the effects of the feed-in tariffs started in 1992.

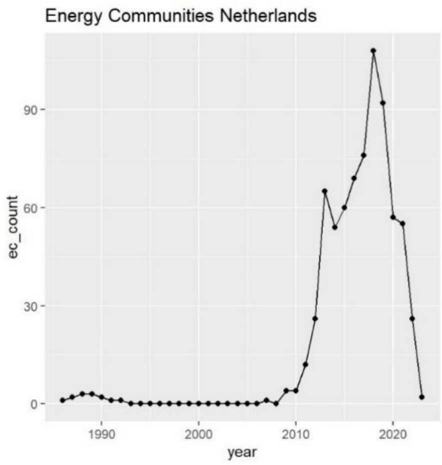

Figure 5: Number of energy communities formed in the Netherlends (1970-2024)

In the case of the Netherlands, feed-in-tariffs were quickly eliminated after their introduction, due to a lack of impact on civic energy production. In 2008, the alternative model of market premiums was applied.

After plotting the number of energy communities registered each year (Figure 5), it can be determined that the plot is consistent with the conclusions of decision-makers (Lensing, 2009), as there is no change that can be seen after introducing feed-in tariffs. For this reason, 2008 will be the chosen year to estimate the impact of switching to market premiums from feed-in tariffs.

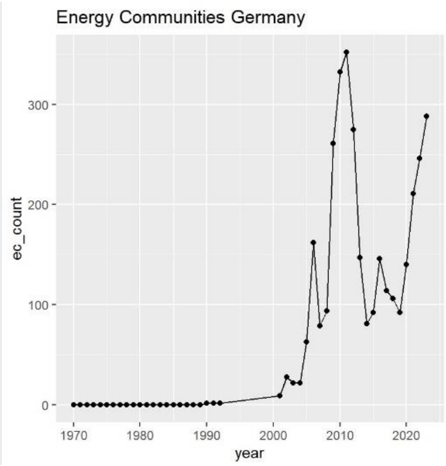

Figure 6: Number of energy communities formed in Germany (1970-2023)

For Germany, the two main points of intervention were in 2000 and 2014, when the feed-in tariffs were introduced and then announced to be phased out. Figure 6 shows the plot of the number of energy communities formed each year in Germany. The introduction of feed-in tariffs in 2000 will be used as the main policy intervention to study.

5.2.2. Using Agricultural Cooperatives as the Control Group

For performing the difference-in-differences, agricultural cooperatives were used as the control group. Agricultural cooperatives can be a good comparison since similar factors influence their formation as energy communities, such as civic willingness to participate in community initiatives, the strength of civic communities, social capital, and ecological awareness (Giagnocavo, 2020; Saz-Gil, 2021).

Data on agricultural cooperatives was collected with the same method as energy communities, except the selected industry was agriculture, instead of energy. Consistency of the data collection method across the two groups ensures the validity of the comparison. The following search words were applied in the German company register, where it was not possible to filter for the industry.

Lebensmittel (food), *Agrar* (agricultural), *Erzeuger* (producer), *Landwirtschaft* (agriculture), *Bauern* (farmers), *Molkerei* (dairy), *Winzer* (winemakers), *Gemüse* (vegetables), *Obst* (fruits), *Getreide* (grain), *Fleisch* (meat), *Bio* (organic). *Bio-Landwirtschaft* (bio-agriculture), *Getreideproduktion* (grain production).

Since the pre-trends before the treatment were not perfectly parallel, Masnki's bounding (Manski & Pepper, 2018) was applied to account for the pre-existing divergence when calculating the difference between the treatment group (energy communities) and the control group after the intervention. The treatment effect was computed under the strong difference-in-differences assumption (Manski & Pepper, 2018).

The data was converted into a time series format for performing the difference-in-differences analysis. The treatment effect was computed, as well as the upper and lower bounds of the treatment effect based on the 75th percentile of the absolute differences between the treatment and the control groups, to ensure the robustness of the results.

6. Results

The analysis in this section focuses firstly on the visual comparison of the number of agricultural cooperatives and the number of energy communities formed each year after 1970. Then, by computing the difference between the numbers of the treatment and the control groups pre-intervention, the minimum and maximum of the pre-trend difference will also be determined. The treatment effect for the selected policy interventions will be computed, as well as the lower and upper bounds of the treatment effect based on the 75th percentile of the absolute differences between the treatment and the control groups. Following the presentation of results, the implications of the calculated impact of feed-in tariffs in Germany and Denmark, and the impact of introducing market premiums in the Netherlands will be discussed with a focus on the time and amount of compensation offered by each policy. Understanding and comparing the results of the models helps shed light on how fixed tariffs operate under various conditions in the examined countries, versus how the market-price-dependent premiums impacted the numbers of energy communities in the Netherlands. In the case of Germany, the potential role played by its complex financial infrastructure available to civic energy producers will also be discussed.

6.1. Denmark

Visually exploring the trends of the number of energy communities formed each year before the 1992 treatment (Figure 7) shows they were similar before the number of energy communities started to increase following the 1985 decision to phase out nuclear energy. This supports the idea that without policy intervention, the trends follow similar patterns, which reinforces the notion of agricultural cooperatives being a legitimate control group for energy communities.

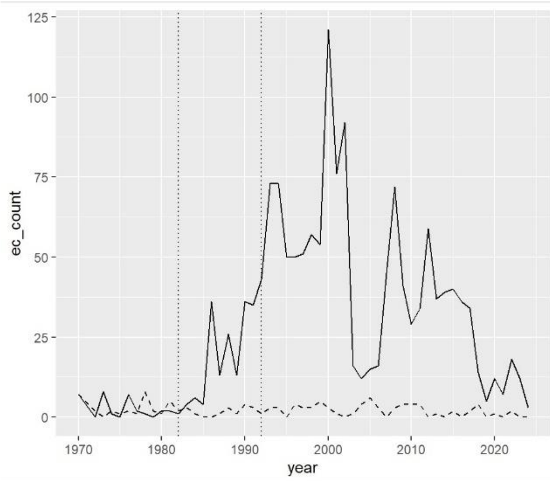

Figure 7: Number of energy communities and agricultural cooperatives formed in Denmark (1970-2023)

The plot of the difference between the two groups (Figure 8) is consistent with these observations since the difference started increasing after 1985. Based on the plot, the maximum of the difference was 41, whereas the minimum was -6. These values will be used for visualising the bounds of what the trend of the number of energy communities would have looked like after 1992 without the intervention.

Figure 8: The difference between the number of energy communities and agricultural cooperatives formed in Denmark

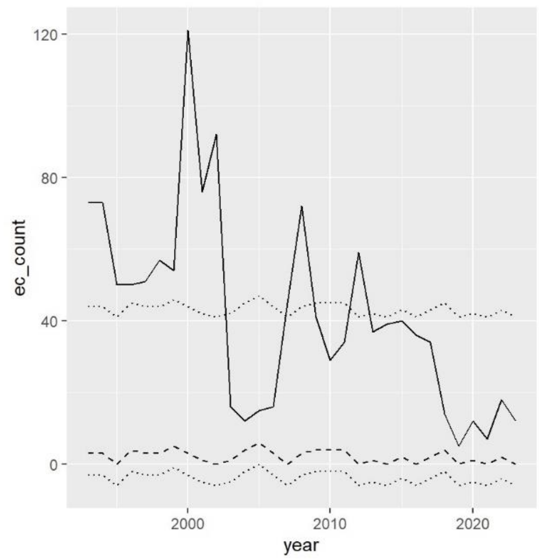

Figure 9: Plot of the number of energy communities in Denmark after the policy intervention

From 1999, the trend was divergent, which could be explained by the policy mix introduced in those years. The dashed line in Figure 9 shows the number of agricultural cooperatives, whereas the dotted lines visualise the lower and upper bounds for what the number of energy communities formed each year would be without the policy intervention. This was calculated based on the difference between the pre-trends of the two groups, and the number of agricultural cooperatives formed after 1992. The graph shows that the number of energy communities started to rapidly increase after 1992. However, the increase did not last for longer than a few years.

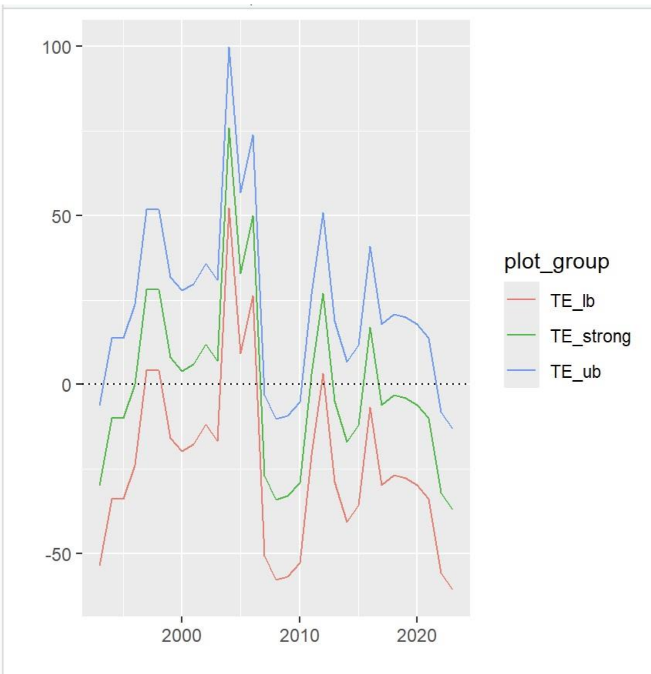

Figure 10: Visualised treatment effect for Denmark with lower and upper bounds

	year	TE_lb2	TE_strong2	TE_ub2
1	1993	-146.1	-37	72.1
2	1994	-126.1	-17	92.1
3	1995	-126.1	-17	92.1
4	1996	-116.1	-7	102.1
5	1997	-88.1	21	130.1
6	1998	-88.1	21	130.1
7	1999	-108.1	1	110.1
8	2000	-112.1	-3	106.1
9	2001	-110.1	-1	108.1
10	2002	-104.1	5	114.1
11	2003	-109.1	0	109.1
12	2004	-40.1	69	178.1
13	2005	-83.1	26	135.1
14	2006	-66.1	43	152.1
15	2007	-143.1	-34	75.1
16	2008	-150.1	-41	68.1
17	2009	-149.1	-40	69.1
18	2010	-145.1	-36	73.1
19	2011	-113.1	-4	105.1
20	2012	-89.1	20	129.1
21	2013	-121.1	-12	97.1
22	2014	-133.1	-24	85.1
23	2015	-128.1	-19	90.1
24	2016	-99.1	10	119.1
25	2017	-122.1	-13	96.1
26	2018	-119.1	-10	99.1

Figure 11: Treatment effect for Denmark with lower and upper bounds

In the first four years after the introduction of the feed-in tariffs, the estimated treatment effect is negative (Figure 11, plot: Figure 10). However, starting from 1997, the treatment effect is calculated to be positive. Since the lower bound is still negative for those years, the estimates did not produce results which would suggest with certainty that the treatment had a positive effect on the number of energy communities.

The possible uncertainty and the shorter timeframe in this scheme could partially explain the limited effect of Danish feed-in tariffs. This FiT was unconventional in the sense that it did not operate with an actual fixed amount of compensation, but the compensation was determined as 85% of the energy production cost. Furthermore, the guaranteed time of compensation was also only 10 years, as opposed to the 20 years guaranteed by the German system. These factors can decrease the impact of the policy, which reinforces the idea that the length of time for which ECs can receive compensation influences the impact of FiT.

Due to the absence of other financing opportunities tailored to the needs of these communities, the policy scheme in place is almost solely responsible for providing financial support for ECs. For this reason, a short timeframe of compensation and the instability of the policy tools can cause major issues for energy communities.

6.2. Netherlands

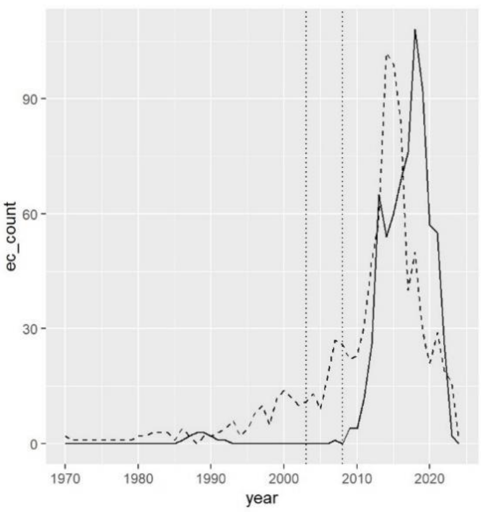

Figure 12: Number of energy communities and agricultural cooperatives formed in Netherlands (1970-2023)

Observing the plot of the number of energy communities and agricultural cooperatives formed each year in the Netherlands (Figure 12) shows that before 1989, the trends of the two groups did not differ to a great extent. However, after 1989, the counterfactual group started to increase compared with the treatment group. The second vertical line in the graph was drawn at 2008, when the introduction of market premiums took place.

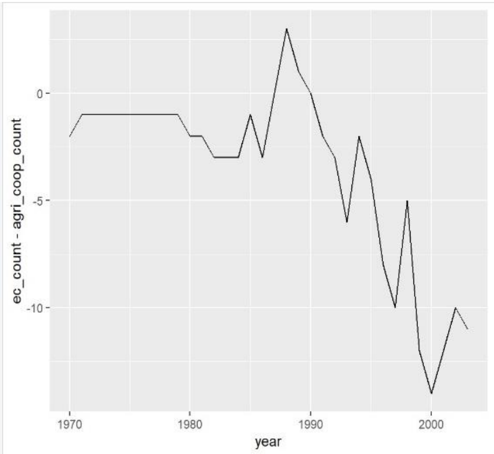

Figure 13: The difference between the number of energy communities and agricultural cooperatives formed in the Netherlands

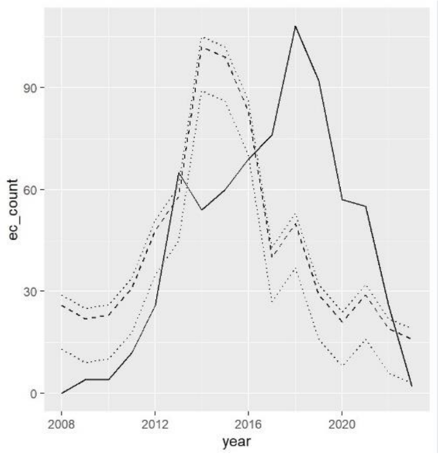

Figure 14: Plot of the number of energy communities in Denmark after the policy intervention

Based on the plot of differences in the pre-trends of the two groups (Figure 13), the maximum of the differences was 3, and the minimum was minus 17. The plot of energy communities after the treatment was also visualised in Figure 14, along with the upper and lower bounds of the estimated numbers of energy communities if the treatment had not occurred, which was calculated based on the pre-trends.

The treatment effects computed in Figure 16 and their plot in Figure 15 show a positive impact of the shift to market premiums on the numbers of Dutch energy communities. The lower and upper bounds of the treatment effect are also positive, indicating the positive impact of the market premiums.

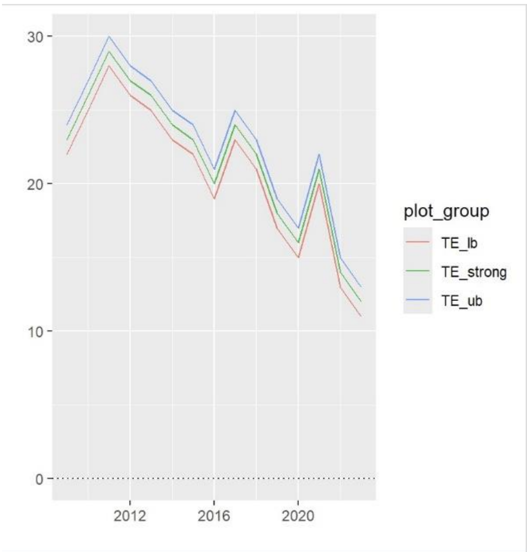

Figure 15: Treatment effect for the Netherlands with lower and upper bounds

	year	TE_lb	TE_strong	TE_ub
1	2009	22	23	24
2	2010	25	26	27
3	2011	28	29	30
4	2012	26	27	28
5	2013	25	26	27
6	2014	23	24	25
7	2015	22	23	24
8	2016	19	20	21
9	2017	23	24	25
10	2018	21	22	23
11	2019	17	18	19
12	2020	15	16	17
13	2021	20	21	22
14	2022	13	14	15
15	2023	11	12	13

Figure 16: Visualised treatment effect for the Netherlands with lower and upper bounds

Stable, long-term compensation can be an influential tool in the Dutch system as well. The compensation system of market premiums offers guarantees for 15 years, as opposed to the 10 years guaranteed by the FiT system which was in place for 3 years. Furthermore, the level of compensation (premium plus market price) was also higher under these regulations, than under the feed-in tariff system. Feed-in tariffs, which were quickly deemed ineffective, were only in place for a short period. The instability of the regulation could also have reinforced the ineffectiveness of feed-in tariffs. Since market premiums remained in place up until now (2024) after their introduction, the stable policy environment can also be a factor contributing to the positive impact of the policy.

These results also suggest that the observation of Mey et al. (2023) on the backlash caused by the German shift from FiT to market premiums is not generalisable to other countries. In the Dutch case, market premiums were shown to be more effective, than feed-in tariffs in incentivising energy community formation.

6.3. Germany

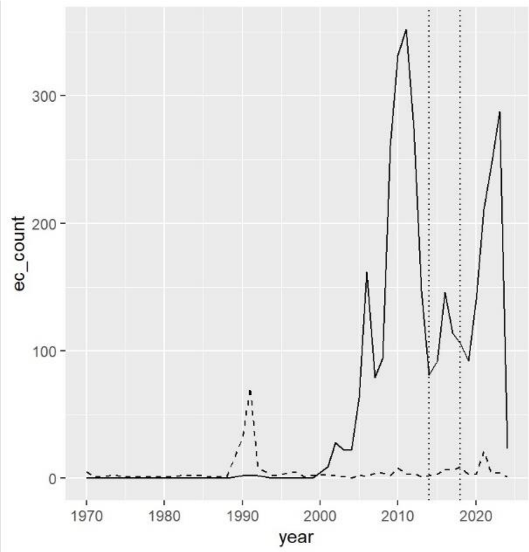

Figure 17: Number of energy communities and agricultural cooperatives formed in Germany (1970-2023)

Exploring the pre-trends of the number of ECs and agricultural cooperatives formed before the 2000 intervention (Figure 17) shows that trends for agricultural cooperatives were not fully parallel with energy communities, but similar to them. There was a sudden increase in their numbers before 2000, but the divergence can be included in the model by the bounds applied.

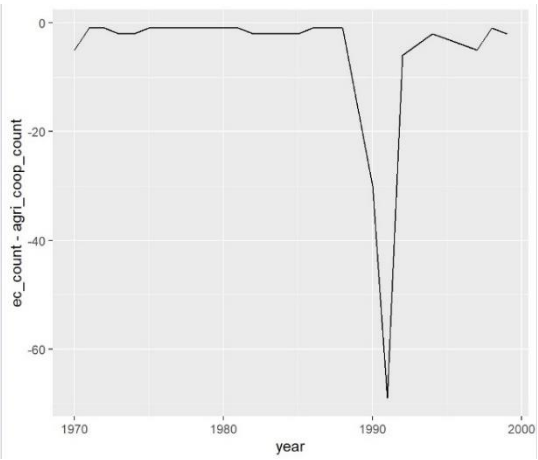

Figure 18: The difference between the number of energy communities and agricultural cooperatives formed in Germany

Plotting the difference between the treatment and the control groups in Figure 18 indicates the maximum of their difference was zero and the minimum was minus 68.

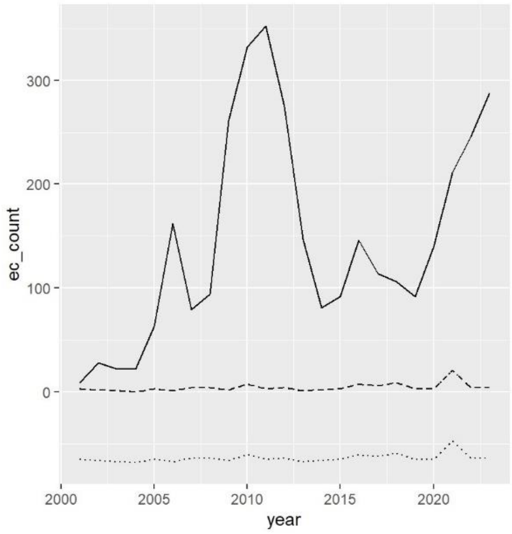

Figure 19: Plot of the number of energy communities in Denmark after the policy intervention

In Figure 19, the plot of the number of energy communities formed after the policy intervention shows that the increase in their numbers only started a few years after the introduction of feed-in tariffs. The increase was not constantly present, because the number of newly formed energy communities dropped after 2006 and only started to increase again later.

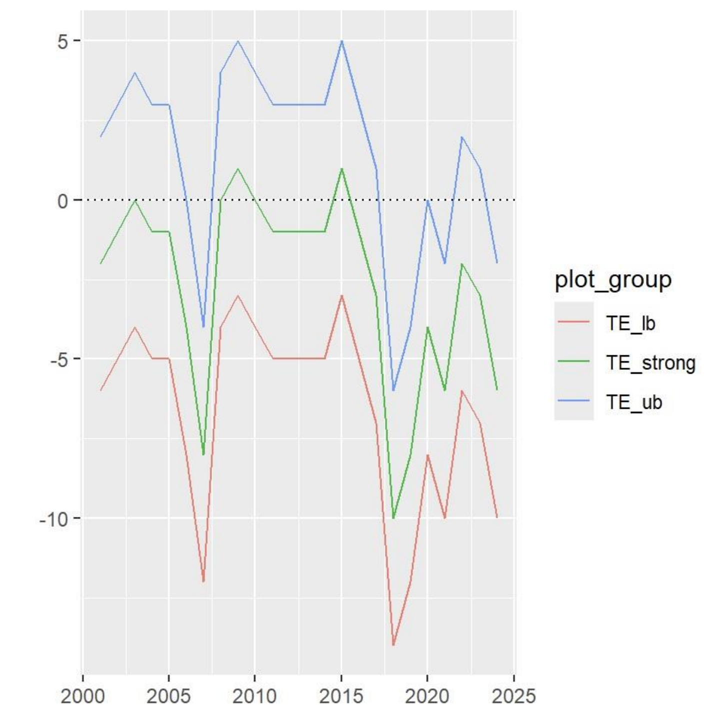

Figure 20: Visualised treatment effect for Germany with lower and upper bounds

	year	TE_lb	TE_strong	TE_ub
1	2001	-6	-2	2
2	2002	-5	-1	3
3	2003	-4	0	4
4	2004	-5	-1	3
5	2005	-5	-1	3
6	2006	-8	-4	0
7	2007	-12	-8	-4
8	2008	-4	0	4
9	2009	-3	1	5
10	2010	-4	0	4
11	2011	-5	-1	3
12	2012	-5	-1	3
13	2013	-5	-1	3
14	2014	-5	-1	3
15	2015	-3	1	5
16	2016	-5	-1	3
17	2017	-7	-3	1
18	2018	-14	-10	-6
19	2019	-12	-8	-4
20	2020	-8	-4	0
21	2021	-10	-6	-2
22	2022	-6	-2	2
23	2023	-7	-3	1
24	2024	-10	-6	-2

Figure 21: Treatment effect for Germany with lower and upper bounds

The estimated treatment effect in Figure 21 shows only a small effect after the introduction of the FiT, which is negative. However, the upper bounds estimated are positive, indicating that it cannot be determined what effects the treatment had in those years, if any. In 2009, the treatment effect was positive, however, the lower bound was still negative. These results indicate the actual treatment effect to be significantly lower than it would appear based on the first visualisation of the numbers. On the other hand, results started declining shortly after 2014, which is when the phasing out of FiT started. Starting from 2018, the upper bound of the treatment effect also becomes negative. Hence, despite the estimated impact of feed-in tariffs not being positive, their suspension is still associated with a decrease in the formation of energy communities in comparison with agricultural cooperatives. This suggests that even though feed-in tariffs were not estimated to have a positive impact on the number of energy communities, they might have still been relevant in slowing down their decrease.

The German feed-in tariff system offered a more generous level of compensation, than the Dutch market premium scheme, furthermore, it was guaranteed for 20 years, which is the longest out of the compensation systems discussed in this thesis. For this reason, the lower estimated treatment effect compared to what was calculated for the Netherlands cannot be explained by the timeframe of compensation.

The low impact of the German feed-in tariffs is interesting, because Germany is the country with the highest number of energy communities, hence, the cause of the success must be rooted in factors other than the direct impact of policies. Since Germany offers the most developed loan opportunities for community businesses throughout every stage of their projects, furthermore, the strength of civic society is also high, it is plausible that the high numbers of energy communities are driven by the interplay of the former factors, rather than feed-in tariffs or tenders.

The most unique factor affecting German energy communities compared with Denmark and the Netherlands is the complex financial infrastructure available to ECs. The low-interest-rate loans coupled with the rolling grants to finance the initial stages of the projects are not available in the other two countries studied in this analysis. For this reason, in light of the low impact of feed-in tariffs, the loan and grant schemes of Germany (Rescoop.eu, 2023) discussed in chapter 3 are likely to be factors in incentivising civic energy production and contributing to the high number of ECs in the country. This highlights the importance of providing a complex financial infrastructure to enable energy community formation. However, due to the absence of the financial framework from the quantitative model, the exact impact it had is unclear and it would require more research to unpack this.

The estimated impact of FiT in Germany suggests that fluctuations in the number of ECs can occur despite providing favourable conditions for them. Since the same fluctuation did not occur in the number of agricultural cooperatives, the cause is not rooted in factors influencing cooperatives in general, nor was a new policy introduced over the period considered by the analysis. The results highlight the complexity of energy transitions and that despite considering most of the known drivers of EC formation, unexpected changes can still occur.

7. Conclusion

The comparison of the number of energy communities formed over the years with the number of agricultural cooperatives served the purpose of creating a model which reflects how the formation of energy communities is simultaneously driven by top-down and bottom-up factors. The goal was to estimate the impact of the selected policies to gain an understanding of how the feed-in tariffs and market premiums affected ECs in the selected cases and unpack the role of the stability of compensation by also considering the timeframe each policy covered. The treatment effects were estimated by using the method of difference-in-differences with bounding (Manski & Pepper, 2018) to account for the non-parallel pre-trends.

The estimated treatment effects for Denmark and the Netherlands follow the hypothesis that long-term compensation schemes are associated with higher treatment effects. In the case of the Netherlands, feed-in tariffs were observed to be ineffective by the policymakers, who decided to replace them with a market premium system. The system offers longer guarantees and higher compensation than the previous Dutch or the Danish FiT, which can explain why the treatment effect was higher than for the latter ones. In these cases, the strength of the treatment effect was connected to how long the guarantees were under various compensation schemes.

The case of Germany suggests that factors other than feed-in tariffs contributed largely to the leading position of the country in the number of energy communities. The tariffs did not have a strictly positive effect on the number of energy communities formed, however, the decline after they were phased out suggests their relevance. The effect of the German feed-in tariffs was estimated to be high by observers who focused on the changes in the numbers of energy communities after the introduction of the tariffs (Mey et al., 2023; Norden, 2013). This controversy is rooted in the focus of the present thesis on comparing differences between the treatment and control groups before and after the policy change, rather than solely focusing on the number of energy communities. Hence, by incorporating how the number of agricultural cooperatives changed over the years, the treatment effect was estimated to be lower than what the visual inspection would suggest. This also reinforces the idea that other factors, such as the German financial infrastructure available to energy communities combined with a strong civic society are powerful factors driving the mushrooming of ECs in Germany.

The German example also poses the question of whether there is a ceiling for energy community formation. Since Germany is the country with the most energy communities, there is a possibility that further policies can achieve only limited change in these numbers. To answer this question, further inspection of energy community formulation trends is necessary.

Future research with a focus on the role of the financial infrastructure available to energy communities is essential for mapping out the most influential drivers of EC formation. The role of policies in helping the foundation of these communities is crucial, however, the unmatched success of Germany in fostering civic energy production in the EU suggests that factors beyond policy also have a substantial role in incentivising civic engagement in the energy markets. To understand the drivers of ECs better, additional research with a specific focus on loan and grant structures is required.

8. Policy Implications

The policy implications of studying Denmark, the Netherlands, and Germany include the importance of providing a predictable and stable compensation framework for civic energy producers. The analysis suggests that stability does not only consist of the same policies staying in place for longer periods but also of the timeframe throughout which the compensation is available for each energy community.

Feed-in tariffs were deemed ineffective in the Netherlands, where market premiums incentivised energy community formation more. On the other hand, in the German case, the shift to market premiums was associated with a decrease in the number of energy communities, even though feed-in tariffs were not largely impactful. For this reason, it cannot be stated that either feed-in tariffs or market premiums are the best tools, regardless of the exact compensation scheme they offer.

The timeframe covered by the compensation scheme is essential in incentivising the formation of energy communities in the EU. The analysis suggests that in the Danish and Dutch cases, the length of the guaranteed compensation was a key factor in driving the mushrooming of energy communities. In the Netherlands, measuring the number of energy communities founded each year, the more impactful market premiums were offered for 15 years, as opposed to the 10 years of the seemingly ineffective feed-in tariffs. Similarly, in the Danish case, where feed-in tariffs were shown to have a very limited impact, they were only offered for 10 years. Additionally, the constantly changing policy environment in Denmark could have further diminished the effects of this policy tool. Hence, policies, which offer compensation for more than 10 years and do not change frequently are favourable for energy community formation.

Limitations of the study include the scope of the research being the EU core, which means the results are not necessarily representative of other regions. Each policy occurs in the specific socio-economic context of the given country and should reflect the challenges of the targeted renewable energy markets and the existing and potential civic producers. Furthermore, the financial infrastructure offered by Germany was not included in the quantitative analysis, despite being a potentially crucial element in incentivising energy community formation.

Bibliography

Arnould, J., & Quiroz, D. (2022). Energy communities in the EU: Opportunities and barriers to financing. *Friends of the Earth Europe*.

Bauwens, T., Gotchev, B., & Holstenkampf, L. (2016). What drives the development of community energy in Europe? The case of wind power cooperatives. *Energy Research & Social Science*, *13*, 136-147.

Bedrijvenmonitor. (n.d.). Available at: https://bedrijvenmonitor.info/branche/bedrijven-in-de-branche-energie-productie-en-distributie?page=1

Bode, A. (2022). To what extent can community energy mitigate energy poverty in Germany?. *Frontiers in Sustainable Cities*, *4*. https://doi.org/10.3389/frsc.2022.1005065

Business in Denmark (n.d.). Available at: https://businessindenmark.virk.dk/

Diestelmeier, L. (2021). The role of energy communities in facilitating sustainable energy democracy. In R. Fleming, K. Huhta, & L. Reins (Eds.), *Sustainable energy democracy and the law* (pp. 124-143). *Brill / Nijhoff*. https://doi.org/10.1163/9789004465442_007

Energy Community Secretariat. (2024). *Policy guidelines on the concepts of energy communities* (PG 01/2024).

European Commission. (2022). In focus: Energy communities to transform the EU's energy system. Available at: https://energy.ec.europa.eu/news/focus-energy-communities-transform-eus-energy-system-2022-12-13_en [Accessed 06 April 2024]

European Commission. (2023). Commission welcomes completion of key 'Fit for 55' legislation, putting EU on track to exceed 2030 targets. Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_23_4754 [Accessed 15 January 2024]

European Commission. (n.d.). Energy communities. Available at: https://energy.ec.europa.eu/topics/markets-and-consumers/energy-communities_en [Accessed 15 January 2024]

European Union. (n.d.). Renewable Energy Directive. Available at: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

Giagnocavo, C. (2020). The development of the cooperative movement and civil society in Almeria, Spain: Something from nothing? *Sustainability, 12*(23), 9820.

International Renewable Energy Agency. (2013). 15 years of wind energy in Denmark. IRENA. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/GWEC/GWEC_Denmark.pdf?la=en&hash=C14BEEC4FFEEBA20B2B1928582AA23931F092F48

Klagge, B., & Meister, T. (2018). Energy cooperatives in Germany–an example of successful alternative economies?. *Local Environment, 23*(7), 697-716.

Koltunov, M., Pezzutto, S., Bisello, A., Lettner, G., Hiesl, A., van Sark, W., Louwen, A., & Wilczynski, E. (2023). Mapping of energy communities in Europe: Status quo and review of existing classifications. *Sustainability, 15*(10), 8201. https://doi.org/10.3390/su15108201

Legal Sources on Renewable Energy. (2019a). Premium tariff (Law on the promotion of renewable energy). Res-Legal. Available at: http://www.res-legal.eu/search-by-country/denmark/single/s/res-e/t/promotion/aid/premium-tariff-law-on-the-promotion-of-renewable-energy/lastp/96/

Legal Sources on Renewable Energy. (2019b). Premium tariff (SDE+). Res-Legal. Available at: http://www.res-legal.eu/search-by-country/netherlands/single/s/res-e/t/promotion/aid/premium-tariff-sde/lastp/171/

Lensink, S. M. (2009, December 5). Walking the tightrope: Balancing effectiveness against cost in the Netherlands' feed-in tariffs. Global Subsidies Initiative. https://www.iisd.org/gsi/commentary/walking-tightrope-balancing-effectiveness-against-cost-netherlands-feed-tariffs

Lokale Energie Monitor. (2023). Available at: https://www.hier.nu/lokale-energie-monitor-2023

Manski, C. F., & Pepper, J. V. (2018). How do right-to-carry laws affect crime rates? Coping with ambiguity using bounded-variation assumptions. *The Review of Economics and Statistics, 100*(2), 232–244.

Mey, F., Kallies, A., Wiseman, J., & Watson, M. (2023). Legitimizing energy transitions through community participation: Germany and Australia at a crossroad. *Globalizations, 20*(8), 1344-1362.

Mignon, I., & Rüdinger, A. (2016). The impact of systemic factors on the deployment of cooperative projects within renewable electricity production - An international comparison. *Renewable and Sustainable Energy Reviews, 65*, 478-488.

Mora, M. (2024). Energy-Communities [Source code]. GitHub. https://github.com/mentamora2/Energy-Communities.git

Netztransparenz.de. (n.d.). Abwicklungshinweise und Umsetzungshilfen. [Implementation Guidelines and Implementation Aids]. Available at: https://www.netztransparenz.de/de-de/Erneuerbare-Energien-und-Umlagen/EEG/EEG-Abrechnungen/Abwicklungshinweise-und-Umsetzungshilfen

Norden, C. (2013). Governing community energy—Feed-in tariffs and the development of community wind energy schemes in the United Kingdom and Germany. *Energy Policy, 63*, 543-552.

Nordic Energy Research. (2023a). Denmark. Available at: https://pub.norden.org/nordicenergyresearch2023-03/denmark.html#:~:text=An%20energy%20community%20can%20be,%2C%20cooperative%2C%20or%20capital%20company.

Nordic Energy Research. (2023b). Germany. Available at: https://pub.norden.org/nordicenergyresearch2023-03/germany.html#:~:text=The%20most%20common%20legal%20frameworks,(GmbH%2FUG%20%26%20Co.

Nordic Energy Research. (2023c). Netherlands. Available at: https://pub.norden.org/nordicenergyresearch2023-03/netherlands.html#:~:text=Energy%20communities%20in%20the%20Netherlands,)%2C%20and%20sometimes%20a%20company.

Proka, A., Loorbach, D., & Hisschemöller, M. (2018a). Leading from the niche: Insights from a strategic dialogue of renewable energy cooperatives in The Netherlands. *Sustainability, 10*(4106). https://doi.org/10.3390/su10114106

Proka, A., Hisschemöller, M., & Loorbach, D. (2018b). Transition without conflict? Renewable energy initiatives in the Dutch energy transition. *Sustainability, 10*(1721). https://doi.org/10.3390/su10061721

Rentenbank.de (n.d.-a). About us. Available at: https://www.rentenbank.de/en/

Rescoop.eu. (n.d.-a). Denmark. Available at: https://www.rescoop.eu/policy/transposition-tracker/enabling-frameworks-support-schemes/denmark

Rescoop.eu. (2023). Germany. Available at: https://www.rescoop.eu/policy/transposition-tracker/enabling-frameworks-support-schemes/germany-2?fbclid=IwAR3U0JOt1Y6AOyVOV1XUUn8NVyvadraQVnYLGDX_aY0RpolaVmCUavnazjk_aem_AYh57xAqxIcrA3yDBJo07rW3cBJGh6ZNFfqtPKMP1Z30g2bbrg3N8TS4O6OiR3Dv7rrHdO_vkZoczs97vk0MENoG

Rescoop.eu. (2022). Netherlands. Available at: https://www.rescoop.eu/policy/netherlands

Rescoop.eu, & Ecopower. (2023). Financing guide for energy communities. Available at: https://energycommunityplatform.eu/wp-content/uploads/2023/02/SCCALE203050_financingguide_energycommunities.pdf

Ruggiero, S., Busch, H., Isakovic, A., & Hansen, T. (2021). Community energy in the Eastern Baltic Sea region: From standstill to first steps. In F. H. J. M. Coenen & T. Hoppe (Eds.), *Renewable energy communities and the low carbon energy transition in Europe* (1st ed.). *Springer Nature Switzerland.*

Saz-Gil, I., Bretos, I., & Díaz-Foncea, M. (2021). Cooperatives and social capital: A narrative literature review and directions for future research. *Sustainability, 13*(2), 534.

Stojilovska, A. (2021). Energy poverty and the role of institutions: Exploring procedural energy justice – Ombudsman in focus. *Journal of Environmental Policy & Planning, 1*(13). https://doi.org/10.1080/1523908X.2021.1940895

Unternehmenregister. (n.d.). Available at: https://www.unternehmensregister.de/ureg/registerPortal.html;jsessionid=5E900DEAFF9D2FB43B6DBDAC53C058F8.web04-1 van Sambeek, E. J. W., & van Thuijl, E. (2003). The Dutch renewable electricity market in 2003: An overview and evaluation of current changes in renewable electricity policy in the Netherlands. *ECN Policy Studies*.

Wainer, A., Petrovics, D., & van der Grijp, N. (2022). The grid access of energy communities: A comparison of power grid governance in France and Germany. *Energy Policy, 170*. https://doi.org/10.1016/j.enpol.2022.113014

Wierling, A., Schwanitz, V. J., Zeiss, J. P., et al. (2023). A Europe-wide inventory of citizen-led energy action with data from 29 countries and over 10000 initiatives. *Scientific Data, 10*(9). https://doi.org/10.1038/s41597-022-01902-5

Wierling, A., Schwanitz, V. J., Zeiss, J. P., et al. (2018). Statistical evidence on the role of energy cooperatives for the energy transition in European countries. *Sustainability, 10*(9). https://doi.org/10.3390/su10093339