EMpowering Communities for EneRGy Transition towards Carbon NEutrality in Romania EMERGE – Romania

Local Energy Communities in Norway:

Case Studies and Best Practices

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Definitions

AMS	Advanced Metering System
CEC	Citizen Energy Community
DSO	Distribution System Operator
EU	European Union
EV	Electric Vehicle
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
IMED	Internal Market for Electricity Directive
LEC	Local Energy Community
LFM	Local Flexibility Market
NVE	Norwegian Water Resources and Energy Directorate
PED	Positive Energy District
REC	Renewable Energy Community
REDII	Recast of the Renewable Energy Directive
RME	The Norwegian Energy Regulatory Authority
ToU	Time-of-use
TSO	Transmission System Operator
V2B	Vehicle to Building
V2G	Vehicle to Grid
ZEN	Zero Emission Neighborhood

1. Executive summary

This report, "Energy Communities in Norway: Case Studies and Best Practices," provides an in-depth exploration of energy communities in Norway, with the objective of offering insights that can be adapted to the Romanian context. The work is part of the EMpowering Communities for EneRGy Transition towards Carbon NEutrality in Romania (EMERGE) project aimed at strengthening cooperation between the two countries in the green energy transition and financed by the EEA and Norway grants. The Romanian partners of the EMERGE project include the Academy of Economic Studies of Bucharest (ASE), Renergia, The Politehnica University of Timișoara, the Municipality of Alba Iulia, the Municipality of Buteni (Arad County) and the Municipality of Crucea (Constanța County).

1.1. Key findings and objectives of the report

Local Energy Communities (LECs) are innovative legal entities that operate at the local level, focusing on the production, consumption, storage, and sharing of renewable energy. These communities are characterized by open, voluntary participation and are controlled by their members. A primary goal of LECs is to advance the development of distributed energy technologies and strengthen consumer participation in the energy markets. EU defines two key types of communities: Renewable Energy Communities (RECs), primarily concerned with renewable energy production, and Citizen Energy Communities (CECs), which have a broader scope, including energy services. The term LEC often serves as an umbrella term for both.

Norway is not an EU member and is not directly obligated to EU directives, so the concepts of CECs and RECs have not been implemented in national law or practice. The existing framework, with its state-controlled approach, limits the ability of LECs to operate independently. Nevertheless, several pilot projects and initiatives are exploring and developing energy communities in Norway. Although the projects are not explicitly labelled as LECs, their characteristics and objectives demonstrate a strong connection to the core principles of LECs. The projects, often conducted through regulatory sandboxes, are typically driven by property developers, real estate companies, and Distribution System Operators (DSOs). They focus on creating energy-efficient residential buildings and microgrids to reduce the load on the main grid.

A crucial component for energy communities in the Norwegian context is smart metering, which helps managing energy flows and incentivizing demand response. Furthermore, various incentives for self-consumption, including subsidies, tax exemptions, and the "plus-customer" scheme for selling excess electricity back to the grid, are important factors. Recent expansions to the plus-customer scheme allowing for larger photovoltaic systems and the sharing of surplus energy and proposed extensions for neighboring properties, represent further progress.

These efforts position Norway as a leader in energy community development, reflecting the country's dedication to modernizing the electricity grid, improving energy efficiency, and facilitating the integration of renewable energy sources. Several case studies of energy communities in Norway, such as the +CityxChange project in Trondheim and the Smart Senja project, along with pilot projects from the FME ZEN research center, demonstrate various approaches to energy management and community involvement.

1.2. Application for Romanian energy communities

Romanian partners aiming to develop energy communities can draw from valuable lessons from Norway's experience. To support Romania's efforts towards decarbonization and energy self-sufficiency, it is crucial to establish a supportive legal and regulatory framework for LECs. Learning from Norway's regulatory sandbox approach for pilot projects and streamlining grid connection processes can be particularly beneficial.

Implementing a smart metering infrastructure is essential for effective monitoring of energy flows and facilitating dynamic pricing schemes. Romania can take inspiration from Norway in this regard. Given that funding is a significant barrier for energy communities in Romania, adopting incentives similar to those in Norway, such as tax exemptions and subsiies, can promote self-consumption of renewable energy. Additionally, establishing local flexibility markets, inspired by the +CityxChange model, to encourage local energy balancing. Integrating smart power management systems and energy storage, as demonstrated by the Smart Senja project, is also recommended. Community engagement and collaboration are vital, and Romania can learn from Norway's strategies in involving residents, businesses, and stakeholders in the planning and implementation phases.

Both Norway and Romania face unique challenges in implementing LECs, but there is a growing potential for the development of these communities in both countries. Key factors for growth include regulatory clarity, financial incentives, community engagement, and the adoption of smart technologies. Insights from the Norwegian context provide valuable lessons for the EMERGE consortium and can be used to support the development of sustainable and resilient energy communities in Romania.

2. Introduction

2.1. Purpose and scope of the report

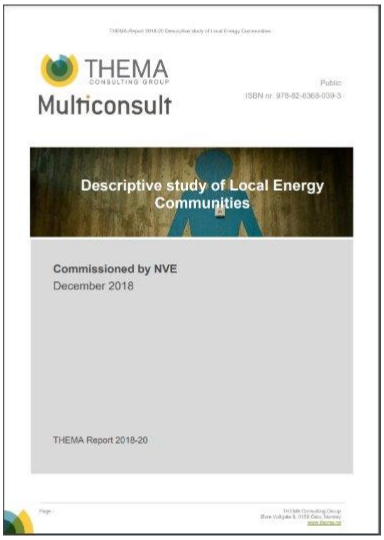
The purpose of this report, titled "Energy Communities in Norway: Case Studies and Best Practices," is to offer an in-depth exploration of how energy communities function in Norway and how these insights can be adapted to the Romanian context. This report is part of the EMERGE project, which aims to strengthen cooperation between Norway and Romania in the green transition. By focusing on Norwegian experiences, the report seeks to highlight best practices in the governance, operation, and regulatory frameworks of energy communities. These insights will be valuable for Romanian partners in developing their own models for energy communities, aiding in the country's efforts toward decarbonization and energy self-sufficiency.

The scope of the report covers several key areas that are critical to understanding and replicating successful energy communities. First, it examines the regulatory environment in Norway, particularly the role of the Norwegian Water Resources and Energy Directorate (NVE) and how grid operators such as transmission system operators (TSOs) and distribution system operators (DSOs) support energy communities. It also looks into the various organizational models used in Norway, from cooperatives to community-based systems, providing an analysis of how these models are structured and operated.

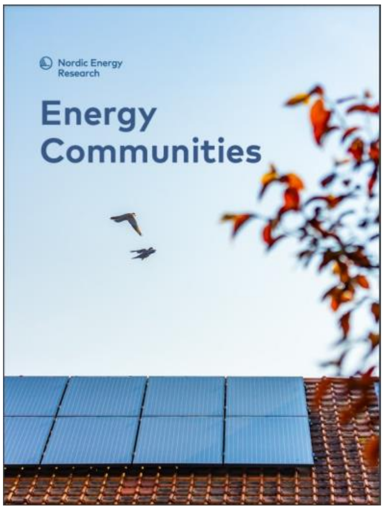
2.2. Methodology and approach

The study started with a literature review focusing on energy communities in EU and Norway. During this process, three key reports were identified as particularly relevant:

"A roadmap for a policy and legal framework for energy communities" [1], released by the Energy Communities Repository in 2024, which outlines essential building blocks and steps to establish robust frameworks for energy communities in EU member states.



"Descriptive study of Local Energy Communities" [2], authored by THEMA Consulting Group and Multiconsult Norge AS in 2018, which offers an overview of energy communities in Norway.



"Energy Communities" [3], published by Technopolis Group and Nordic Energy Research in 2023, which examines the implementation of energy communities in Norway, Sweden, Finland and Denmark, as well as similar models in three other European countries.

In addition to these reports, other relevant documents and publications were reviewed to gain a deeper understanding of the Norwegian energy system. The study also utilized knowledge from projects that Smart Innovation Norway has contributed to or is still involved in. This approach ensured a robust and comprehensive understanding of the current landscape and the potential for energy communities in Norway, which in turn is relevant for the Romanian partners.

3. What are local energy communities (LECs)?

3.1. Overview of definitions and features

The term Local Energy Community (LEC) is described in the roadmap from Energy Communities Repository [1] as an innovative legal entity that typically operates at a local level, focusing on the production, consumption, storage, and sharing of renewable energy. It is characterized by open and voluntary participation and is effectively controlled by shareholders or members, which can include individuals, small enterprises, or local authorities such as municipalities. The European Union (EU) has been a strong proponent of LECs, defining two key community types in its directives:

- Renewable Energy Community (REC): As outlined in the recast of the Renewable Energy Directive (REDII, 2018/2001) [4], RECs are primarily concerned with renewable energy production. The shareholders or members of RECs are typically located near the renewable energy projects they own and develop.

- Citizen Energy Community (CEC): According to Article 16 of the Internal Market for Electricity Directive (IMED, 2019/944) [5], CECs have a broader scope than RECs, as they can also engage in aggregation or provide energy services to their members. CECs may facilitate active consumer participation by allowing members to generate, consume, share, or sell energy, offer flexibility services through demand-response and storage, and, if permitted by member states, operate the required electricity grid under the applicable requirements for distribution system operators (DSOs). CECs can include different types of energy sources in addition to renewables, such as natural gas installations or even diesel generators, but focus only on electrification.

The term LEC is often used as an umbrella term for REC and CEC [1]. The primary objectives of LECs are to advance the development of distributed energy technologies and to strengthen consumer participation in the energy markets. They aim at prioritizing the local production of electricity from renewable energy sources, emphasizing citizen ownership and participation in the energy system.

Key features that may vary across different LEC models include:

- **Organizational form**: LECs can be organized as associations, cooperatives, partnerships, non-profit organizations, or other legal entities.
- **Technology**: LECs may use various technologies, such as solar panels, wind turbines, biogas plants, and batteries, to generate and store energy.
- **Energy sharing models**: LECs can implement diverse approaches to energy sharing, including direct physical sharing, administrative sharing through the grid, offsetting energy components, and sharing remunerations or tariff adjustments.
- **Activities**: LECs may engage in a range of activities beyond energy generation and consumption, including energy efficiency, supply, aggregation, mobility, and heating and cooling.

In the Norwegian context, two concepts closely related to LECs that are more widely recognized are Positive Energy Districts (PEDs) and Zero Emission Neighbourhoods (ZENs). PEDs refer to urban areas or clusters of interconnected buildings that are designed to be energy-efficient and flexible, producing at least as much energy as they consume on an annual basis [6]. This surplus energy can be shared within a community or fed into the broader grid, aligning with the principles of LECs. PEDs have been a focus in the H2020 project +CityxChange[1], with the Norwegian University of Science and Technology (NTNU) hosting and demonstrating a PED in Trondheim Kommune.

On the other hand, ZENs are defined as a group of interconnected buildings and their associated infrastructure within a confined geographical area [7]. These neighbourhoods aim for net zero energy performance with a strong emphasis on environmental sustainability. The ZEN concept incorporates a mix of passive design strategies, energy-efficient appliances, and active solar

[1] https://cityxchange.eu/

systems to ensure optimum sustainability for the entire community. Test areas for ZENs have been demonstrated through FME ZEN, a large research centre in Norway[2].

Both PEDs and ZENs share the same objectives as LECs in terms of promoting sustainability and energy self-sufficiency. While PEDs and ZENs have specific focuses on energy surplus and emissions, respectively, LECs are more broadly defined by their emphasis on community engagement and energy sharing. Therefore, PEDs and ZENs can be considered as specific implementations or subsets of the LEC concept, with additional criteria related to energy balance and emissions. This relationship underscores the flexibility and adaptability of the LEC framework in encompassing various approaches to sustainable energy management.

3.2. Drivers and barriers to establishing and operating local energy communities

LECs are gaining traction as a transformative approach to energy production and consumption. They represent a shift towards more decentralized, sustainable, and community-driven energy systems. However, the establishment and operation of LECs are influenced by a range of drivers and barriers that can either facilitate or hinder their development, as identified in a recent reports released by Nordic Energy Research [3] and Energy Communities Repository [8].

The drivers include financial incentives, such as the potential for cost savings and stable energy prices, as well as environmental incentives, like the desire to contribute to the energy transition and increase the use of renewable energy. Additionally, the prospect of greater control over energy supply and the ability to reinvest profits into the community are powerful motivators. The democratic nature of LECs, which allows for citizen participation in local energy decisions, also plays a significant role in driving their adoption.

On the other hand, several barriers can impede the advancement of LECs. A lack of public awareness and technical knowledge can make it difficult for communities to initiate projects. Regulatory and legal obstacles, such as unclear legal framework or restrictive regulations, can also pose significant challenges. Financial hurdles, including securing upfront investment and

[2] https://fmezen.com/

covering infrastructure costs, are common barriers. Additionally, reliance on other actors, like municipalities and grid operators, can lead to authority imbalances and limited support. Technical barriers include difficulties in obtaining grid connections, integrating distributed generation, and navigating existing grid infrastructure pose technical barriers. Limited access to energy markets, challenges in competing with larger actors, and underdeveloped flexibility markets further hinder participation. Lastly, the complexity of setting up and operating LECs, along with scalability issues, can deter communities from pursuing these initiatives.

Understanding these drivers and barriers is crucial for policymakers, community leaders, and stakeholders who are interested in promoting the growth of LECs. By addressing the barriers and leveraging the drivers, it is possible to create an environment that supports the development of sustainable and resilient energy communities.

4. Norwegian background information

4.1. The Norwegian power system and potential for local energy communities

Norway's power system is distinguished by its significant reliance on renewable energy, leading Europe in the proportion of electricity generated from renewable sources and reporting the lowest emissions from the power sector. As illustrated in Figure 1, hydropower constitutes approximately 88% of Norway's electricity generation capacity, with wind, solar, and thermal making up the remainder. The total installed production capacity is 39.7 GW as of 2023, and typical annual production is 156 TWh [9].

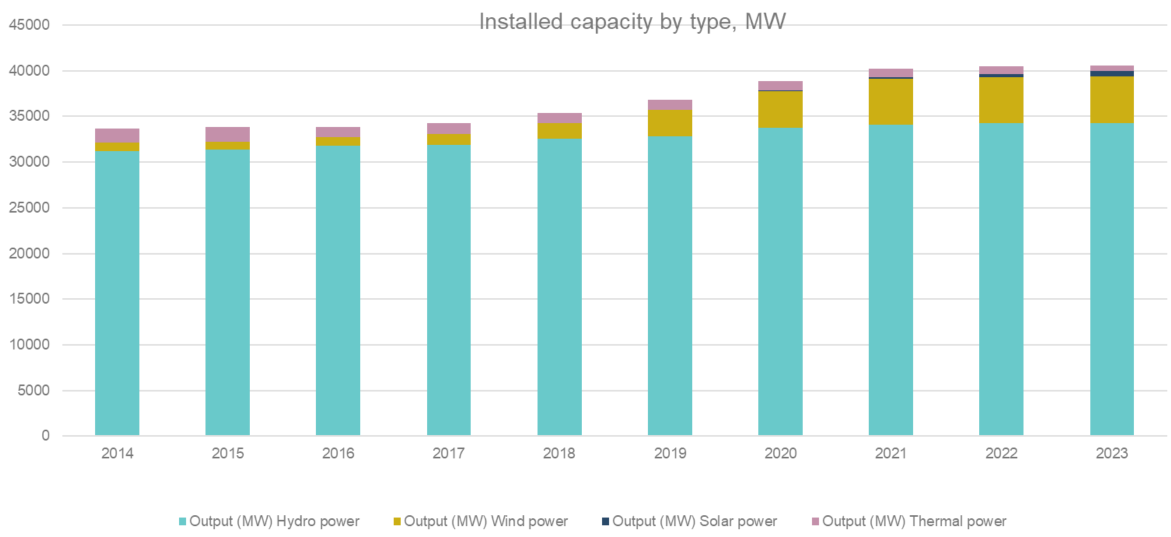


Figure 1. Installed power production capacity in Norway. Numbers from Statistics Norway [10].

Electricity counts for almost half of Norway's total final energy consumption. The residential sector's high per capita electricity consumption (6.5 MWh in 2022 [11]) is mainly due to the widespread use of electricity for heating and hot water. Norway has also been a global leader in electrifying transportation, a key component of the green transition. Battery electric and chargeable hybrid vehicles dominate new car sales, achieving a market share above 90% in 2023 [12]. Additionally, the country is actively engaged in the electrification of trucks, ships and construction sector, demonstrating its commitment to sustainable practises.

The shift towards electrification is driving up electricity demand, necessitating a corresponding increase in renewable energy supply. To this end, Norway has set an ambitious target to achieve 8 TWh of solar energy production annually by 2030, equivalent to an installed capacity of approximately 10 GW [13]. This goal aligns with the country's overall strategy to increase renewable energy production and improve energy efficiency. As of the end of 2023, Norway had 604 MW of installed solar power capacity, generating 0.454 TWh of solar energy [10]. Over 90% of this capacity is grid-connected, with most solar power coming from rooftop installations on residential and industrial buildings, primarily for self-consumption. Looking ahead, the first large-scale solar power plant, with a 7 MWp capacity, was grid connected in the fall of 2023 [14], and several other projects are in the planning stages. These developments signal positive progress towards achieving the 2030 solar energy target.

To efficiently transport electricity from producers to consumers, the electricity grid acts as the backbone of the distribution system. In Norway, the grid is structured into three levels [15]:

1. **Transmission grid**: Operating at 300 kV or 420 kV, this grid level transports large amounts of power across regions and connects large power plants directly.
2. **Regional distribution grid**: With voltage levels ranging from 33 to 132 kV, this grid transports power within regions and connects medium-sized power plants and energy-intensive industries.
3. **Local distribution grid**: Operating at voltages from 230 V to 22 kV, this grid delivers power to end consumers, including residential and commercial buildings, as well as less energy-intensive industries.

Statnett SF serves as Norway's sole transmission system operator (TSO), overseeing the entire transmission grid. The regional and distribution grids, on the other hand, are managed by approximately 120 distinct distribution system operators (DSOs), each responsible for a specific region. Given that both the TSO and the DSOs hold natural monopolies in their geographical areas, they are subject to stringent regulations by national authorities, as further described in Section 4.2.

Increasing electricity demand puts a strain on the electricity grid, especially the distribution grid during peak hours. This challenge is amplified by the uneven patterns of electricity consumption throughout the day. Traditionally, grid operators have managed this by upgrading grid infrastructure, but this approach is time-consuming and costly. With the pressing need for additional capacity, operators are now exploring alternative methods to enhance the efficiency of the existing grid, such as implementing smart grid technologies and promoting demand-side management practises. LECs can play a pivotal role in this initiative by contributing to a more efficient and sustainable energy system [1]. By generating and consuming electricity locally, they reduce the need for electricity transportation and the associated transmission losses. LECs also manage variable renewable generation on-site, mitigating intermittency issues. Moreover, LECs can utilize locally stored energy during peak demand periods, effectively reducing the maximum load on the distribution grid. Shared storage solutions within LECs allow for storing excess energy generated during off-peak hours, thus smoothing the demand curve and preventing grid overloads. This process helps to prevent overloads and maintain grid stability. In addition, LECs can also shift loads to times with high local renewable energy generation or move non-essential consumption to off-peak hours, further lowering peak demand.

However, realizing the full potential of LECs in easing the electricity grid requires supportive regulatory frameworks, innovative business models, and the appropriate market mechanisms. Addressing challenges related to grid connection, data management, and cybersecurity is also crucial for the successful integration of LECs into the electricity system. With the right measures in place, LECs can significantly contribute to a more resilient and efficient energy infrastructure in Norway.

4.2. Regulatory frameworks

The regulatory landscape relevant for LECs in Norway is shaped by the interplay between the Norwegian Water Resources and Energy Directorate (NVE), the Regulator for Energy (RME), and energy-related legislation. NVE, operating under the Ministry of Petroleum and Energy, oversees the management of the country’s water and energy resources, ensuring an energy system that is efficient, reliable, and environmentally sound sustainable. NVE is also responsible for granting licenses for energy production and transmission [16]. RME, a division within NVE also known as NVE-RME, serves as the national regulatory authority for the electricity and downstream gas markets in Norway. Its primary objective is to foster socioeconomic development and an environmentally sound energy system, characterized by efficient and reliable transmission, distribution, trade, and use of energy. RME monitors the TSO and DSOs to ensure consumers receive electricity supplied with adequate quality [17].

NVE and RME are empowered to enforce laws and regulations within Norway’s energy sector, ensuring compliance with the legal framework established by the Norwegian government. It is important to note that the concept of LECs has not yet been implemented in nation law or practice according to the EU definitions. While Norway is not an EU member and not directly obligated to EU directives, it is part of the European Economic Area (EEA). This means that EU directives can be adopted in Norway through the EEA agreement, provided they are deemed relevant by the EEA and EFTA. Given the growing recognition of the potential benefits that LECs can bring, there is a movement towards adapting the existing framework to better accommodate these initiatives. However, as it stands, LEC actors must rely on established energy-related regulations in Norway.

Several key pieces of legislation that govern the Norwegian energy system are particularly relevant for LECs, and understanding these can help in navigating the regulatory landscape:

- **The Energy Act** (“*Energiloven”*) [18]: This act, implemented in 1990, ensures that all energy produced in Norway is used in a societally rational manner. It regulates the production, transformation, sale, distribution, and use of energy. Importantly, it establishes the licensing regime for operating grid assets, granting exclusive rights to DSOs within designated areas. This poses a significant challenge for larger LECs aiming to own and operate their own grid infrastructure.
- **The Energy Regulations** (*“Energilovforskriften”*) [19]: Implemented in 1990 under the Energy Act, these regulations provide a comprehensive and detailed framework of the conditions to be granted licenses to develop and maintain regional and local distribution grids. They ensure that the production, conversion, transmission, turnover, distribution, and use of energy are rational from a societal perspective and consider private and public interests. They also facilitate an efficient energy market where the sale of energy takes place in a socially rational manner and ensure effective market monitoring.
- **The Grid and Energy Market Regulation** (*“Forskrift om nettregulering og energimarkedet”*, NEM) [20]: Implemented in 2019, NEM regulates the Norwegian energy market, facilitating an efficient energy market where operations within the market are conducted in a socially rational manner and to ensure effective market surveillance. Furthermore, NEM constitutes a detailed framework of the Norwegian energy market's legislative conditions. RME is responsible for monitoring the energy market to ensure that NEM is enforced.

Additionally, Norway’s commitment to environmental sustainability in energy production is reinforced by several frameworks. The Electricity Certificate Act, introduced in 2011, encourages renewable energy generation through a market-based scheme shared with Sweden. Under this act, producers of renewable electricity earn one certificate per megawatt-hour (MWh) of electricity produced, valid for up to 15 years. Furthermore, The National Climate Plan and the Climate Change Act are the most significant sustainability-related frameworks regulating the energy system. The Climate Plan outlines Norway’s prioritized measures to reduce emissions, while the Climate Change Act aims for a long-term reduction in greenhouse gas (GHG) emissions, targeting a significant decrease by 2050. All actors within the Norwegian energy system must consider these overarching environmental frameworks.

In many ways, the Norwegian legislation portrays a state-controlled framework for energy regulations. The Energy Act and its secondary regulations limit the ability of LECs to independently produce, share and store energy. The requirement for area licenses, primarily granted to DSOs, restricts the development of larger LECs with their own grid infrastructure. However, the regulatory sandbox framework for energy systems, introduced by RME in 2019, offers a mechanism for temporary exceptions [21]. This initiative aims to facilitate pilot and demonstration projects in a controlled environment, providing a pathway for innovation within the regulatory bounds. The sandbox allows innovators to test new technologies, services, business models, and approaches in real-world settings, which is particularly beneficial for LECs. These communities often operate with innovative concepts that may not fully align with existing regulatory frameworks. A list of all projects that have been approved for the sandbox can be found at the NVE website[3].

The sandbox framework promotes a collaborative process between RME and innovative concepts such as LECs, enhancing the understanding of the evolving energy landscape. RME provides regulatory guidance and advice, clarifying ambiguities regarding the application of existing regulations to innovative LEC projects. The framework includes a transparent process for granting temporary exemptions from licensing requirements, allowing LECs to apply for derogations if their projects demonstrate innovation and potential benefits for the power system.

4.3. Smart metering and grid tariffs

Smart metering and grid tariffs are key components of Norway’s energy infrastructure, reflecting the country’s dedication to modernizing the electricity grid, improving energy efficiency, and facilitating the integration of renewable energy sources. The deployment of smart metering in Norway, known as Advanced Metering System (AMS), started with pilot projects in the early 2000s and became a legal requirement for all grid companies in 2019. Today, nearly 99% of Norwegian households have smart meters installed, capable of

[3] https://www.nve.no/reguleringsmyndigheten/bransje/bransjeoppgaver/pilot-og-demonstrasjonsprosjekter/vedtak-dispensasjonssoeknader/

measuring electricity consumption on an hourly basis, with the option to increase the frequency to every 15 minutes if needed [22].

The DSOs are responsible for the installation and operation of the AMS system. The collected data is automatically transmitted to Elhub, a centralized data hub responsible for managing metering data nationwide. Elhub ensures that data is securely collected, stored, and shared with authorized parties, eliminating the need for manual meter readings.

Ownership and privacy energy data are strictly regulated to safeguard consumers' personal information and ensure secure handling. Norway's compliance with the General Data Protection Regulation (GDPR) guarantees that consumers own their energy consumption data and have the right to access and control its usage. Consumers can access their energy data through their energy supplier or through Elhub[4]. Energy suppliers and grid operators are allowed to access data necessary for settlement and invoicing purposes but must implement stringent security measures to protect the data from unauthorized access and breaches. Additionally, consumers can choose to share their data with third-party services that offer energy management solutions, provided they give explicit consent for such sharing.

In relation to LECs, smart metering is essential for effective interaction with the grid. Real-time data from smart meters allows DSOs to monitor local energy flows and manage grid congestion more effectively. This is particularly important as LECs often involve distributed renewable energy generation, which can introduce intermittency and fluctuations into the grid. Moreover, smart metering enhances transparency and trust within the communities. Members can access their own consumption data and verify the accuracy of energy bills, fostering confidence in the community's operations. This is especially important in decentralized energy systems, where multiple actors are involved and maintaining trust among participants is crucial.

Smart metering also opens possibilities for innovative business models relevant for LECs. For example, dynamic pricing schemes, where electricity prices vary based on real-time supply and demand, can be implemented more effectively with smart meters. This allows communities to incentivize energy consumption during periods of low demand or high renewable energy generation, further optimizing energy use and reducing costs.

[4] https://elhub.no

In Norway, the granularity of the smart meter data has enabled the implementation of electricity bills based on spot prices and time-of-use tariffs (ToU). For residential customers in Norway, the bill is comprised of three key components: the retail electricity price, grid rent, and taxes, as illustrated in Figure 2 [23].

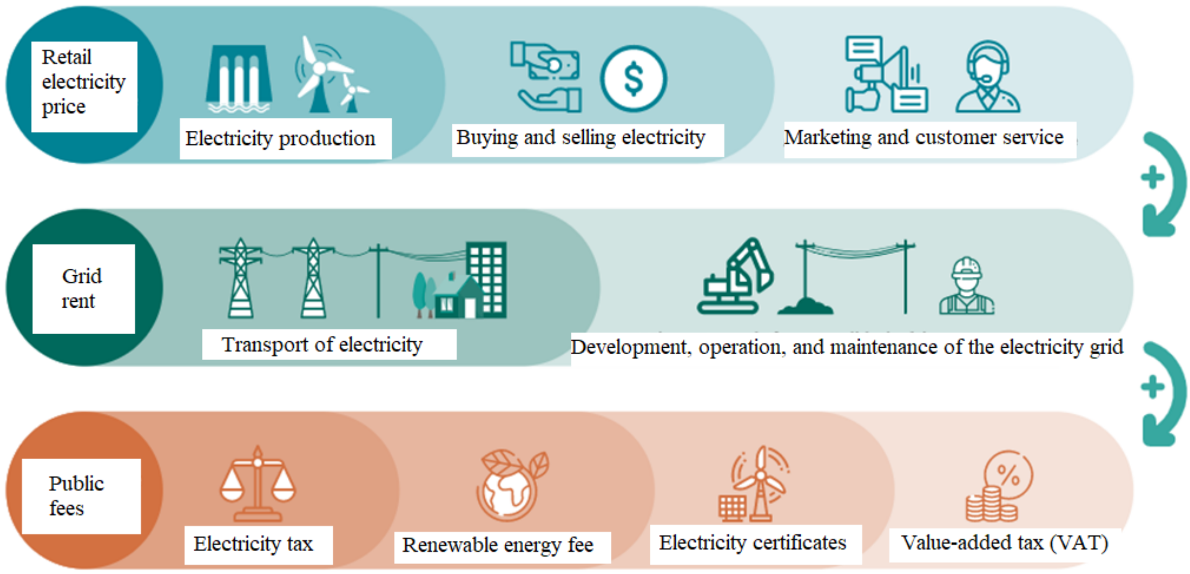


Figure 2. Illustration of how the Norwegian electricity bill consists of retail electricity price, grid rent, and public fees.

The retail electricity price is marked-driven, reflecting Norway's participation in the Nord Pool power marked where electricity prices are dictated by supply and demand. Consumers have the freedom to select their electricity supplier for this portion of the bill. However, due to legislative constraints, they are limited to one single supplier. The high AMS coverage has led to a high share of contracts being linked to the spot price, meaning consumers pay a variable electricity price that aligns with the hourly fluctuations of the wholesale marked. Additionally, the electricity supplier may add a surcharge to cover for marketing and customer services. This scheme contrasts with other European countries, where fixed-price contracts are more common.

The grid rent is set by the DSO assigned to the customers based on their geographical location, but it is closely regulated by RME. This portion of the electricity bill covers the costs of developing, operating, and maintaining the electricity grid. RME's regulation ensures that the grid is developed in a socioeconomically efficient manner, providing oversight to maintain fair pricing and encourage the optimal development of the grid infrastructure. In July 2022, a new scheme was introduced to incentivize the limitation of peak load demand through a type of ToU tariff. The grid rent now consists of a monthly fixed fee related to power peaks and an energy component being a variable cost related to electricity consumption. The fixed fee is organized in capacity steps, where the step is determined by the average of the three hours the consumer demands the most power, spread across three different days in a month. While most DSOs operate with the same capacity steps, they may have different prices for each step. Considering the energy component, DSOs have the flexibility to tailor this based on the specific challenges they face in their local distribution grid. For instance, prices could be varied based on the time of day, distinguishing between peak and off-peak hours, as well as weekends and different seasons. This flexibility allows DSOs to manage demand and encourage consumption patterns that align with the grid's capacity and the availability of renewable energy sources. Finally, taxes are imposed by the government and vary depending on the policy objectives and incentives. They consist of electricity tax (*"Elavgift"*), renewable energy fee (*"Elsertifikat"*), and VAT (25% on the total). Price examples from three of the largest DSOs in Norway as of November 2024 are given in Table 1 and Table 2.

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Table 1. Monthly fixed fee of grid rent for three of the largest DSOs in Norway (Elvia, BKK and Tensio). The step is determined by the average of the three hours which the consumer demands the most power, spread across three different days in a month. The numbers are in NOK, where 1 NOK = 0.083 EUR.

Step	Power	Elvia [NOK / month]	BKK [NOK / month]	Tensio [NOK / month]
Step 1	0 – 2 kW	140	160	134
Step 2	2 – 5 kW	230	260	239
Step 3	5 – 10 kW	375	430	408
Step 4	10 – 15 kW	525	620	601
Step 5	15 – 20 kW	675	800	794

Table 2. Energy component of grid rent for three of the largest DSOs in Norway, including taxes. The numbers are in NOK, where 1 NOK = 0.083 EUR. Note that:
** BKK differentiates between January – March / April – December*
*** Tensio does not differentiate between weekday and weekend.*

	Elvia [NOK / kWh]	BKK [NOK / kWh]*	Tensio** [NOK / kWh]

Weekday - day 06:00 – 22:00	0.525	0.5059 / 0.5925	0.5018
Weekday – night 22:00 – 06:00	0.450	0.3786 / 0.4652	0.3593
Weekend / public holidays	0.450	0.3786 / 0.4652	0.5018 / 0.3593

The Norwegian system allows for a more dynamic and responsive energy market, aligning with real-time changes in supply and demand. However, Norway's relatively low electricity prices compared to the rest of Europe can lead to less motivation for demand-response and LECs. Another aspect is whether the grid rent design effectively alleviates grid stress. Under the current system, once a capacity threshold is reached within a month, consumers lack economic incentives to reduce demand below this limit for the remainder of the month. Consequently, consumers may maximize consumption during low retail price periods, potentially causing more severe peaks for the electricity grid. This issue is exacerbated if all customers shift their demand to these low-price periods.

A notable flaw in the Norwegian grid rent is that it encourages consumers to lower their individual peak demand, regardless of whether there is a system-wide peak. An improved solution proposed by Bjarghov et al. [24] is a dynamic tariff, where capacity limits are only activated during grid capacity shortages. Their study indicates that this approach would keep annual electricity costs stable and similar for most consumers, though those with high coincidental peaks would experience greater economic impacts.

Companies and commercial customers with an annual consumption of less than 100,000 kWh follow the same model as residential customers. However, larger customers often have more complex contracts that may include elements such as capacity charges, which are based on the maximum demand over a period, and energy charges that reflect the actual consumption. These customers may also engage in demand response programs, receiving financial incentives for reducing consumption during peak periods or when the grid is under stress.

4.4. Incentives for self-consumption and energy sharing

In Norway, there are national support schemes and tax deductions specifically directed at small-scale distributed energy production. The country offers a variety of incentives to promote self-consumption of energy, particular from renewable sources like solar power. Enova, the country's clean energy agency, provides financial support energy efficiency measures, including subsidies for residential solar installations. Homeowners can receive a base subsidy of NOK 7,500[5] plus an additional NOK 1,250 per kW of installed capacity. Enova also offers subsidies of up to NOK 10,000 for energy management systems that are often installed alongside solar arrays. Moreover, many municipalities provide specific grants for households and businesses to install solar panels. Innovation Norway also offers grants and loans to businesses for renewable energy projects, including solar energy.

Electricity customers who also produce their own electricity, known as prosumers, benefit from several financial advantages in Norway [25]. They are exempt from the variable component of the grid rent, as well as electricity tax and VAT, for the electricity they produce and consume themselves. This exemption is part of a regulation from the Parliament, which generally mandates that everyone must pay taxes on all electricity delivered in Norway, including self-produced electricity. The aim of this regulation is to generate state income and reduce energy consumption. However, electricity produced by solar cells and used directly by the producer is exempt from tax. To qualify for this exemption, the electricity must be for personal use, produced on-site, and distributed through internal wiring. This means that the electricity prosumers self-consume is effectively free of charge, providing a strong incentive for self-generation and consumption of renewable energy.

Additionally, prosumers have the opportunity to sell excess electricity back to the grid trough a plus-customer scheme, provided they have an agreement with an electricity supplier that offers this option. During periods when their production exceeds their consumption, they can feed the surplus energy back into the grid. The energy flow is measured using a smart meter, which tracks both consumption and production. Plus-customers do not pay a fixed fee for feed-

[5] 1 NOK = 0.083 Euro

in, and they receive the spot price for their sold electricity. This scheme is designed for single customers with a production capacity below 100 kW and encourages small-scale distributed generation. However, prosumers that inject above 100 kW and up to 9 GW are subject to tariffs and transaction costs. While income from the sale of self-produced electricity is basically taxable, the Ministry has stated that they will not tax it for now due to the complexity of different contractual arrangement.

As of November 2024, there are around 30,000 registered plus-customers in Norway, of which 25,000 are residential and 5,000 are commercial customers. Updated statistics may be found on the NVE-RME webpage[6].

The Norwegian government has recently expanded the plus-customer scheme to enable the sharing of self-generated solar electricity [26]. As of October 1, 2023, a new model allows for sharing of surplus production from installations with up to 1 MW installed capacity, referring to the nominal power of the inverter. The scheme is valid for properties with multiple electricity subscribers provided they are within the same property, as defined by the same municipality, cadastral, and property number. This includes residents in apartment complexes, multi-family houses, and commercial buildings. Subscribers can share surplus energy without paying taxes on it. However, this surplus energy cannot be further distributed to other grid customers, and subscribers receiving shared production cannot have their own production behind their meter. If the installed capacity of the property exceeds 1 MW, the electricity produced from the excess capacity will not be eligible for tax exemption.

In practice, the energy sharing is managed through a virtual distribution system, with calculations handled by Elhub. Smart meters, which are crucial components of this system, provide real-time data on energy production and consumption. This enables precise tracking and allocation of energy shared within a property. The energy consumption and production are measured separately, and the amount of production is deducted from each consumption meter’s measured usage. The participants can choose between equal distribution (each meter receives an equal share of the surplus) or a custom static distribution (based on factors like investment share or apartment size). However, the regulation currently restricts energy sharing to physical

6 https://www.nve.no/reguleringsmyndigheten/publikasjoner-og-data/statistikk/statistikk-over-sluttbrukermarkedet/plusskundestatistikk/

connections within the same property. This means residents of different buildings or communities cannot establish a virtual grid to share surplus production. The model primarily focuses on enabling housing associations to share renewable energy among their residents. It does not yet accommodate broader community-based energy sharing models that involve multiple properties or businesses. As of November 2024, there are 156 connection points that in 2024 shared 5,000 MWh. Updated statistics may be found on the Elhub webpage[7] .

The Ministry of Energy has tasked RME with proposing a new sharing scheme specifically tailored for business areas to facilitate the sharing of self-produced electricity between grid customers. In the beginning of December 2024, a proposal was released with the aim of entering into force during summer 2025. This proposal, which follows a report published by RME in early 2024 [27], recommends amendments to the existing sharing scheme. The key proposal is to allow producers to share electricity with customers located on neighbouring properties, with an increased limit on the size of the production facility up to 5 MW. This new scheme would complement the existing one and primarily target customers with annual consumption exceeding 100,000 kWh annually who are subject to grid tariffs reflecting marginal loss costs. Under the proposed scheme, prosumers could share power virtually with other customers on the same property and all their neighbouring properties, including non-adjacent neighbouring properties. Notably, the proposal does not impose a limit on the number of neighbours with whom electricity can be shared. If implemented, this would be a significant step towards the implementation of LECs in Norway.

Another innovative initiative that facilitates the sharing of surplus solar electricity within neighbourhoods is the eNabo initiative by Norgesnett, a Norwegian DSO [28]. Although not a formalized LEC, it acts as a precursor to such communities by enabling households to share excess solar energy. This effectively creates an energy community where members can benefit from each other's excess energy production. Participants can benefit from reduced grid fees by charging their electric vehicles (EVs) with the surplus solar energy, fostering a collaborative approach to energy consumption. The initiative promotes 'grid-smart' charging, aligning with the principles of LECs by optimizing energy usage times for the benefit of the entire community's power grid. By leveraging local renewable energy sources, eNabo enhances the

[7] https://elhub.no/data/delt-produksjon/

sustainability and resilience of the community's energy supply, reducing reliance on external energy sources. Additionally, participants receive compensation for using local solar energy, which serves as a community dividend, rewarding households for their contribution to the local energy ecosystem. This initiative is a significant step towards more sustainable and community-driven energy solutions, reflecting the potential for LECs to play a role in Norway’s energy transition.

5. Case Studies of energy communities in Norway

Interest for LECs in Norway has historically been low, largely due to the country’s robust energy system and low energy prices. However, there is a growing interest in local energy production and consumption, indicating potential for future development.

In 2018, a study by THEMA identified 30 active initiatives in Norway [2]. Although these initiatives do not fully align with EU definitions, as LECs in Norway are not yet defined in national law or practice according to EU definitions, they represent significant activity in the sector. Out of these 30 initiatives, only five had been implemented, while the rest were still in the early stages. Most active projects are organized as pilot studies, focusing on local flexibility markets, energy storage, microgrids on islands, and renewable energy projects within residential housing associations. These implementations are still in their early stages and are relatively small in scale.

Most of these initiatives were started by property developers and real estate companies aiming to increase local power production and self-sufficiency of energy for buildings. Additionally, DSOs are engaging in research projects to strengthen their knowledge of the potential of energy communities.

5.1. Case Study 1: Urban Energy Community Example

Image: Sluppen Positive Energy Building with PV. Photo by Glen Musk

An example of an urban energy community in Norway is the PED pilot in the +CityxChange (Positive City ExChange). Funded by the European Union's Horizon 2020 program, this smart city project ran from 2018 to 2023. It focused on developing and piloting positive energy blocks and districts, which are urban areas that generate more energy than they consume. The long-term goal is to create zero-emission urban ecosystems and achieve 100% renewable energy in city-regions by 2050. The project involved two Lighthouse Cities: Trondheim (Norway) and Limerick (Ireland), and five Follower Cities: Alba Iulia (Romania), Písek (Czech Republic), Sestao Berri (Spain), Smolyan (Bulgaria), Võru (Estonia).

One of the key outcomes was the demonstration of a Local Flexibility Market (LFM) in Trondheim, specifically in the Brattøra and Sluppen areas. This LFM enables neighbourhoods to exchange energy capacity and system services. It supports trading of local energy production, user flexibility, and DSO services through automated trades at a 60-minute time resolution. The market solution incorporates advanced AI trading algorithms, demand-response systems, and detailed weather forecasts to optimize energy trading. Furthermore, the project integrated e-mobility into PEDs by using Vehicle to Grid (V2G) and Vehicle to Building (V2B) technologies to charge and discharge electric car batteries. These technologies allow EVs to provide additional battery storage and support during grid stress or demand spikes.

The project highlighted the importance of storytelling and emotional connection in engaging people with PED initiatives. By creating relatable narratives, the project helped local stakeholders understand the benefits and long-term impacts of investing in such initiatives, paving the way for future projects and funding opportunities. has shown that PED projects rely on the right stories and emotion to connect with people. Creating a story around PED creation can help people to identify with and understand what's going on.

In summary, the +CityxChange project demonstrated how local energy communities can effectively manage and optimize energy production, consumption, and trading, contributing to more sustainable and resilient urban environments. More detailed information about the Norwegian pilot can be found on the project website[8] and the deliverable D5.6: Trondheim Flexibility Market Deployment Report [29].

5.2. Case Study 2: Rural Energy Community Example

Image: 2MWh energy storage installed in the rural area of Senja. Photo by UiT

[8] https://cityxchange.eu/

LECs are particularly beneficial in remote areas, such as islands. In Norway, these remote islands often face harsh weather conditions, leading to power failures. LECs can provide a secure energy supply, sometimes operating entirely off-grid, especially when connections to the main grid are limited or frequently disrupted.

A notable example of a Norwegian energy community project in a rural area is Smart Senja[9], an innovative project launched in 2019 with the aim of meeting the growing electricity demands of the island's fishing industry while maintaining low energy costs. This project is a collaborative effort involving residents, as well as national and international partners. It is owned by the DSO Arva AS and receives financial support from Enova, a Norwegian government agency promoting environmentally friendly energy production and consumption. The project is expected to continue until 2025.

As an island community at the end of the electric grid, Senja faces energy supply issues and variability in renewable energy sources. One of the main challenges is the variability of renewable energy sources compared to conventional ones. Hydropower is affected by seasonal variations in precipitation, while solar and wind power are influences by instantaneous weather changes. Additionally, energy consumption fluctuates throughout the day, with significant peaks and troughs.

Key solutions implemented by Smart Senja include the installation of smart power management systems in homes and businesses to distribute electricity consumption more evenly between day and night. The project also involves large lithium batteries at two locations to help balance out fluctuations in electricity consumption. These solutions will potentially reduce the need for infrastructure development, leading to savings on grid tariffs and electricity bills for both businesses and households.

The Smart Senja project demonstrates the potential of energy communities to address energy challenges in remote locations. However, it also highlights the need for a more supportive regulatory framework in Norway to enable the broader adoption of these innovative energy models that combine smart power management systems, energy storage, and local renewable energy production.

[9] https://smartsenja.no/

5.3. Case study 3: Zero Emission Neighborhoods

Image: Living Lab located in Trondheim. Photo by Katrine Peck Sze Lim.

FME ZEN is a Norwegian research centre established in 2017, hosted by NTNU and co-led with the private research institute SINTEF. The centre aims to create solutions for zero emission buildings and neighbourhoods of the future. Together with public and industry partners, they have developed 11 test areas (pilot projects) spread all over Norway. An overview and experience summary is given in one of the final reports from the project, released in 2024 [30]. Although the research centre does not explicitly label these pilots as LECs, the characteristics and objectives of several of them demonstrate a strong connection to the core principles of LECs, as shown in Table 3.

Table 3. Overview of pilot projects within the research centre FME ZEN that are found to be relevant for the LEC concept [30].

ZEN pilot project	Description	Relevance to LECs
Campus Evenstad	Focused on local energy generation and efficiency, featuring V2G technology and battery banks.	Aligns with LEC principles of using local resources to manage energy needs.
Campus Gløshaugen	Initially ambitious, this project emphasizes low GHG emissions,	Reflects key aspects of LECs.

	energy efficiency, and climate-friendly energy supply.	
Furuset	Explores local energy production through PV and seasonal heat storage, aiming for energy self-sufficiency.	Aligns with a core principle of LEC development.
Mære Agricultural School	Investigates integrating energy systems and local renewable energy production with a goal of becoming a zero-emission farm.	Detailed energy flow monitoring is relevant to managing energy within an LEC framework.
Sluppen	Develops climate and spatial quality indicators and a specific climate norm.	Contributes to the planning and implementation of sustainable energy solutions within a defined area, similar to LEC approaches.
Ydalir	Emphasizes local renewable energy systems and increasing building standards to reach zero-emission goals.	Focus on integrating sustainable practices from the planning phase aligns with LEC approaches.
Zero Village Bergen (ZVB)	Aims to minimize energy demand through energy-efficient buildings and local renewable energy systems.	Reflects the LEC focus on community-level sustainability and reduced reliance on external energy sources.

Many of the pilots prioritize local energy generation and efficiency measures, aiming to reduce dependence on external energy sources. This is a cornerstone of LECs, which strive to create self-sufficient energy systems within communities. The emphasis on renewable energy sources in these projects further strengthens their connection to LECs, which prioritize environmentally sustainable energy solutions. Some pilots explore integrating different energy systems, such as combining heat and power generation or incorporating V2G technology. This integration is crucial for optimizing energy use within LECs. The pilots often operate within defined areas or neighbourhoods, aiming to achieve sustainability goals at a community level. This approach mirrors the LEC concept of collective action towards shared energy goals.

6. Conclusion and recommendations

Both Romania and Norway face challenges regarding definitions and implementation of LECs, albeit for different reasons. While Romania has transposed REDII into national law, the implementation of a supportive legal and regulatory framework specifically designed for energy communities has been significantly delayed, hindering the establishment and growth of these communities. Norway, despite not being obligated to adopt EU directives, faces a lack of awareness and understanding of the LEC concepts, coupled with a historically lower need for such initiatives due to its robust energy system. However, both countries exhibit a growing interest in local energy solutions, indicating potential for future development of LECs if regulatory clarity improves.

The current regulatory framework in Norway, characterized by a state-controlled approach to energy regulations, presents challenges for LEC development. The Energy Act and its secondary regulations, while aiming to ensure rational energy use, limit the ability of LECs to operate independently in producing, sharing, and storing energy. Licensing requirements, primarily granted to DSOs, restrict the development of larger LECs with their own grid infrastructure. Overcoming these regulatory hurdles is crucial for fostering LEC growth in Norway.

Despite the legislative challenges, the regulatory sandbox framework introduced by RME in 2019 offers a valuable mechanism for piloting LEC initiatives, which Romania can learn from. This framework allows for temporary exemptions from existing regulations, enabling innovators to test new technologies, services, and business models in real-world settings. This flexibility is particularly beneficial for LECs, which often operate with innovative concepts that might not fully align with current regulations. The sandbox facilitates collaboration between regulatory authorities and LECs, promoting a better understanding of the evolving energy landscape and fostering innovation within regulatory boundaries.

Furthermore, Norway's focus on streamlined grid connection processes and licensing for pilot energy projects can be relevant in the Romanian context. Simplifying administrative procedures for energy communities is crucial for accelerating project development and reducing barriers to entry. This includes establishing clear guidelines, standardized application processes, and dedicated points of contact for energy community initiatives within regulatory bodies.

The widespread deployment of smart meters in Norway is a significant asset for LEC development, that Romania should take inspiration from. Smart meters provide real-time data on energy consumption and production, enabling DSOs to monitor local energy flows and manage grid congestion effectively, especially given the fluctuating nature of renewable energy sources. Moreover, smart metering enhances transparency and trust within communities, allowing members to track their consumption, verify billing accuracy, and foster confidence in community operations. This data granularity also allows for innovative pricing schemes, such as dynamic pricing and time-of-use tariffs, which can incentivize energy consumption during periods of low demand or high renewable energy generation. Smart metering is not just a technical requirement but a fundamental enabler for local energy communities to achieve their full potential. We suggest prioritizing smart meter rollout and develop robust data management systems as these are crucial steps for policymakers and regulators to foster the growth of LECs and contribute to a more sustainable and decentralized energy future.

The most significant obstacle for energy community initiators in Romania is the lack of access to adequate funding. Existing public funding mechanisms are not tailored to the specific needs of energy communities, and small-scale funding opportunities through NGOs or crowdfunding platforms are insufficient to cover the substantial upfront investment costs associated with renewable energy installations. This lack of financial resources prevents many promising projects from moving beyond the conceptual stage and limits the scalability of existing initiatives. Norway, on the other hand, offers various incentives to promote self-consumption of energy, especially from renewable sources. Financial support from Enova, tax exemptions for self-consumed electricity, and the plus-customer scheme for selling excess electricity back to the grid encourage the adoption of solar power and other renewable energy technologies. Recent expansions to the plus-customer scheme, allowing for sharing of surplus solar energy within properties and proposals to extend this to neighboring properties, demonstrate a positive shift towards enabling community-based energy sharing.

Pilot projects like +CityxChange and Smart Senja offer valuable lessons about LEC implementation in both urban and rural contexts. +CityxChange demonstrated the viability of local flexibility markets, enabling the exchange of energy capacity and system services within a neighborhood. This highlights the importance of incorporating flexibility mechanisms into energy community models. Romania can explore similar approaches to incentivize and manage local energy balancing, enabling communities to contribute to grid stability and optimize the use of renewable energy resources. This includes implementing dynamic pricing signals and aggregator models to facilitate participation in flexibility markets.

Smart Senja showcased the benefits of integrating smart power management systems, energy storage, and local renewable energy production to address energy challenges in remote locations. These projects underscore the potential of LECs in creating more sustainable and resilient energy systems while highlighting the need for a more supportive regulatory environment.

Successful implementation of LECs relies heavily on community engagement and collaboration. Projects like Smart Senja and +CityxChange highlight the importance of involving residents, businesses, and other stakeholders in the planning and implementation process. This participatory approach ensures that the community's needs and priorities are addressed, fosters a sense of ownership, and increases the likelihood of project success. Romania can learn from Norway's recognition of the need for greater public awareness and engagement in the energy transition. Educating citizens about the benefits of energy communities, addressing concerns, and fostering a sense of ownership are crucial for building public support and enabling broader participation.

In conclusion, while Norway's robust energy system and low energy prices have historically resulted in limited interest in formal LECs, there is growing momentum towards recognizing their potential. Overcoming regulatory barriers, leveraging the existing smart metering infrastructure, and providing clear incentives for self-consumption and energy sharing are crucial for fostering LEC growth. Learning from pilot projects and prioritizing community engagement will be essential for successful implementation and realizing the benefits of these innovative energy models. The insights gained from the Norwegian context, including the challenges and opportunities identified, are highly relevant for the EMERGE consortium.

While drawing lessons from Norway, it's crucial for Romania to consider its unique context. Unlike Norway's hydro-dominated power system, Romania has a more diverse energy mix with a significant reliance on fossil fuels. This necessitates a different approach to energy community integration, focusing on maximizing renewable energy penetration and managing the transition away from fossil fuels. Furthermore, Romania's socio-economic context, characterized by lower average incomes and limited access to financing in certain regions, requires targeted support mechanisms to ensure equitable access to energy community benefits.

This includes developing tailored financial instruments and capacity-building programs for communities facing greater economic challenges.

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