FINAL RECOMMENDATIONS REGARDING TECHNICAL, ORGANIZATIONAL, REGULATORY ASPECTS FOR FUTURE ENERGY COMMUNITIES

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About ERA-Net Smart Energy Systems

ERA-Net Smart Energy Systems (ERA-Net SES) is a transnational joint programming platform of 30 national and regional funding partners for initiating co-creation and promoting energy system innovation. The network of owners and managers of national and regional public funding programs along the innovation chain provides a sustainable and service oriented joint programming platform to finance projects in thematic areas like Smart Power Grids, Regional and Local Energy Systems, Heating and Cooling Networks, Digital Energy and Smart Services, etc.

Co-creating with partners that help to understand the needs of relevant stakeholders, we team up with intermediaries to provide an innovation eco-system supporting consortia for research, innovation, technical development, piloting and demonstration activities. These co-operations pave the way towards implementation in real-life environments and market introduction.

Beyond that, ERA-Net SES provides a Knowledge Community, involving key demo projects and experts from all over Europe, to facilitate learning between projects and programs from the local level up to the European level.

www.eranet-smartenergysystems.eu

LIST OF ABBREVIATIONS

LECs	Local Energy Communities
EU	European Union
Demo	Country Demonstration Sites
RED	Renewable Energy Directive
EMD	Electricity Market Directive
REC	Renewable Energy Community
CEC	Citizens Energy Community
GCM	Grid Capacity Management
WoC	Web of Cells
DSO/DNO	Distribution System or Network Operator

EXECUTIVE SUMMARY

The energy system landscape is continuously evolving globally and with the advent of clean energy alternatives there is the push towards sustainable ways of energy generation and supply. With these changes there is a need now to transform our energy systems from the traditional ways of generating, transmitting and distribution electricity.

Local Energy Communities (LECs) will be an essential element of this future energy system. LECs take an approach of allowing a community or communities to be directly involved in deciding how its local energy generation and supply is used within its households. The whole idea is geared towards providing mutual benefits among members of a community.

Within the European Union (EU) member states, energy community is introduced through the clean energy package, and they are two types of energy communities, the renewable energy communities (REC) and the citizen energy communities (CEC). Two EU directives[1] listed below set out how EU member states should adopt this within their respective countries.

1. Renewable Energy Community (REC): Article 2(16) Recast Renewable Energy Directive

2. Citizens Energy Community (CEC): Article 2(11) Recast Internal Electricity Market Directive and Article 2(70) Proposal Recast Internal Gas Market Directive

The ERA-Net project CLUE set out to acquire knowledge on the optimized design, planning, and operation of local energy communities (LEC). This a cross collaboration between some project partners in Austria, Sweden Germany and Scotland (UK). As part of the project, a number of pilot demonstration sites have developed, tested and validated concepts for local energy communities.

This report provides an overview of technical, organisational and regulatory aspects when it comes to energy communities across all four countries involved in the project, This also summaries the proposed recommendations and next steps.

The content of the report is based on information collected in the following ways:

- Two workshops with project partners on experience sharing.

- Questionnaire filled by representatives of each demo site as part of the activities with this work package.

[1] What is an energy community?: available at https://rural-energy-community-hub.ec.europa.eu/energy-communities/what-energy-community_en#two-definitions-of-energy-communities

- The work conducted in work package 3 on the comparison of regulatory frameworks across the countries involved and their respective demonstration sites.
- The deliverables in other work packages of the CLUE project.

Section 1, provides an overview of all demo sites across the countries including the selected uses cases within them for their pilot demonstrations.

Section 2, summaries the progress made between two countries Austria and Sweden which have progressed with enacting some of these directives into their national laws. This section discussed organisational and regulatory barriers and summaries the current state of legislative adoption between Austria and Sweden when compared to the EU Renewable Energy Directive (RED) and Electricity Market Directive (EMD). A general overview of the current state of regulatory and organisational concepts in Scotland (UK) is also presented.

Section 3, summaries lesson learnt and the next steps based on technical, social, business and regulatory barriers and discusses the recommendations and next steps proposed for future projects.

Based on findings in the project, several focus areas and plans in the next step have been identified by the partners. This includes further work on market potential, investigating new business models and solution upscaling.

1 CLUE DEMONSTARTION SITES

The CLUE project is a collaborative and independent exercise across the project partners involved in the participating countries (Austria, Sweden, Scotland, Germany) to understand ways to promote the use of local energy communities (LECs) based concepts. Across all countries, there are 8 demonstration sites that tested and validated different future concepts of LECs, the following subsections provides an overview of the demonstration site in each country.

1.1 Austria

In Austria, there were two demonstration sites in Ollersdorf in Burgenland and Gasen in Styria that focused on validating concepts of digital currencies for RECs and CECs using blockchain technologies and a REC based on flexibility potential with smart metering, integrated with central storage, intelligent energy management systems and flexible community tariffs.

1.1.1 Test bed AT1 - Suedburgenland

In Austria, the first demonstration took place in the province of Burgenland within the innovation lab act4.energy, a living lab initiative that is initiated and managed by Energie Kompass GmbH and supported by the Austrian Federal Ministry of Climate Action. This site validated a proof of concept of a Renewable Energy Community (REC) which included an energy account able to “mint” tokens as a community currency using blockchain technologies.

The pilot trial for the REC included 33 private house owners, 2 small businesses and 4 municipality objects (town house, school, fire station, church office). A general payment system App (Minvera Wallet available on Google Play Store) was developed and adapted to conduct a pilot trial and four uses cases listed below were explored using this concept with workshops held for community members to install the digital wallet and test paying with the digital tokens.

Based on the experience gathered for the community currency and the advancements of stabletokens on public blockchains, another proof of concept was developed to automate the P2P payment, between CEC members, avoiding the need for traditional bank accounts.

- **Use Case 1:** Energy account / Community currency.
- **Use Case 2:** EV-Charging payment with community currency.
- **Use Case 3:** Community currency payment at 3rd parties.
- **Use Case 4:** Fully automated EC payment system.

1.1.2 Test bed AT2 - Municipality Gasen

The second demonstration site in Austria used the Town of Gasen in the "Klima- and Energiemodellregion Naturpark Almenland" (KEM). This site validated a proof of concept of a renewable energy community (REC) with Gasen equipped with smart meters, energy management system, EV charging, PV and battery storage.

The pilot trail involved the development of a rapid deployment platform to validate the optimisation and control algorithms for the renewable energy community (REC). Different functionalities and services were implemented for LECs, and the main control algorithm was based on Grid Capacity Management (GCM) which considers the electrical grid constraints in the optimization and uses the results to control flexible resources. This also included an accounting module to calculate the traded energy within the LEC and with the grid.

1.2 Sweden

In Sweden, the focus was on validating the potential of flexibility from EV charging, power-to-heat, and batteries. The demonstrations in Sweden used four testbeds to demonstrate the flexibility of load management in four different user segments. The testbeds gave proof points on the potential of load management/peak shifting in these user segments and are chosen as references that could be scaled and aggregated.

1.2.1 Test bed SE-1 Test of flexibility using smart charging

The Swedish smart charging demonstration uses the car parks of Anna and Hyllie as testbeds. These car parks serve as good examples of both a city centre car park and a car park that includes commuters in the transportation node Hyllie with the park-and-ride concept. The car parks provide both public and private parking, with 670 parking spaces in Anna and 1400 parking spaces in Hyllie. This includes 12 parking lots in Anna and 16 lots in Hyllie that have charging stations for the electric vehicles the demonstrations are centred around.

The test bed aims to understand the flexibility potential of smart charging functions and assess the potential if the functionality is aggregated across Parkering Malmö's current and future charging infrastructure. This is necessary to meet the needs of electrification, which will lead to a continuous increase in load and power demand on both building and system levels. Tests were carried out with the 28 public EV charging points and three use cases listed below were validated to test the reduction of charging speed under different conditions.

- **Use Case 1:** Site based reduction.
- **Use Case 2:** Session based reduction.
- **Use Case 3:** Customer based reduction.

1.2.2 Test bed SE-2 Test of flexibility in a facility with heat pumps and district heating

The Triangeln building complex serves as a testbed for the second demonstration in Malmö, which aims to better understand the flexibility potential in building energy demand, including alternative heating solutions. Triangeln offers excellent conditions for demonstrating flexibility potential. Several different tenants who rent out office space, apartments, and retail spaces on the property have varying energy requirements over time. Vasakronan, the property owner, owns and operates Triangeln, which is situated in the heart of Malmö. Both district heating and heat pumps that are connected to aquifers provide heat for the property. The system control and data measurement were managed by ectocloud, a digital platform developed by EON which focused on heating from radiators and adjusting the set temperature during limited periods for reducing the power for both heat pumps and district heating.

1.2.3 Test bed SE-3 Stationary battery in a residential building

The third demonstration took place in the student apartment building Rönnen, where a hardware solution with a stationary battery was installed. The aim is to investigate the business potential of a large-scale battery and understand the requirements for further commercialization. The control system, EON's ectocloud was used to steer the stationary battery while measuring the energy consumption of the building, imported energy from the grid, and charging/discharging of the battery.

1.2.4 Test bed SE-4 Construction Site

Malmö uses a building site as a testbed, as Sweden's fourth demonstration. Malmö is no exception to the ongoing urbanization, and the construction sites there create significant capacity needs with fluctuating demand throughout the various stages of the building period. Densification and large-scale new construction in city districts create problems for the grid operator (DSO) and potential costs for the developer. In the fourth demonstration, comprehensive empirical data were collected from the testbed "Kosterbåten," a work-in-progress that will eventually become a long-term hotel in Malmö's Västra Hamnen neighborhood. The two-year construction project got underway in Q2 2020. Kosterbåten is made up of two buildings: the actual construction site (250A) and the office and sheds (125A). The building will have 6324 m^2 of heated gross floor area when everything is finished.

1.3 Scotland

In Scotland, there is one demonstration site at Levenmouth Fife that focused on validating concepts of LEC's based on developing a multi-vector platform (electricity, hydrogen gas), which can support the community-based energy management under different operational conditions.

1.3.1 Test bed SCO -1 Multi-vector energy management systems

The demonstration site is within a local energy community in Levenmouth Fife Scotland UK. This site validated a proof of concept of multi-vector platform that utilizes the asset base of an offshore wind turbine, PV and battery storage at community centers and a virtual simulation-based electrolyser to understand future LEC's concepts for the community.

The pilot trial validated a web of cells concept (WoC) to address communication and resilience challenges within local energy systems. This WoC enables the managing one or a group of energy assets for achieving a micro and macro objectives and will provide opportunities for SMEs to test their products and drive growth at local and regional level. The pilot implemented the three use cases listed below.

- **Use Case 1: Maximise Renewables:** coordinating all energy assets to maximize consumption of local renewable generation.
- **Use Case 2: Maximise Hydrogen Production:** maximize hydrogen production using local renewables sources.
- **Use Case 3: Avoid Grid Network Constraint to Store Hydrogen:** avoid curtailing wind production during grid congestion period by transferring the excess wind power to electrolyser.

1.4 Germany

In Germany, there is one demonstration site at "Shamrockpark" and focused on implementing and testing a smart heating and cooling network with the core energy concept “ectogrid”, a smart energy management system developed by EON.

1.4.1 Test bed GER -1 Smart heating and cooling network

The demonstration was to be located on the former RAG AG headquarters site. This was to be renovated and supplemented by several new buildings to form a mixed-use area. The demo planned to deploy the 5th generation heating network with industrial waste heat and a refrigeration plant as the major heat source. The ectogrid energy system would have allowed for a high share of local or regional renewable energy in the energy system, making it an ideal model for climate-neutral districts.

However, the development of the urban plan and implementation demo was delayed firstly due to COVID 19, lengthy approval process and was finally stopped due to the insolvency of the developer of Shamrockpark, FAKT AG, in autumn 2022. This made the work conducted to be based on scientific studies.

2 OVERVIEW OF TECHNICAL, ORGANISATIONAL AND REGULATORY ASPECTS

This section summaries the progress made between two countries Austria and Sweden which has progressed with enacting some of these directives into their national laws. A general overview of the current state of regulatory and organisational concepts in Scotland (UK) is also described.

2.1 Overview of EU Member States and UK (Scotland)

2.1.1 Current state in EU Member States

In the European Union (EU), technical, regulatory, and organisational concepts adopted by member states are set out with directives (laws) agreed on by member states. In regards to community energy, there are three directives[2] which describe the key elements of two types of Energy Communities that are of interest.

1. Renewable Energy Community (REC): Article 2(16) Recast Renewable Energy Directive
2. Citizen Energy Community (CEC): Article 2(11) Recast Internal Electricity Market Directive and Article 2(70) Proposal Recast Internal Gas Market Directive

This was introduced through the Clean Energy for All Europeans Package, adopted in 2019, by the EU which introduced the concept of energy communities in both legislations.

The renewable energy directive (RED) covers the definition of a Renewable Energy Community (REC) and is the legal framework for the development of renewable energy across all sectors of the EU economy. This sets the overarching European target for renewable energy and includes common principles and rules for renewables support schemes, including the rights to produce and consume renewable energy and to establish renewable energy communities. Its definition focuses on participation effectively controlled by shareholders or members that are in the proximity of the renewable energy projects that are owned by them where shareholders or members can be natural persons, SMEs or local authorities, including municipalities.

Citizen Energy Community (CEC) is set out in internal electricity market directive (EMD) (EU 2019/944) and does not limit stakeholders' proximity and focuses on a structure where a larger number of shareholders could be involved, such as large enterprises. More specifically, the directive includes new rules that enable active consumer participation, individually or through citizen energy communities, in all

[2] What is an energy community?: available at https://rural-energy-community-hub.ec.europa.eu/energy-communities/what-energy-community_en#two-definitions-of-energy-communities

markets, either by generating, consuming, sharing, or selling electricity, or by providing flexibility services through demand-response and storage. The directive aims to improve the uptake of energy communities and make it easier for citizens to integrate efficiently in the electricity system, as active participants.

With these directives in force, EU member states are required to set out national transpositions into their respective national laws which need to be completed within two years at maximum.

An aspect of the CLUE project was summarising the progress so far with the EU countries (Austria, Sweden, Germany) involved in the project. Also, Scotland has a long tradition of enabling energy communities, wherefore the status of these concepts is also elaborated on in Scotland.

2.1.2 Current state in Scotland (UK)

In the case of Scotland (UK), the energy system is already undergoing a period of significant change, transitioning from a centralised fossil-fuel based system to a more decentralised, low carbon system. An essential pillar of this system is investing in building a future low carbon energy system. The role of community energy may be most important not only in terms of community owned energy generation but in enabling the transformation of energy demand, enabling energy users to become active and empowered components forming a new 'local' layer in our energy system.

Yet this 'local energy' is an overlooked scale in analysis of the changes needed for decarbonisation. Failure to engage at a local level is already becoming a substantive barrier to decarbonisation of heating, transport, and the creation of electricity demand flexibility; all of which require locally attuned actions and significant behaviour change by community energy users. Scotland currently lacks the local level democratic institutions, leaving community anchor organisations (and especially Development Trusts), as the only viable organisations able to act effectively at this finely tuned scale[3].

The decentralisation of the energy system is underway but is proceeding very slowly and community engagement in the process is negligible. Legislative hurdles mean that local electricity supply is rarely a viable option and there are very few community-led networks. There have been important pilots that have demonstrated technical viability and there are routes to speed up progress, such as license exempt sale and 'split metering' for electricity supplies, but for both electricity and heat approaches are currently limited to small pilot projects. This might change rapidly if a right to a local supply is established in law, for which support is growing.

[3] Next Steps in Community Energy Discussion Paper: available at https://communityenergyscotland.org.uk/wp-content/uploads/2020/10/Next-Steps-in-Community-Energy-Full-Paper-Final-25-08-20.pdf

2.1.3 Comparison of legislation of Scotland (UK) and EU RED and EMD Directives

Leading up to Brexit, the UK was not obliged to follow the EU directives and have a different approach to how local energy community projects are implemented. The UK looks at local energy communities from a UK regional perspective (England, Scotland, Wales, Northern Ireland). The only region where we are aligned in some way to the EU internal market and directives are through the border between Northern Ireland and Ireland and the Brexit withdrawal agreement provides some broad context of how this might work. However, we are still the early stages of understanding this implementation in the UK.

Following the end of the implementation period, the agreement with respect to energy matters between the UK and the EU is now comprised within:

- the UK-EU Trade and Cooperation Agreement (TCA)
- the UK-Euratom Nuclear Cooperation Agreement (an agreement for cooperation on the safe and peaceful uses of nuclear energy)
- the revised Withdrawal Agreement published on 19 October 2019

The UK and the EU have not yet reached agreement on all aspects of their future energy relationship. The energy aspects of the TCA will terminate on 30 June 2026, although this may be extended by agreement of the Partnership Council established under the TCA, to 31 March 2028 at the latest.

2.2 Regulatory Overview (Austria and Sweden)

The summary of the transposition into national law of Austria and Sweden based on the stipulated clauses on community energy as stated out in the renewable energy directive (2018/2001/EU) and the internal electricity market directive market (EU 2019/944) are provided in Appendix A. This was provided through a consultation with the project partners of each country.

In Austria, the most important points in both directives are set in comparison with the national transposition into Austrian law (EAG – Erneuerbaren-Ausbau-Gesetz and amendment of the ElWOG – Elektrizitätswirtschafts- und Organisationsgesetz). The Austrian energy community legislation has been enacted in July 2021. As part of the Austrian CLUE project, a journal paper[4] has been published based on this

[4] B. Fina, H. Fechner; *"Transposition of European Guidelines for Energy Communities into Austrian Law: A Comparison and Discussion of Issues and Positive Aspects"*; Energies, MDPI; 2021; https://doi.org/10.3390/en14133922

legislative draft and a summary of changes made from the legislative draft to the enacted legislation is provided in an additional publication[5].

In Sweden, the Swedish Energy Markets Inspectorate (Ei) is the Swedish authority responsible to propose how the the internal electricity market directive market (EU 2019/944) and parts of the the renewable energy directive (2018/2001/EU) will be incorporated in the Swedish legislation. Ei suggested a new law on Energy Communities, a law called *Lagen om energigemenskaper* (Law on energy communities) [6].

The adoption of the national transposition of RECs and CECs for Sweden and Austria of the EMD and RED legislation is presented in the Table 1 and Table 2 in Appendix A.

2.3 Regulatory Overview Scotland (UK)

2.3.1 Structure of Community Energy in the UK

The UK looks at local energy communities from a regional perspective (England, Scotland, Wales, Northern Ireland). Under these, the following organisations are key in progressing the agenda of local energy community projects.

- Community Energy Scotland
- Community Energy England
- Community Energy Wales
- Community Energy Northern Ireland

Community Energy Scotland (CES)[7]who we work with on the CLUE Scottish Cell Demo cover the region of Scotland, Community Energy England[8], Community Energy Wales[9] and Community Energy Northern Ireland[10] covers the regions of England, Wales, and Northern Ireland, respectively. These different organisation approach local energy communities in their own way based on their regional requirements

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[5] B. Fina, C. Monsberger; *"Transposition of European Guidelines for Energy Communities into Austrian Law: Changes from the Legislative Draft to the Finally Enacted Law"*; Energies, MDPI; 2021; currently under review

[6] Swedish Energy Markets Inspectorate (Ei), 'Ren energi inom EU Ett genomförande av fem rättsakter', Ei R2020:02, February, 2020. https://www.ei.se/

[7] Community Energy Scotland: https://www.communityenergyscotland.org.uk/

[8] Community Energy England: https://communityenergyengland.org/

[9] Community Energy Wales: http://www.communityenergywales.org.uk/

[10] Community Energy Northern Ireland: http://www.nicommunityenergy.org/

while abiding with the legal framework of the Electricity Act[11] (licensing of generators, supply, and distribution) and the UK Grid Code.

2.3.2 Key Regulatory Barriers

The current policy enables local generation but not local supply

The main regulatory blocker in progressing local energy communities in the UK is that the rules still in use governing the UK grid are outdated were developed following privatisation of the energy system in the Electricity Act of 1989. By law, energy flowing through the grid can only be sold to an end user by a licensed supply company. However, the licensing process was designed based on a nationalised and highly centralised energy system back then, and on the basis that there could only be one supplier of energy and associated services to a consumer – the 'supplier hub' model. It makes no provision for local energy supply by small scale or regional suppliers, or by multiple suppliers through one meter.

There are not enough incentives for local supply

At the moment local energy communities in the UK operate based on (feed in tariffs) FiT's and renewable obligation schemes (ROCs). This is the existing revenue model developers have used but is now in question as FiT's have come to an end April 2021 and new scheme Smart Export Guarantee (SEG)[12] which replaces that, has put the revenue mechanisms of local energy communities in doubt.

2.3.3 Recommendations for Scotland (UK)

A future strategy is required which rewards local communities for their role in reducing energy demand, developing local supply, increasing flexibility, and strengthening the community capacity to act. It needs to place more significance on their role in the energy transition. Pilot projects, general support measures, policy and regulatory measures, capacity-building and geographically defined approaches all have a part to play in this strategy. The following are some recommendations that might foster the future adoption of local energy communities in the UK.

- Creation of a new UK Community Energy Plan, which takes account of the new context for community energy including aligning the UK interests to the RED community energy EU directives.
- Establishing 'Local energy zones' to take forward the full range of measures in an integrated way.

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[11] UK Electricity Act: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/490992/Electricity_Act_1989__Energy_Bill_2015-16_Keeling_Schedule_.pdf

[12] Smart Export Guarantee Scheme: https://www.ofgem.gov.uk/environmental-and-social-schemes/smart-export-guarantee-seg

- Support the right to local electricity supply, by lobbying Westminster politicians to enable local trading on electricity distribution networks.
- A ‘Community Contracts for Difference’ in Scotland – Investigate potential for procurement of power from community generators by public sector bodies.
- Unlock PV on tenement buildings and develop the scope for local generation and supply from vacant and derelict land.
- A more supportive regulatory framework, to enable community level flexible demand response.
- A national ‘Community Energy Futures’ programme to build community group capacity to take forward local ‘smart’ energy demand reduction measures.

2.4 Mapping of the regulatory framework to parent use cases

The use cases identified in Task 3.1 of the CLUE project have been mapped to the existing regulatory barriers in the different countries. This is summarised in Table 3 - **Error! Reference source not found.** in Appendix B based on how these are r elevant to Parent Use Cases agreed on earlier on during the project.

This project has received funding in the framework of the joint programming initiative ERA-Net Smart Energy Systems, with support from the European Union's Horizon 2020 research and innovation programme.

3 LESSONS LEARNT AND RECOMMENDATIONS

The section below summaries the lessons learnt and recommendations across the countries and demonstration sites.

3.1 Summary from the CLUE demonstration sites

Technical Barriers:

Across all demonstration sites, installing and validating activities took more time than anticipated which in some instances was due to integration of hardware taking longer than expected due to sourcing the right partners to undertake the work. However, in the Scotland demonstration site it was noted that the implementation part took less time and due to them having as part of the project, partners who had the right expertise on integrating the hardware and software required.

Furthermore, some projects like in Scotland were not able to test to the full potential due to no direct engagement with the DSO and the regulations hindering testing the full capability of the solutions developed.

It is suggested in future projects, to leave a specific head room to account for such delays. It was also noted that there needs to be a right balance between the partners involved in future projects. Too many partners might delay the project and too less might lead to a difficult implementation. Having the right group of partners and community members with real interest in the project is important because it saves a lot of time as it often leads to less explanations required. Also mentioned was that the scientific work must be decoupled from the implementation part in big projects, as there are lots of uncertainties involved.

Social Barriers:

All projects had the COVID-19 pandemic as one of the major barriers. It was also noted that the degree of user acceptances varied as across the most countries. In all countries, the concept of local energy community is still not yet very popular among potential participants and people who are participating are not prepared to organize themselves for the change. However, in Scotland, there was a better user acceptance by the community due to the fact the community region had been used to similar net zero type projects. In Swedish Demo 1 on smart charging, most interviewed EV owners were also positive towards smart technology and showed willingness to contribute to grid stability by being more flexible when charging their vehicles. In Austrian Demo 2 with the REC community currency, a typical percentage of users (10-15%) showed high interest in the new payment option.

Hence, it was noted that those communities who are aware of the net zero goals are always inclined to accept the changes.

Furthermore, in Sweden with the EV charging fleet demonstration site noted there is no need to worry too much about user acceptance for communities which will require more assistance. This was because the vehicle owners did not notice when charging power was reduced. It was rather suggested it is more important to adapt the solutions that do not affect users much.

Business Barriers:

Across all countries, it was noted that it is difficult to quantify value of services provided. As more and more countries adapt to the changing electrical infrastructure, possible new business opportunities are bound to happen in this dynamic environment. There will be new business models when regulation is ready. For example, in Austria, renewable energy expansion act which utilizes an unified platform for data exchange, where processes have to be adjusted for all participants. The DSO/DNO needs incentive to prioritise local energy communities type innovations.

Project finance, planning consents and regulations were also noted to be considered as a barrier. This was evident in the Germany demo site which had to be stopped due to the developer filing for insolvency.

Regulatory Barriers:

The regulatory barriers across all counties have been summarised in the previous Section 2. There needs to be a sufficient level of engagement between local energy community and DSO/DNO. The regulations must be easy for local energy community to participate in the energy market which will incentivise the consumer to become prosumer. Energy sharing can be done using fixed algorithm to allocate energy. Static distribution of surplus energy can be done with the distribution factor defined by DSO. Clearer policies and regulations are needed from the government to realise the benefits to community energy generation and sharing.

3.2 Next steps and Road ahead

In Sweden, there is a proposed legislation for the local energy community on how the energy sharing could be implemented and they are looking at how to explore this legislation when passed. Energy communities could realize energy sharing either virtually with the support of blockchain technology or virtual power plan, or physically by utilizing an internal network at low-voltage level. Other countries can learn from the proposed legislation and tailor it according to the needs to the specific country.

In Austria, they would be exploring new projects to further explore the opportunities and business model offering value to communities. Scaling up the project to more community sites with DSO/DNO involvement. Local energy communities have the potential to provide grid supporting services to DSO/DNO. Austria to continue activities expanding solutions in Gasen.

In Scotland, they will be looking at further work for economic benefits and challenges for local energy community with the ability to test the multi vector integration to full scale. There are potential sites in discussion for future expansion of the solution developed. There is also interest for a direct engagement with DSO/DNO to test this at full scale.

In summary, all the partners agreed to investigate on potential business models involving local energy communities, for example, industrial energy community can also be looked at in the future. It was also highlighted the need for potential grants from governments and future horizon projects fundings to carry out further work. Consumer needs to be educated.

Digital platform solutions for energy communities were also considered as important factors to facilitate the procedures and enable LECs Collaborations. Some solutions like this are under development.

APPENDIX A

Table 1: Renewable Energy Communities in the suggested national law on energy communities in comparison to the supranational RED (Austria and Sweden)

EU Legislation, RED and EMD	**Austria**	**Sweden**
"...renewable energy communities are entitled to produce, consume, store and sell renewable energy, including through renewables power purchase agreements;" RED, Article 22, (2a) *"...access all suitable energy markets both directly or through aggregation in a non-discriminatory manner." RED, Article 22, (2c)* *"...renewable energy communities that supply energy or provide aggregation or other commercial energy services ..." RED, Article 22, (4b)*	RECs can generate, consume, store, or sell energy from renewable sources. In addition, RECs can be active in aggregation and provide other services. EAG §79 (1)	Ei emphasizes that energy communities (EC) are subject to the same rules and regulations as other actors on the energy market. But it is also included in Ch 1 §3 Law on EC that ECs will contribute to its members by produce, sell, store, and consume electricity, through aggregation, or by EV charging, energy efficiency services or other energy services.
"Household consumers and communities engaging in renewables self-consumption should maintain their rights as consumers, including the rights to have a contract with a supplier of their choice and to switch supplier." RED (72)	The free choice of supplier remains. EAG §79 (1)	Included in the new law on EC, Ch 3 §4: An energy community cannot limit its members rights as stated by chapter 9 of the electric law (Ellagen, 1997:857).

ERA-Net Smart Energy Systems

This project has received funding in the framework of the joint programming initiative ERA-Net Smart Energy Systems, with support from the European Union's Horizon 2020 research and innovation programme.

"...the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities;" RED, Article 2, (16b)	Members or partners of a REC are natural persons, municipalities, legal entities of public authorities in relation to local services, other legal entities under public law or SMEs. EAG §79 (2)	These actors are included as possible members of an energy community in the new law on EC Ch 4 §1 "An energy community is formed by three or more natural/physical or legal persons". The proposed law does not specify the actors, but Ei's report discusses small companies, local authorities, and municipalities.
"...,it should be possible for Member States to choose any form of entity for renewable energy communities,..." RED (71)	A REC may be organized as an association, cooperative, business partnership, corporation, or similar association with legal personality. EAG §79 (2)	An energy community is defined as an economic association (ekonomisk förening) in the new law on EC.
"...the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits;" RED, Article 2, (16c)	The primary purpose of a REC is not financial gain, but to provide environmental, economic, or social community benefits to its members or the areas in which it operates. EAG §79 (2)	Both citizen energy communities and renewable energy communities are defined as to have this primary purpose.
"To avoid abuse and to ensure broad participation, renewable energy communities should be capable of remaining autonomous from individual members and other traditional market actors that participate in the community as members or shareholders, or who	Participation in a REC is voluntary and open. In the case of private companies, participation must not be their main commercial or professional activity. EAG §79 (2)	The law on economic associations is applicable on energy communities.

cooperate through other means such as investment." RED (71) *"...is based on open and voluntary participation..." RED, Article 2, (16a)*		The energy community should be open to new members and members have the right to resign from the community.
"Member States shall carry out an assessment of the existing barriers and potential of development of renewable energy communities in their territories." RED, Article 22, (3)	By the end of the first quarter of 2024, the regulator must publish a cost-benefit analysis to determine whether an appropriate and balanced participation of the RECs in the system costs is ensured. EAG §79 (3)	No further action required to fulfill this paragraph.
„...is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects..." RED, Article 2, (16a) *"Member States may provide for renewable energy communities to be open to cross-border participation." RED, Article 22, (6)*	The generation and consumption plants within a REC must be connected via the low-voltage grid or at least via the medium-voltage grid in the concession area of a grid operator. ElWOG §16c (2)	Members should be living in, working in or have a continuous association with the area where the renewable energy community is based. Cross-border participation will not be allowed for Swedish renewable energy communities.
"Member States should ensure that renewable energy communities can participate in available support schemes on an equal footing with large	RECs shall be subsidised. EAG §80	The suggested entity for the energy communities gives the communities the same

participants. ...or allowing renewable energy communities to be remunerated through direct support where they comply with requirements of small installations." RED (26) *"...community members should not be exempt from relevant costs, charges, levies and taxes that would be borne by final consumers who are not community members, producers in a similar situation, or where public grid infrastructure is used for those transfers." RED (71)* *"renewable energy communities are subject to fair, proportionate and transparent procedures, including registration and licensing procedures, and cost-reflective network charges, as well as relevant charges, levies and taxes, ensuring that they contribute, in an adequate, fair and balanced way, to the overall cost sharing of the system in line with a transparent cost-benefit analysis of distributed energy sources developed by the national competent authorities;" RED, Article 22, (4d)*		rights and obligations on the energy market as other actors.

"...the relevant distribution system operator cooperates with renewable energy communities to facilitate energy transfers within renewable energy communities;" RED, Article 22, (4c)	Generators that deliver electric energy to a grid in the local or regional area may participate in a REC provided they are not controlled by a utility, supplier, or power trader. ElWOG §16c (1) RECs can own as well as operate distribution networks. ElWOG §16d (4) Network users have a legal claim against network operators to participate in a REC. ElWOG §16d (1) Grid users shall be informed within 14 days to which part of the distribution grid their consumption or generation facilities are connected. ElWOG §16c (3) Network operators must be informed about the establishment of a REC as well as about various contents and, if necessary, changes to these contents: generation and consumption facilities, metering point numbers, allocation of generated energy, allocation of non-consumed energy per 15 minutes, data management by the network operator, operation, maintenance and servicing of generation facilities, liability, insurance, admission and withdrawal of participating network users, termination of the REC, and dismantling of generation facilities. ElWOG §16d (2) und (3) The grid operator shall measure generation and consumption. If the consumption facilities are not equipped with a smart meter, the grid	The enabling framework in article 22 (4) will be implemented through the new law on EC.

	operator shall install them within two months. The measured values must be made available to the REC and suppliers ElWOG §16e (1). The grid operator shall allocate the agreed static or dynamic share of the generated energy to the respective plants of the grid users. ElWOG §16e (3)	
"Empowering jointly acting renewables self-consumers also provides opportunities for renewable energy communities to advance energy efficiency at household level and helps fight energy poverty through reduced consumption and lower supply tariffs." RED (67) *"...the participation in the renewable energy communities is accessible to all consumers, including those in low-income or vulnerable households;" RED, Article 22, (4f)*	From 2022 onwards, consumption and generation units may participate in more than one energy community. ElWOG §111 (8)	*The current legislation is considered enough to protect vulnerable consumers.*
"Member States shall provide an enabling framework to promote and facilitate the development of renewable energy communities. That framework shall ensure, inter alia, that unjustified regulatory and administrative barriers		The enabling framework in article 22 (4) will be implemented through the new law on EC.

to renewable energy communities are removed;" RED, Article 22, (4a)		

Table 2: Citizen Energy Communities in the suggested national law in comparison to the supranational EMD (Austria and Sweden)

EU Legislation, RED and EMD	**Austria**	**Sweden**
"citizen energy community means a legal entity that may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders;" RED, Article 2, (11c)	BEGs can generate, consume, store, or sell electrical energy. In addition, they can be active in aggregation and offer energy services to members. ElWOG §16b (1)	These terms are included in the definition of citizen energy community in the proposed law on EC.
"citizen energy community means a legal entity that is … effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises." RED, Article 2, (11a)	Members or shareholders of a BEG are natural or legal persons and local authorities. ElWOG §16b (2)	These actors are included as possible members of an energy community. Law on EC Ch 4 §1 "An energy community is formed by three or more natural/physical or legal persons".

		The proposed law does not specify the actors, but Ei's report discuss small companies, local authorities and municipalities.
"Membership of citizen energy communities should be open to all categories of entities.... It should therefore be possible for Member States to provide that citizen energy communities take any form of entity, for example that of an association, a cooperative, a partnership, a non- profit organisation or a small or medium-sized enterprise" EMD (44)	BEGs may be organized as an association, cooperative, partnership, corporation, or similar association with legal personality. ElWOG §16b (2)	An energy community is defined as an economic association. (Proposed Law on EC Chapter 1 §3)
„for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits;" RED, Article 2, (11b)	The main purpose of a BEG is not financial gain, but to provide environmental, economic or social community benefits to its members. ElWOG §16b (2)	Both citizen energy communities and renewable energy communities are defined as to have this primary purpose.
"Household customers should be allowed to participate voluntarily in community energy initiatives as well as to leave them..." EMD (43) *"...participation in a citizen energy community is open and voluntary; members or shareholders of a citizen energy community are entitled to leave*	Participation in BEGs is voluntary and open. ElWOG §16b (2)	The energy community should be open to new members and members have the right to resign from the community (Law on EC, chapter 4, §9)

the community,…" RED, Article 16, (1a, 1b)		
"…, the decision- making powers within a citizen energy community should be limited to those members or shareholders that are not engaged in large-scale commercial activity and for which the energy sector does not constitute a primary area of economic activity." EMD (44)	Control within a BEG is limited to natural persons, local authorities, and small companies, if participation is not their main commercial or professional activity. Control is given if the majority provided for in the articles of association amending the chosen form of the company is held by the aforementioned members. ElWOG §16b (3)	This is not a requisite for a citizen energy community.
"Access to a citizen energy community's network should be granted on fair and cost- reflective terms." EMD (43)	Network users have a legal claim against network operators to participate in a BEG. ElWOG §16d (1)	A citizen energy community will not be allowed to own a network[13].
"…relevant distribution system operators cooperate with citizen energy communities to facilitate electricity transfers within citizen energy communities;" EMD, Article 16, (1d)	*Grid operators are to be informed about the establishment of a BEG as well as some contents and possible changes of the contents. This includes information regarding generation and consumption facilities, metering point numbers, allocation of generated energy, allocation of non-consumed energy per 15 minutes, data management by the grid operator, operation, maintenance and servicing of generation facilities, liability, insurance, admission and withdrawal of participating grid users, termination of the REC*	An energy community has the same rights and obligations as other actors. A new paragraph will be introduced in current legislation, in the Electricity Act, where the DSO is required to collaborate with the TSO to ensure that all market actors can participate on the end-customer, wholesale and balance markets.

[13] This statement was based on Ei's proposal in 2020. Some adjustments have been made later to allow internal networks inside ECs under some circumstances, see Table 4.

	and dismantling of generation facilities. ElWOG §16d (2), (3) The grid operator shall measure the consumption of the consumption facilities and the feed-in of the generation facilities. If the consumption facilities are not equipped with a smart meter, the grid operator shall install them within two months. The metered values shall be made available to the suppliers and BEG. ElWOG §16e (1). In addition, the metered values of a grid operator shall be made available to all other grid operators having generation and consumption facilities of BEG members in their concession area. ElWOG §16e (2) The grid operator shall allocate the agreed static or dynamic share of the generated energy to the respective plants of the grid users. ElWOG §16e (3)	
"This Directive empowers Member States to allow citizen energy communities to become distribution system operators either under the general regime or as 'closed distribution system operators'. Once a citizen energy community is granted the status of a distribution system operator, it should be treated as, and be subject to the	BEGs can be both owner and operator of a distribution network. ElWOG §16d (4)	Energy communities will not be allowed to act as distribution system operators.

same obligations as, a distribution system operator." RED (47)		
"The provisions of this Directive on citizen energy communities provide for rights and obligations, which are possible to deduce from other, existing rights and obligations, such as the freedom of contract, the right to switch supplier,…" EMD (45)	From 2022 onwards, consumption and generation units may participate in more than one energy community. ElWOG §111 (8)	An energy community´s members retain their rights as stated by chapter 9 of the Electric Act (Ellagen, 1997:857).

APPENDIX B

Austria

Table 3: Austria - Mapping of regulatory framework to Use Cases

Use Cases	Existing Regulations
Capacity Sharing	Capacity sharing with batteries is possible under the Austrian legislative framework. RECs and CECs are entitled to store energy within the community (EAG §79 (1) and ElWOG §16b (1)). So far in Austria, grid tariffs would have to be paid for in-store and out-store electricity in the community battery storage. This is a key point since capacity sharing is thus significantly hampered due to reduced profitability. However, for RECs in Austria, reduced grid tariffs apply for electricity transfer within the community. Reduced grid tariffs (the exact numbers have not yet been published) are also applicable for using the grid to store or un-store electricity from a battery. Nevertheless, paying grid tariffs twice – even in reduced form – makes the economic situation of battery storages difficult.
Energy Trading	Energy trading is possible within RECs and CECs. Within energy communities, the trading of electricity does not require the status of a supplier (ElWOG §7, Z45 ff). This is an important alleviation, since the requirements of becoming a licensed supplier are significant, which would hamper the diffusion of the energy community concept immensely. Moreover, the quantities of electricity generated and consumed within RECs or CECs remain outside the balancing group system. (To be found in the annotations to the legislative draft). Balancing for individual citizens is done by the conventional electricity suppliers that also cover the residual demand of their customers. However, alleviations concerning the supplier status are strictly applicable to electricity transfer within the community only. As soon as electricity would be traded between different communities, the status of a licensed supplier and the fulfilment of duties that come with that situation would be required.

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Energy Account(ing)	In Austria, the distribution grid operators (DSOs) are responsible for allocating the generated electricity within RECs and CECs, based on the agreed static or dynamic distribution key (ElWOG §16e (3)). The according data must be made available to the energy communities, who can then do the accounting themselves, or assign a third party.
Planning and Operation	The European Directives (f.e. RED (59)) foresee that member states should provide guidance by means of an administrative contact point with the intention of reducing complexity for project developers. This European provision is not specifically laid down in the legislative draft. However, Austria is setting up such official body for the support of both RECs and CECs. This body will be called Österreichische Koordinationsstelle für Energiegemeinschaften and will be implemented at a national and a federal level. Tasks of this official body are to provide administrative support for the set-up of energy communities, such as answering organisational and regulatory questions, provide useful documents such as "step-by-step" guidelines for the establishment of energy communities and more. There are no specific provisions concerning the actual operation of energy communities. It is recommended to determine a responsible person who represents the community externally. The operation can be conducted by community members themselves or be outsourced.
Demand Response	Demand response is highly beneficial for energy communities to maximise their benefits. However, there are no specific requirements concerning demand response in the Austrian legislation. What can be mentioned though is, that according to EAG §79 (3), the Austrian regulator needs to publish a cost-benefit analysis until the first quarter of 2024 to determine, whether RECs are adequately contributing to the system costs. This cost-benefit analysis shall then be – according to the annotations of the new legislation – the basis for the determination, whether existing provisions (such as the reduction of grid tariffs) need to be adjusted. Therefore, the more demand response mechanisms are implemented in the community, the more likely the grid tariff reductions will hold.

Emergency Supply	There are no legal provisions concerning emergency supply in the context of energy communities in Austria. However, similarly to demand-response it would be beneficial if initiatives concerning emergency supply are addressed in the context of energy communities, since this would be an additional benefit.

Sweden

Table 4: Sweden - Mapping of regulatory framework to Use Cases

Use Cases	**Existing Regulations**
Capacity Sharing	Sharing the storage capacity or renewable production capacity is possible under the Swedish regulatory framework. But according to Ei's proposal (Ei, 2020)[6], RECs and CECs are not given the right to own and manage their own network, either through a granted concession or within the framework of the exceptions in the IKN (non-concession grids) legislation. Therefore, an EC cannot transfer electricity among separate buildings via internal networks. The IKN legislation has been adjusted in November 2021, which increases the possibility for energy sharing in ECs. A new exception[14] was introduced for allowing an internal low-voltage network for sharing energy to be built and used without a grid concession. When community members are not connected at the same metering point, the most likely form of sharing is through e.g., blockchain technology or virtual power plant. This may result in less profit for ECs compared with sharing via internal grids due to the network fee and energy tax.
Energy Trading	Energy trading inside and among ECs are possible under the Swedish regulatory framework. As Ei suggested, available electricity from own production can be sold, bought, and settled within ECs via a platform or blockchain technology. But a supporting framework is neglected in Ei's proposal. For example, ECs cannot benefit from self-produced renewable production in the same way as other micro producers. In

[14] 22 c § in "Förordning (2007:215) om undantag från kravet på nätkoncession enligt ellagen (1997:857)".https://www.riksdagen.se/

	Sweden, small scale solar electricity that is produced and consumed in the same building is exempted from energy tax (for installations up to 255 kW[15]), and there is also tax reduction for the electricity sold to the grid. Several of the item of written comments to Ei's proposal suggest that members of ECs should also be exempted from energy tax for the energy produced and consumed within the community, which is not the case in Ei's proposal. This is one of the aspects that might affect the implementation and diffusion of energy communities in Sweden. Furthermore, it is important to find proper business models to encourage and incentivize the community participation. It can be foreseen that ECs will become new market players and participate actively in the existing energy markets. New marketplaces would also be created to enable the interactions inside or among ECs, although it has not been mentioned in Ei's proposal.
Energy Account(ing)	Since ECs are not allowed to own grids, Ei suggests that the trading and accounting among community members could be facilitated by e.g., a conventional electricity retailer. The agreements between retailers and ECs need to be well defined regarding the cooperation and balance responsibility. However, there is no regulation forcing retailers to cooperate with ECs. In case that there is no suitable retailer able to assist the community with internal energy trading, the community itself has the right and obligation to take the role. On the other hand, as a retailer or aggregator, the proposal emphasizes ECs may not restrict the members' rights, e.g., switching the suppliers, by provisions in its statutes or in any other ways according to Electricity Act (1997: 857).
Planning and Operation	Ei's proposal contains the common provisions on energy community concerning formation, statutes, membership, decision making, etc. It briefly outlines the mandatory information that

[15] This level will increase to 500 kW from 1st of July 2021 https://www.riksdagen.se/sv/dokument-lagar/dokument/proposition/utokad-befrielse-fran-energiskatt-for_H803113/html

	shall be included in the statutes e.g., the activities carried out by the energy community, the numbers of board members/auditors/other deputies and their assignments, how the meeting shall be convened, etc. It also requires a clear statement about the mandatory contribution of each member, how the contribution should be fulfilled, and the principle of profit distribution. The proposal specifies the right and obligations of community members, highlights their volunteer participation and their awareness of power and duty. On the other hand, it does not clearly explain the benefits and advantages of ECs. Furthermore, Ei's proposal emphasizes the roles of individuals, local authorities, small businesses, and micro-enterprises in energy communities, who may be lack of experiences to operate an economic association. This may imply a need of new actors who can facilitate the establishment and operation of energy communities
Demand Response	Although Ei's proposal does not directly mention demand response, it defines a scope of activities that can be carried out by ECs. According to Ei' definition, one of ECs' purposes is to bring benefits through energy aggregation, energy efficiency services or other energy services. The definition also highlights energy storage and EV charging, which are important flexible resources. ECs are supposed to benefit from demand response in different ways e.g., profile optimization, trading in local flexibility market, participation in balancing markets. Ei has delivered another report (Ei, 2017)[16] to investigate the flexibility potential in Sweden and propose measures to increase the demand side flexibility. However, in Ei's proposal about ECs, there is a lack of incentives to encourage demand response in ECs.
Emergency Supply	There are no specific requirements concerning emergency supply in Ei's proposal about ECs.

Scotland (UK)

Table 5: Scotland (UK) - Mapping of regulatory framework to Use Cases

Selected Use Cases	**Existing Regulations**

[16] Swedish Energy Markets Inspectorate (Ei), 'Measures to increase demand side flexibility in the Swedish electricity system', Ei R2017:10, May, 2017.

Demand Response	• Local generation is possible thorough feed in tariffs (FiT's) but there is no regulation or policy for local supply to communities.
Capacity Sharing	• Storage can be in a community, but storage and generator assets currently are not owned by communities. • There is also still a need for market mechanisms that are tailored to the use of local energy community generation or supply.
Energy Trading	• Energy trading markets are not currently open to local energy communities to participate in • There is a need for existing aggregator platforms to be extended for local energy communities energy assets or the need for a role to establish community owned aggregators

APPENDIX C

Austria

Demo 1

What are the best practices in the demo?	Look out for early involvement of users if there is a need for new concepts and interaction interfaces.
What are the lessons learnt and recommendations?	The value of e-kWh changes with the electricity market in real time. To overcome this, a closed regional economy can be made, in a way to decouple it from the overall market. To keep sync with energy market is still a challenge.

What are the barriers?	• **Technical barriers:** Blockchain technologies are rapidly evolving and therefore demands constant attention on what is happening. Application updates or pivots should be always counted in when dealing with such a novel technology. • **Economic barriers:** At the time of testing applications, it is hard to prognose the expected economical scaling path. Business models are typically building on fees and because they are lower than in traditional financial systems, they need scale. • **Social barriers:** For new technologies there is always hard to satisfy everyone. Users have different reservations when it comes to trusting in technologies and use new applications. Wallets must become more mainstream and intuitive to use and usability testing is therefore of key importance. • **Regulatory barriers:** Regional currencies are clearly regulated in Austria, but it still needs more clarifications through the upcoming enaction of the MiCA regulation in 2024. This will also simplify the use of e-money on blockchains and reduce the potential administrative burden coming from Austrian authorities.

Sweden

Demo 1

Table 6: General experiences and reflections from the demo 1.

What are the best practices in the demo?	User Case 1 gave the highest flexibility delivered without affecting user to a large degree.
What are the lessons learnt and recommendations?	No need to worry about user acceptance for this kind of application because they will not notice when charging power is reduced. There is a large potential for flexibility when many sources are aggregated.

	Chose a software that is easy to use and developed for this functionality. It would have been better to control charging stations individually than in groups. Group control proved to be difficult to validate and predict. For scaling up things, such as bids, need to be automated to a higher degree.
What are the barriers?	• **Technical barriers:** Not simple to get the smart changing system to work as intended. Very difficult to validate the flexibility delivered. • **Economic barriers:** The value of flexibility is difficult to predict. • **Social barriers:** Many factors affect the social acceptance, such as size of battery in car, BEV/PHEV, user experience of BEV, type of charging station (long or short time) • **Regulatory barriers:** For net owner it is still more economic to invest in net than flexibility. The current regulatory remuneration scheme is the barrier here.

Demo 2

Table 7: General experiences and reflections from the demo 2.

What are the best practices in the demo?	Best practice is to have the battery being able to supply electricity to both apartments and utility to maximise its use.
What are the lessons learnt and recommendations?	For a few hours, the power used in the heat pump could be decreased without compensation with increased district heating due to thermal inertia in the buildings without affecting comfort significantly. The inertia makes changes quite slow and that should be considered when planning to deliver flexibility. Future work could include weather as a parameter to adjust to.

What are the barriers?	• **Technical barriers:** It takes longer time to implement than anticipated. • **Economic barriers:** Incentives for this is unclear. As an example, it is different companies that handles district heating and electric. • **Social barriers:** Many different people involved with unclear responsibilities. No red thread in the project.

Demo 3

Table 8: General experiences and reflections from the demo 3.

What are the best practices in the demo?	Best practice is to have the battery being able to supply electricity to both apartments and utility to maximise its use.
What are the lessons learnt and recommendations?	Installing a battery and software-based control can easily take longer time than anticipated. A lot longer. Having different companies responsible for different parts of installation can increase time manyfold. Scalability should be easy if there is an aggregator.
What are the barriers?	• **Technical barriers:** As above. • **Economic barriers:** Difficult to prove profitability for a battery solution only used for peak shaving. • **Social barriers:** No social barriers.

Demo 4

Table 9: General experiences and reflections from the demo 4.

What are the best practices in the demo?	Demonstration was more about examining than realizing potential. No best practices were developed. However, potential for peak balancing was found as well as potential for energy efficiency measures.

What are the lessons learnt and recommendations?	It is complicated to measure electricity use on a building site. Especially with many measure points. If something similar would be undertaken this should be considered. It is unclear where the responsibility for this kind of measures lies. Conservative field reluctant to try new things that might affect time plan and economy.
What are the barriers?	• **Technical barriers:** If batteries and PV are to be used to alleviate peaks it can be difficult to find a place to put them. Building site often have limited space as it is. • **Economic barriers:** Up until recently the cost of electricity have not been high enough to give energy efficiency high priority. • **Social barriers:** Industry conservatism, lack of top-management support, lack of energy-efficiency monitoring, and low prioritization of energy efficiency. • **Regulatory barriers:** The lack of forcing regulations.

Scotland

What are the best practices in the demo?	• Working with the community was vital in allowing us to use the community centres as demonstrated sites. • A good understanding the region and community plans allowed us to make decision of how to develop the use cases. • Good understanding and collaboration within the ScotCLUE partners also allowed us to achieve our desired outcomes and goals.
What are the lessons learnt and recommendations?	The focus on the demo site in Scotland was to develop and validate an energy management architecture around the future concepts of local energy communities (LEC). **Lessons learnt:** Part of our lessons learnt was that

	• the community had a general acceptance for carbon free (net zero) type projects like ours which was helpful is allowing test our downscaled versions of the concept we developed. • there were initial challenges in understanding and deciding how far our use cases could be tested and validated at the demonstration site and we took in our best understanding to create a design that could be scaled up and incorporate future changes. **Recommendations:** In Scotland UK, there are currently challenges in adopting the concept of local energy communities (LECs). This is mostly around providing the right regulatory policies and incentives that would enable concepts like what we developed in the demo site to be implemented. A key blocker in the UK is that energy cannot be sold form one household or community to another because the legislation does not allow for them to be licensed suppliers. Our recommendations are • Clearer polices that would enable the growth and use of local energy communities. This could be like the EU directives (RED) adopted by EU member states. • There is also a need for incentives to realise the benefits of having the communities involved in local energy generation and sharing. • If LEC's are to be adopted in future, there is also a clear understanding around the ownership structures and business models required to make this commercially viable.
What are the barriers?	**Technical barriers:** The concept we developed cannot be tested to scale or its full potential due to local energy communities being very early-stage concepts and might be less of an appeal to some key stakeholders. Some of the technologies investigated hydrogen gas production (e.g., hydrogen electrolysers) are still concepts and the relevance in a local community setting is still yet to be understood clearly.

	Economic barriers: In Scotland UK, there are no clear incentives to promote the use of local energy communities. The incentives are tailored towards solar PV and home battery installations (i.e., feed in tariffs) and doesn't incentive the use of local energy from communities. **Social barriers:** The concept of a community or communities benefiting from sharing energy between themselves is one of interest but the policies and guidance in Scotland are not yet established to make this possible. There is also a general acceptance in using carbon free technologies including renewables and the use of hydrogen but similarly the incentives and regulations to make this viable are not currently available. **Regulatory barriers:** In Scotland UK, there are no clear directives like the EU Renewable Energy Directive (RED) that creates a mandate for the adoption of energy communities within member states. The current regulation also does not allow for local supply of energy between communities due to legislation around supply licenses being available to grid and distribution network operators. This make is it hard to adopt local energy community concepts.

Germany

What are the best practices in the demo?	The development of the urban plan and implementation was delayed (and finally stopped due to the insolvency of the developer).
What are the lessons learnt and recommendations?	It is important to decouple the scientific work from the implementation part, especially in big development processes, where a lot of uncertainties are out there.

What are the barriers?	• **Technical barriers:** The results of the German cells and other cells are often not comparable, the reporting scheme (ERA-NET) was sometimes not appropriate to the heating system, however, awareness has been raised on this issue. • **Economic barriers:** Insolvency of the developer. • **Social barriers:** Difficulties due to COVID 19 crisis delayed the implantation in the first place. • **Regulatory barriers:** Energy communities are not implemented in Germany yet regarding energy sharing. Germany has a lot of energy communities, but no energy sharing is allowed yet. So, demonstration of energy communities was not possible, however it has been evaluated how energy communities with energy sharing could improve the energy system and operation.

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