D3.1 HIGH-LEVEL DESCRIPTION OF USES CASES AND BUSINESS MODELS

VERSION 1.0

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ERA-Net Smart Energy Systems

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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

1 INTRODUCTION

The ERA Net project CLUE (*Concepts, Planning, Demonstration and Replication of Local User-friendly Energy Communities)* aims to acquire knowledge on optimized design, planning and operation of Local Energy Communities (LECs) and will develop a tool kit for planning and operation as key elements for successful replication and upscaling of LECs. Research and development will be conducted on technologies with the focus on flexibilities and sector coupling for LEC energy systems, on services by developing business models and recommendations on improved regulatory framework, as well as on stakeholder involvement by collaborating with developers and service providers and integrating consumer, prosumer, and organizer of LECs in a living-lab concept.

CLUE is executed by leading European research institutes, industry, and local partners, working together in five demo sites in four countries. By implementing and testing different technological and market solutions and executing a cross-country analysis, CLUE is able to develop optimized LEC solutions in dependency on country and site-specific framework conditions.

1.1 Focus of Deliverable

The aim of this deliverable is

- a common definition of use cases and business models and
- the characterization of the demo sites

1.2 Definitions

The following terms are central within CLUE, for a common understanding a definition is given hereafter.

<u>Energy Community (EC):</u> With the comprehensive update of its energy policy - the Clean energy for all Europeans package ("Clean Energy Package"), the European Union introduced new provisions on the energy market design and frameworks for new energy initiatives. Specifically, the actual recasts of the renewable energy directive (RED II) and the electricity market directive (EMD II) provide general definitions and requirements for activities of individual and collective self-consumption. In this regard, the Clean Energy Package also introduces energy communities into the European legislation, which allow citizens to collectively organise their participation in the energy system. There are two definitions, which are generally similar, but have some critical differences: Citizen Energy Community (CEC), as well as Renewable Energy Community (REC). These activities for citizen participation are covered under two umbrella terms, which show similarities in their conception, however, indicate several crucial differences: Citizen Energy Community (CEC) and Renewable Energy Community (REC). The detailed definitions of those two concepts of energy communities differ between the countries participating in CLUE.

Demo site / testbed: Predefined cluster of pro- and consumers in each of the participating countries (Austria, Germany, Scotland and Sweden) for demonstrations within the CLUE research project.

Use case: A use case defines the relations between the components and users and their interaction within a system to attain particular goals, primarily from a technical/energy (and not from a commercial) perspective

Parent use case: generic description of a use case, focussing on one specific target/application (e.g. capacity sharing, demand response…) which allow cross-country comparisons of use cases and serves as a baseline for the country-specific use cases

Country-specific use-case: detailed testbed-specific description of one or more use-cases

Prosumers: EU legislation addresses "prosumers as active energy consumers who both consume and produce electricity"[1] with the objective of facilitating the involvement of (household) consumers in renewable energy deployment.

Stakeholders: individuals, groups or organizations that are involved, concerned or affected by the actions or decisions made within the use case. This comprises not only the members (both prosumers and consumers) of the community, but also further parties as the local DSO, energy suppliers, local authorities, municipalities and companies. In the context of business model development for EC, primary stakeholders are all parties for whom value should be created to ensure economic sustainability.

Participants/Members: Prosumer and consumers participating in the energy community.

Business models: A business model

- can build up on one or more use cases and extends this/these use-case(s) with economic information (e.g. flexibility trading using capacity sharing and demand response) and/or
- can also work without a use-case e. g. development of hard- or software

[1] European Economic and Social Committee (2018). Opinion of the European Economic and Social Committee on 'The transition towards a more sustainable European future — a strategy for 2050', Link

1.3 Overview: Parent and Country-specific Use Cases within CLUE

Table 1: overview of parent and country-specific use cases within CLUE

<table>
<tr><th>Parent Use Cases</th><th>AT</th><th>DE</th><th>SCOT</th><th>SE</th></tr>
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<tr><td rowspan="2">Control-Based DR</td><td>Local Self Optimization with control-based DR</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">Flexibility in a facility with heat pumps & DH</td></tr>
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<tr><td>Flexibility on Building Site</td></tr>
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<tr><td rowspan="2">Community Currency</td><td>EV-charging payment with community currency</td><td></td><td></td><td></td></tr>
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2 PARENT USE-CASES

2.1 Energy Trading

2.1.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
ENERGY_ TRADING	• Domains: Generation (CEC), Transmission, Distribution, DER, Customer • Zones: Market, Enterprise, Operation, Station, Field, Process	Energy Trading between community customers Energy Trading between community customers and communities Energy Trading between communities	Community customers RECs CECs

2.1.2 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Energy Sharing in/between (Renewable/Citizen) Energy Communities
Type of Energy Community	REC (CEC)
Objective(s)	Optimal distribution of surplus energy within an Energy Community and between Energy Communities.
Connected Use Cases	

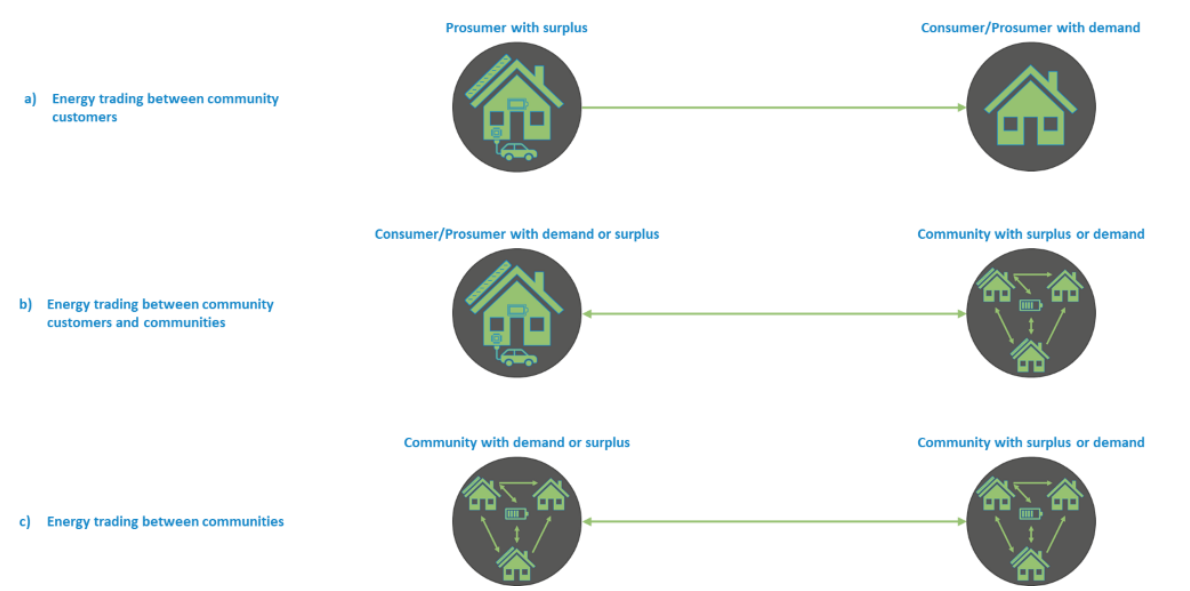
2.1.3 Narrative of Use Case

Narrative of Use Case
Short description
Simple energy sharing/trading a) between community customers, b) between community customers and communities, c) between communities. Information about demand and surplus (including prices) are provided to the settlement system which calculates a matching between customer and provides the billing information.

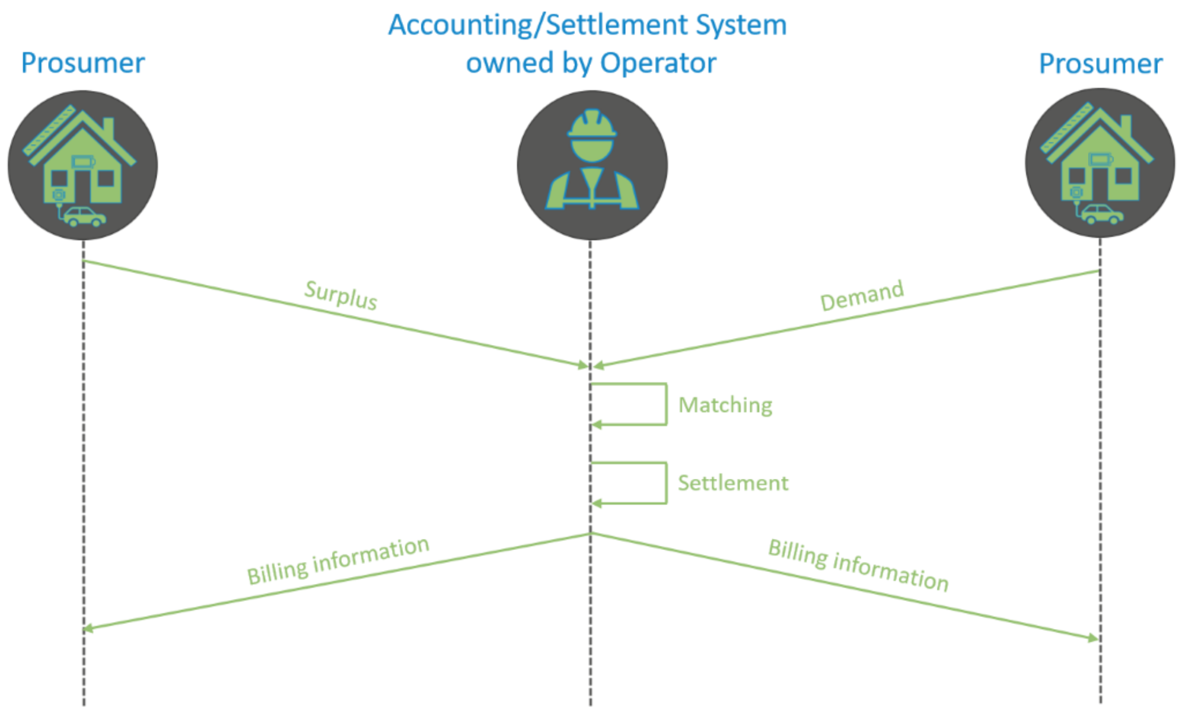
Complete description
Customers or communities with surplus will sell their energy to customers or communities with demand (controllable devices, storage systems are not considered). The sequence/structure of the use case is equal in case of customers or communities participating at the trading/sharing system. Customers or communities provide information about their demand and surplus to a settlement system. This system will calculate a matching based on the customer/community information (and preferences) and will calculate the settlement. The bill is provided to each customer/community. A customer could be a simple consumer, producer, prosumer, battery, or other energy community (REC).

2.1.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



Remark: Customer could be consumer, producer (e.g., community PV), prosumer, storage (e.g., community battery), or other energy community.

2.1.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Energy information	Customer information about its energy surplus/demand in kWh for the next timestep (and price)
Billing information	Information from the settlement system about the energy trading process of the previous timestep (from/to other customers, kWh, €)

2.1.6 Relevant Actors

Actors	
Grouping	***Group Description***
Customer	Customers can be consumers, producers, prosumers, storage devices, CECs, RECs.
Operator	Operator of community – providing software and hardware services for community members

Actor Name	*Actor Type* *cf. Grouping*	*Actor Description*	*Further information* *specific to this Use Case*
Customer device	Customer	Community customer which can participate in energy trading/sharing processes. Customer is connected to the system via dedicated device (e.g., EMS with connection to community).	
Accounting/ Settlement System	Operator	System collecting all customer information, creating matchings between surplus and demand, creating the bill, sending out billing information to customers. The system is owned/operated by the community (operator)	

2.2 Control-Based Demand Response

2.2.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
UC Control-Based Demand Response	• Domains: Generation, Distribution, DER, Customer • Zones: Market, Enterprise, Field, Process, Operation	control-based demand response	flexibility owners

2.2.2 Scope and Objectives of Use Case

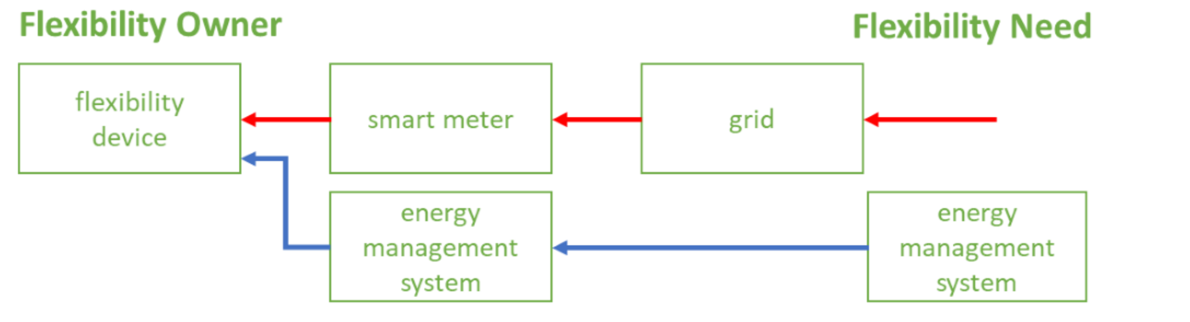
Objectives of Use Case	
Scope	Demand Response
Type of Energy Community	REC, LEC
Objective(s)	activate flexibilities by means of direct access to the device
Connected Use Cases	

2.2.3 Narrative of Use Case

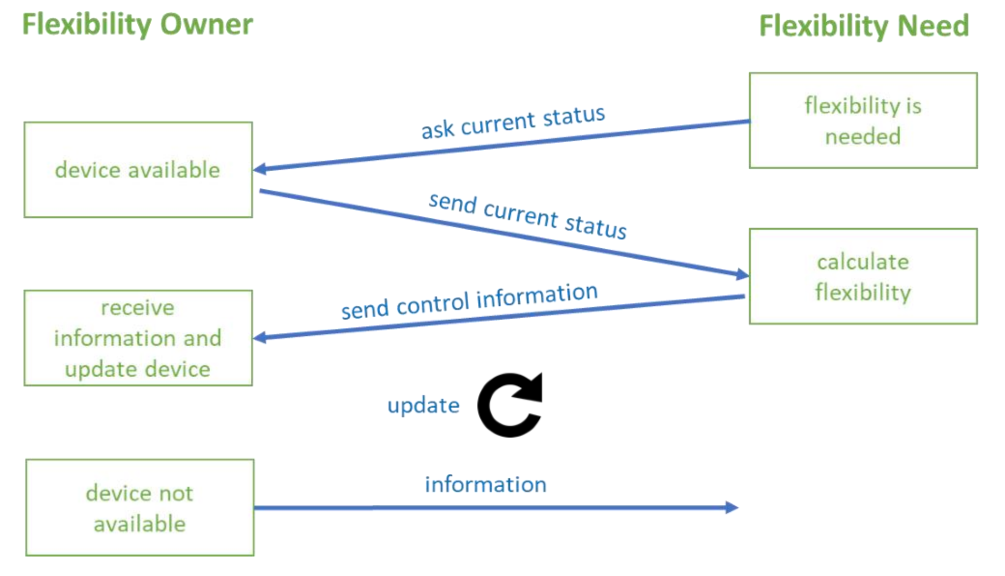
Narrative of Use Case
Short description
This use case is the parent use case for the control-based demand response use cases. It describes the activation of flexibility by means of direct access to the flexibility device in a very general way: If flexibility is needed, the need-owner can directly access and control the device.

2.2.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



2.2.5 Exchanged Information

Exchanged Information

Type	***Information Description***
ask current status	ask the current status of the flexibility device to calculate the flexibility potential
send current status	Send the current status of the flexibility device
send control information	send binding control information to the flexibility device (or control flexibility device in another way)

2.2.6 Relevant Actors

Actors			
Grouping		***Group Description***	
Communication partner		Entity taking part in the communication process.	
Management entity		Actor that manages a part of the use case.	
Controller		Controller that can activate a certain device or behaviour.	
Communication infrastructure		Communication infrastructure needed for transmitting information on energy needs/provisions.	
Meter		Metering equipment required for settlement process.	
Indirectly involved stakeholder		Stakeholder that is affected but not directly involved in the trading process	
Actor Name	***Actor Type*** cf. Grouping	***Actor Description***	***Further information*** specific to this Use Case
owner of flexibility device	Communication partner	entity that owns flexibility device	
flexibility device	Controller	consumes or feed-in energy, communicates directly or via EMS with need-owner	
energy management system (EMS)	Management entity	enables communication between flexibility device and need owner (can also be part of the flexibility device)	
Energy Meter	Meter	metering of generated/consumed energy and power	

need owner / energy management system (EMS)	Management entity	enables communication between flexibility device and need owner	
Energy Provider	Indirectly involved stakeholder	Entity that produces excess electric energy to be sold to customers.	

2.3 Customer-based demand response

2.3.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
UC 1	• Domains: Generation, Distribution, DER, Customer • Zones: Market, Enterprise, Field, Process, Operation	customer-based demand response	flexibility owners

2.3.2 Scope and Objectives of Use Case

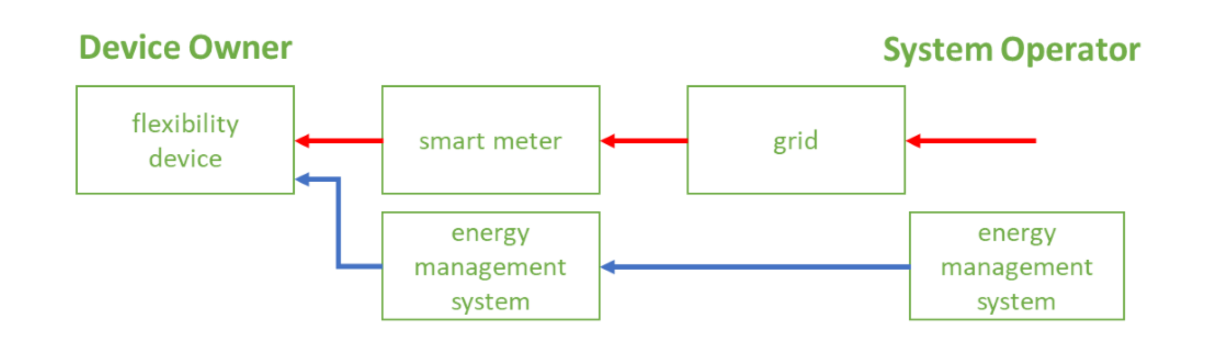
Objectives of Use Case	
Scope	Demand Response
Type of Energy Community	REC, LEC
Objective(s)	try to coordinate available capacities within EC
Connected Use Cases	

2.3.3 Narrative of Use Case

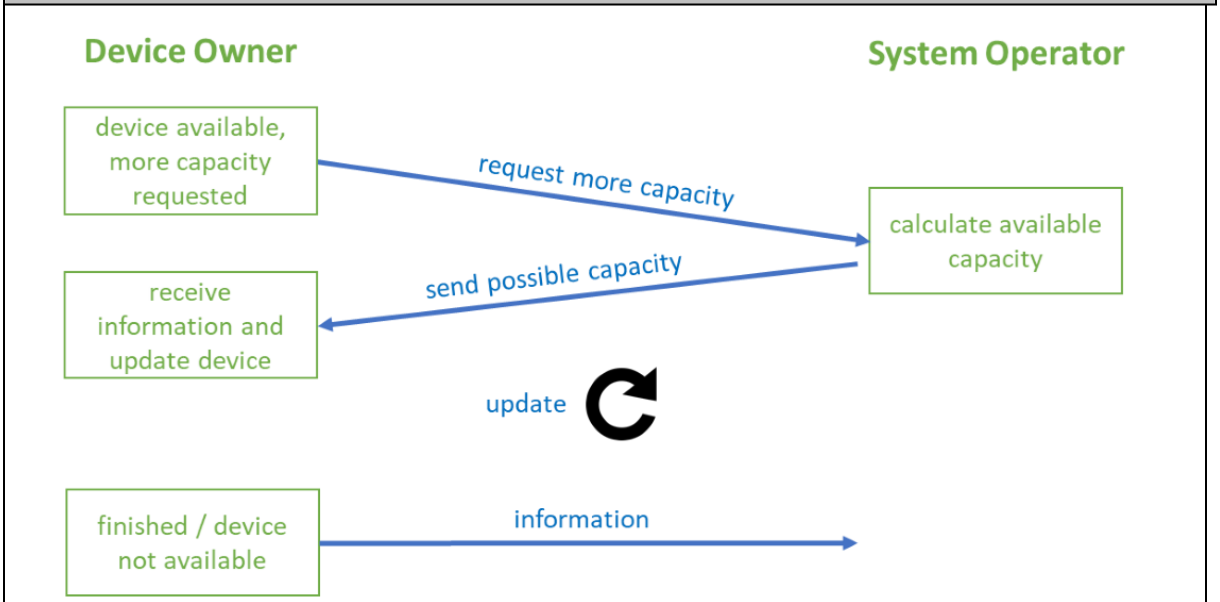
Narrative of Use Case
Short description
This use case is the parent use case for the customer-based demand response use cases. It describes the coordination of available capacities within an EC in a very general way: If more capacity is needed, the device owner has to request information about the max. available capacity from the system operator. If the available capacity changes, the system operator has to send an update. After finishing the process, the device owner has to inform the system operator.

2.3.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



2.3.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
request (more) capacity	request available capacity from system operator
send possible capacity	Send available capacity
update capacity	update if the available capacity changes
finished	information process is finished or device is no longer available

2.3.6 Relevant Actors

Actors	
Grouping	***Group Description***
Communication partner	Entity taking part in the communication process.
Management entity	Actor that manages a part of the use case.
Controller	Controller that can activate a certain device or behaviour.
Communication infrastructure	Communication infrastructure needed for transmitting information on energy needs/provisions.
Meter	Metering equipment required for settlement process.
Indirectly involved stakeholder	Stakeholder that is affected but not directly involved in the trading process

Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
owner of device	Communication partner	entity that owns device	
device	Controller	consumes or feed-in energy, communicates directly or via EMS with need-owner	
energy management system (EMS)	Management entity	enables communication between flexibility device and system operator (can also be part of the device)	
Energy Meter	Meter	metering of generated/consumed energy and power	

system operator / energy management system (EMS)	Management entity	enables communication between device and system operator	
Energy Provider	Indirectly involved stakeholder	Entity that produces excess electric energy to be sold to customers.	

2.4 Incentive-based demand response

2.4.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
INCENTIVE-BASED DEMAND RESPONSE	• Domains: Generation, Distribution, DER, Customer • Zones: Market, Enterprise, Field, Process, Operation	incentive-based demand response	flexibility owners

2.4.2 Scope and Objectives of Use Case

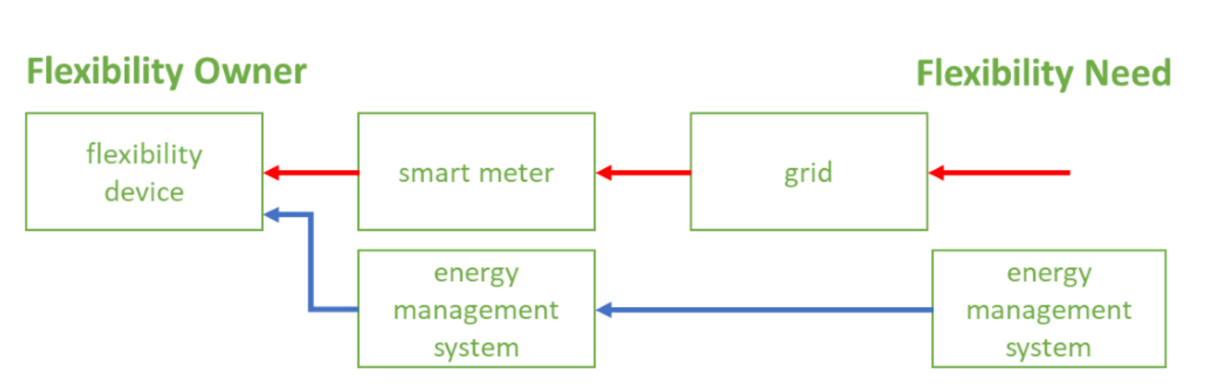
Objectives of Use Case	
Scope	Demand Response
Type of Energy Community	REC, LEC
Objective(s)	try to activate flexibilities based on incentives
Connected Use Cases	

2.4.3 Narrative of Use Case

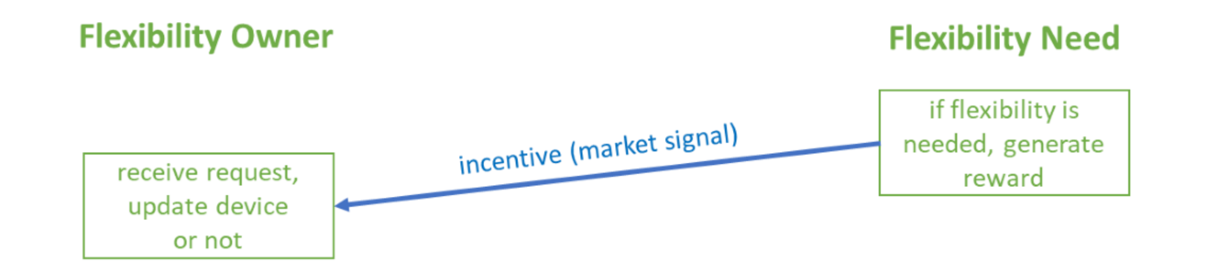
Narrative of Use Case
Short description
This use case is the parent use case for the incentive-based demand response use cases. It describes the voluntary activation of flexibility based on incentive in a very general way: If flexibility is needed, the need-owner offers an incentive (e.g. higher or lower tariffs). If this incentive is sufficient for the flexibility owner, the behavior of the flexibility-device will be adjusted. There is no feedback from the flexibility owner to the need-owner. The flexibility owner cannot be forced to adjust their behavior (or the behavior of their devices), but the need-owner can increase the incentive at any time.

2.4.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



2.4.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
incentive	incentive to change consumption or feed-in, mostly higher or lower tariffs

2.4.6 Relevant Actors

Actors	
Grouping	***Group Description***
Communication partner	Entity taking part in the communication process.
Management entity	Actor that manages a part of the use case.
Controller	Controller that can activate a certain device or behaviour.
Communication infrastructure	Communication infrastructure needed for transmitting information on energy needs/provisions.
Meter	Metering equipment required for settlement process.
Indirectly involved stakeholder	Stakeholder that is affected but not directly involved in the trading process

Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
owner of flexibility device	Communication partner	entity that owns flexibility device	
flexibility device	Controller	consumes or feed-in energy, communicates directly or via EMS with need-owner	
energy management system (EMS)	Management entity	enables communication between flexibility device and need owner (can also be part of the flexibility device)	
Energy Meter	Meter	metering of generated/consumed energy and power	
need owner / energy management system (EMS)	Management entity	enables communication between flexibility device and need owner	
Energy Provider	Indirectly involved stakeholder	Entity that produces excess electric energy to be sold to customers.	

2.5 Capacity Sharing

2.5.1 Use Case Identification

Use Case Identification			
ID	**Domain(s)/Zone(s)**	**Name of Use Case**	**Target entity**
UC 1	• Domains: Distribution, DER, Customer • Zones: Field, Station, Operation,	Capacity Sharing	Community Customers

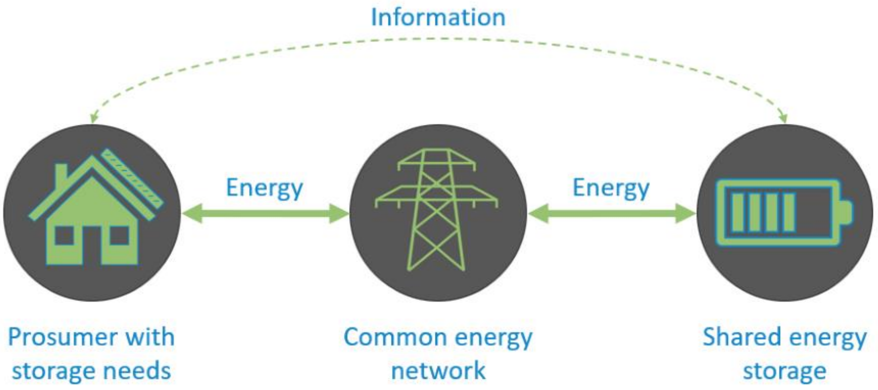
2.5.2 Scope and Objectives of Use Case

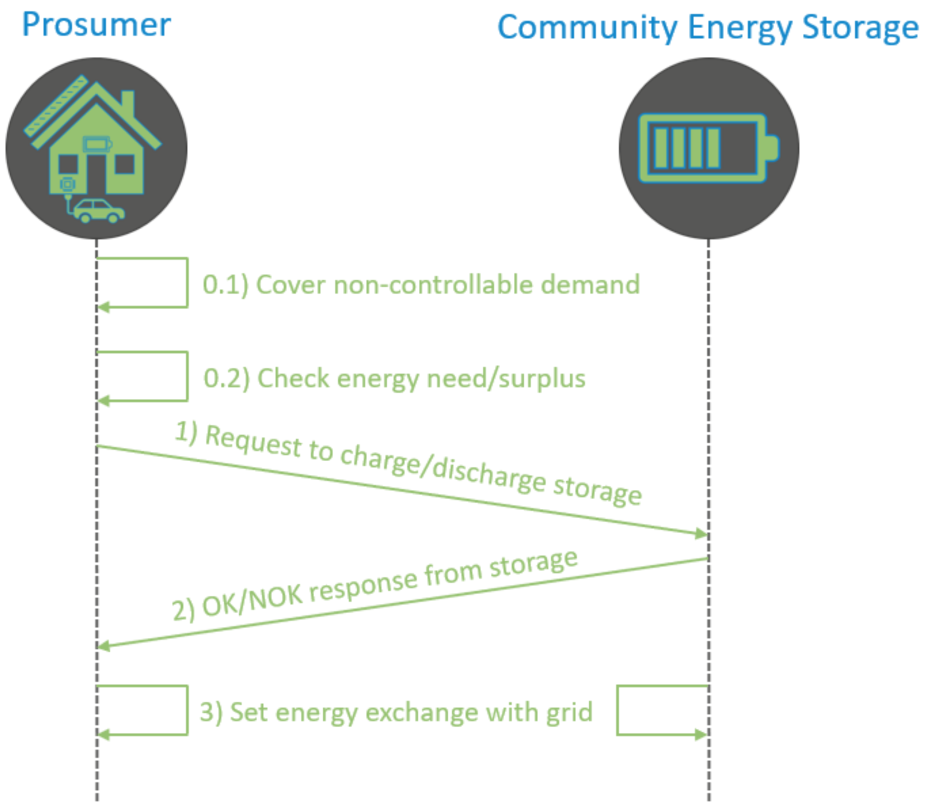
Objectives of Use Case	
Scope	Sharing of Community Storage
Type of Energy Community	CEC, REC
Objective(s)	Sharing Community Storage
Connected Use Cases	-

2.5.3 Narrative of Use Case

Narrative of Use Case
Short description
A large storage is being shared by community members to store energy. This can include electrical, thermal or chemical energy. With such a storage, excess energy that is produced by prosumers in the community can be stored and directly consumed or used to generate other useful forms of energy at a later point in time. The storage is placed in the community energy distribution grid to minimize losses in the transmission of the energy.
Complete description
A large energy storage system is being operated by the community or a member of the community to store excess energy. This helps to increase self-consumption of the energy that is being generated within the community. The Storage being provided can be financed by the community members that will be using it, or it can be owned by a central stakeholder that loans shares of the community storage to the community members. Who is accountable for the energy lost in the transmission process from the prosumer household to the battery needs to be defined.

2.5.4 Diagrams of Use Case

Functional Diagram of Use Case


Sequence Diagram of Use Case


2.5.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Charge Request	Request from community member to charge the portion of the storage that is assigned to the community member.
Discharge Request	Request from community member to discharge the portion of the storage that is assigned to the community member.
OK	Response from the storage signifying that it can be charged/discharged with requested power.
NOK – storage capacity	Response from the storage signifying that it cannot be charged/discharged further due to insufficient state of charge.
NOK – power limitation	Response from the storage signifying that it cannot be charged/discharged with requested power – but can with limited power.
NOK – other reason	Response from the storage signifying that it cannot be charged/discharged with requested power.

2.5.6 Relevant Actors

Actors			
Grouping		***Group Description***	
Communication partner		Entity taking part in the communication process.	
Management entity		Actor that manages a part of the use case.	
Controller		Controller that can activate a certain device or behaviour.	
Settlement Responsible		Infrastructure Operator responsible for settlement of energy exchange	
Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Prosumer Household Management	Management entity	System managing the own consumption of electrical energy generated within the household	Sends requests to community storage
Storage Management System	Management entity	System managing available storage capacity for each of the members	Charges/discharges if requested
Storage Operator	Settlement Responsible	Operator of the storage responsible for settlement of exchanged energy and billing of users	Handles settlement & billing of storage users

2.6 Emergency Supply

2.6.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
UC 1	• Domains: Generation, Distribution, DER, Customer • Zones: Market, Enterprise, Field, Process, Operation	Emergency Supply	House owner, landlord, etc.

2.6.2 Scope and Objectives of Use Case

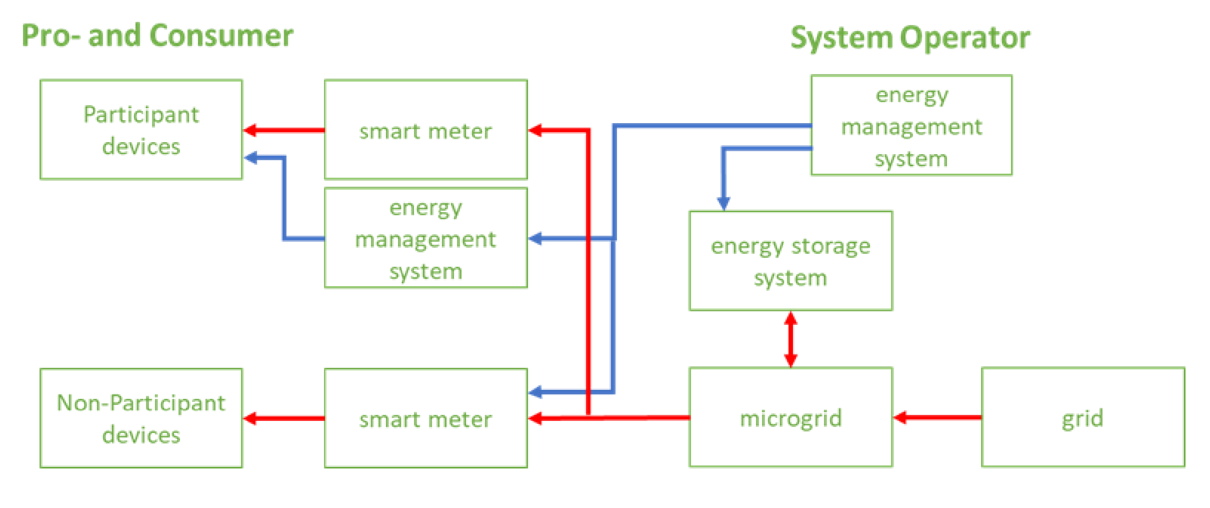
Objectives of Use Case	
Scope	Emergency Supply
Type of Energy Community	REC, CEC
Objective(s)	Ensure power supply in the event of a blackout for various (partly controllable) pro- and consumers in a microgrid with a community energy storage system
Connected Use Cases	

2.6.3 Narrative of Use Case

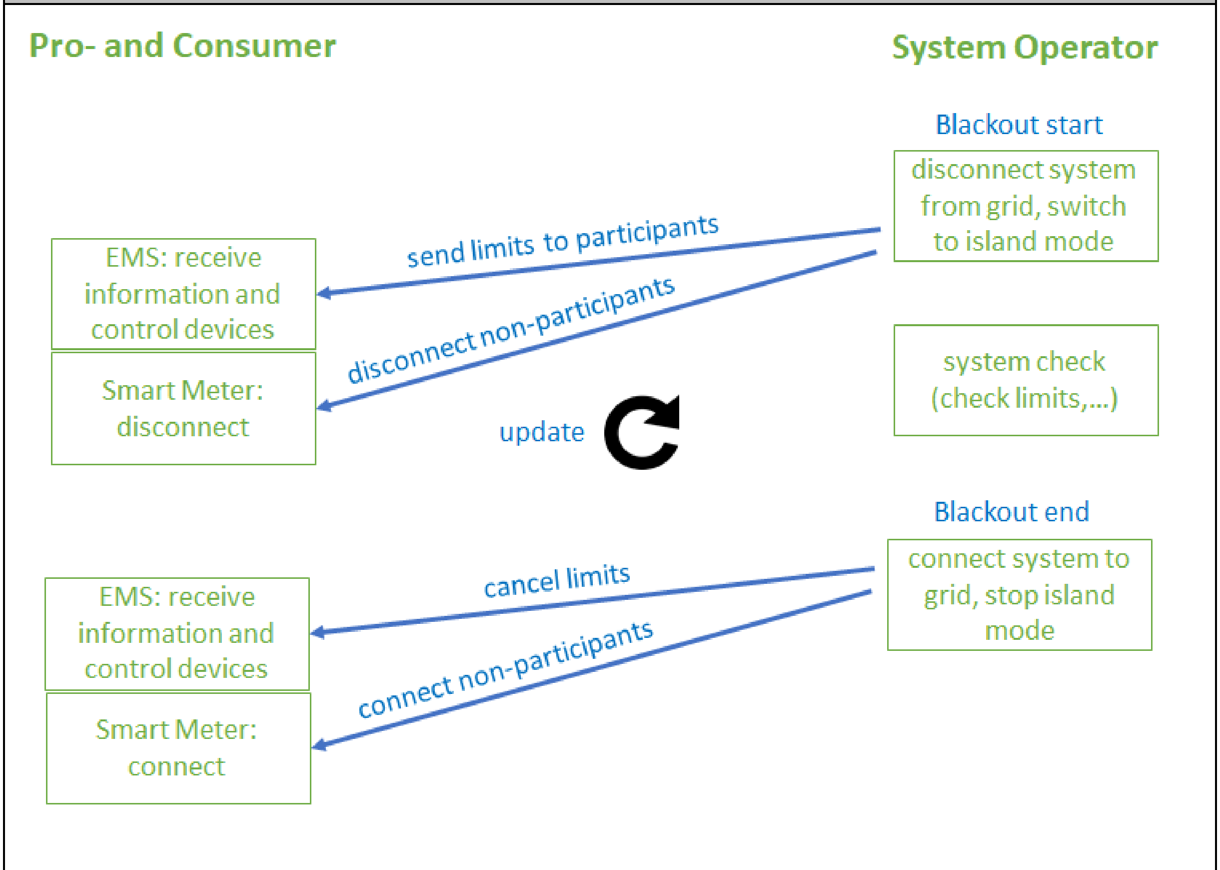
Narrative of Use Case
Short description
In the event of a blackout the microgrid – with various (partly controllable) pro- and consumers and a community energy storage system - will be disconnected from the grid, island mode will be switched on. During the blackout only active community participants will be supplied with a certain/limited capacity to ensure a stable emergency supply, considering the available capacity within the microgrid. At the pro- and consumers an energy management system will ensure the capacity limits. Non-members will be disconnected from the grid e.g. by using the Smart Meter breaker function.

2.6.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



2.6.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Send limits to participants	send the maximum available capacity for the pro-/consumer to the EMS of the pro-/consumer, which has to ensure this limit with control-based demand response (see Use Case control based demand response)
disconnect non-participants	Try to disconnect non participants from the microgrid e.g. by using the Smart Meter breaker function
update	update power limits and check, if every pro-/consumer meets its limit
cancel limit	after the end of a blackout the power limits will be canceled
connect non-participants	after the end of a blackout try to reconnect non participants to the microgrid

2.6.6 Relevant Actors

Actors			
Grouping		***Group Description***	
Communication partner		Entity taking part in the communication process.	
Management entity		Actor that manages a part of the use case.	
Controller		Controller that can activate a certain device or behaviour.	
Communication infrastructure		Communication infrastructure needed for transmitting information on energy needs/provisions.	
Meter		Metering equipment required for settlement process.	
Indirectly involved stakeholder		Stakeholder that is affected but not directly involved in the trading process	
Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
owner of device	Communication partner	entity that owns device	

device	Controller	consumes or feed-in energy, communicates directly or via EMS with need-owner	
energy management system (EMS)	Management entity	enables communication between device and system operator (can also be part of the device)	
Energy Meter	Meter	metering of generated/consumed energy and power, with breaker function	
system operator / energy management system (EMS)	Management entity	enables communication between device and system operator	
Energy Provider	Indirectly involved stakeholder	Entity that produces excess electric energy to be sold to customers.	
community energy storage system	Controller	consumes or feed-in energy, communicates directly or via EMS with need-owner	

2.7 Network Security

2.7.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
UC 1	• Domains: Distribution, DER, Customer • Zones: Enterprise, Operation, Station, Field, Process	Network Security	DSO, EC operator

2.7.2 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Detect anomalous system behaviour due to system malfunctioning or deliberate attacks.
Type of Energy Community	REC, CEC

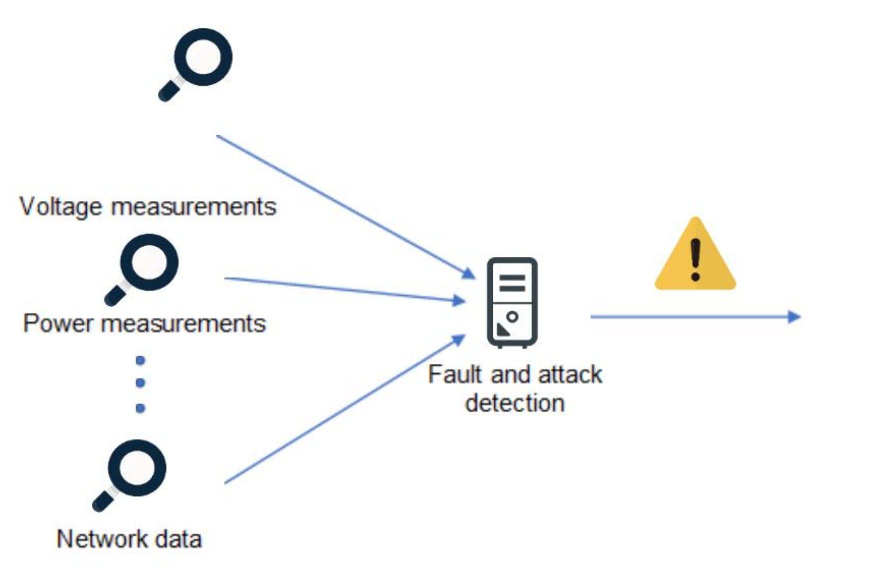
Objective(s)	• Ensure smooth and reliable operation of ECs • Fast detection and recovery from faults and attack
Connected Use Cases	

2.7.3 Narrative of Use Case

Narrative of Use Case
Short description
The anomaly detection system will consider different kinds of available information like raw or aggregated network data, measurement data or system status information to determine in a first step the normal system behaviour or patterns of abnormal behaviour caused by cyber-attacks or system faults. This information will be detect abnormal behaviour and classify system pertubations.
Complete description
Collect and analyse different kinds of available system information like network traces, measurement data, set points, etc. to define normal system behaviour and being able to identify anomalous system behavior.

2.7.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case

2.7.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Measurement data	Measurement of voltage, power, etc in relevant parts of the system
System status	Position of breakers, tap changers, etc
Network traffic data	Raw of aggregated network traffic (IP packets, flow information,...)
Extracted features	Features extracted from the raw input data that are relevant for anomaly detection.
Feature batches	Collection of features in a defined time period
Alarm	Indication of a detected anomaly

2.7.6 Relevant Actors

Actors	
Grouping	***Group Description***
Communication partner	Entity taking part in the communication process.
Management entity	Actor that manages a part of the use case.
Controller	Controller that can activate a certain device or behaviour.

Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Distribution Sensor	Communication partner	A device that measures a physical quantity and converts it into a signal.	Measurements can be used to identify abnormal system states.

Distribution Management System (DMS)	Communication partner, controller	A suite of application software that supports electric system operations including energy communities.	DMS is essential for the external control of the EC and could be a target of attacks.
Customer Energy Management System	Communication partner	An application service or device that communicates with devices in the home. It will receive set points from the DMS	CEMS are residing in the customer domain and can thus not be considered to be trusted. They can be source as well as target of attacks.

2.8 Energy Account | Community Currency

2.8.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
	• Domains: Transmission, Distribution, DER, Customer • Zones: Market, Enterprise, Operation, Station, Field, Process	Energy Account | Community Currency	Community Consumers REC CEC

2.8.2 Scope and Objectives of Use Case

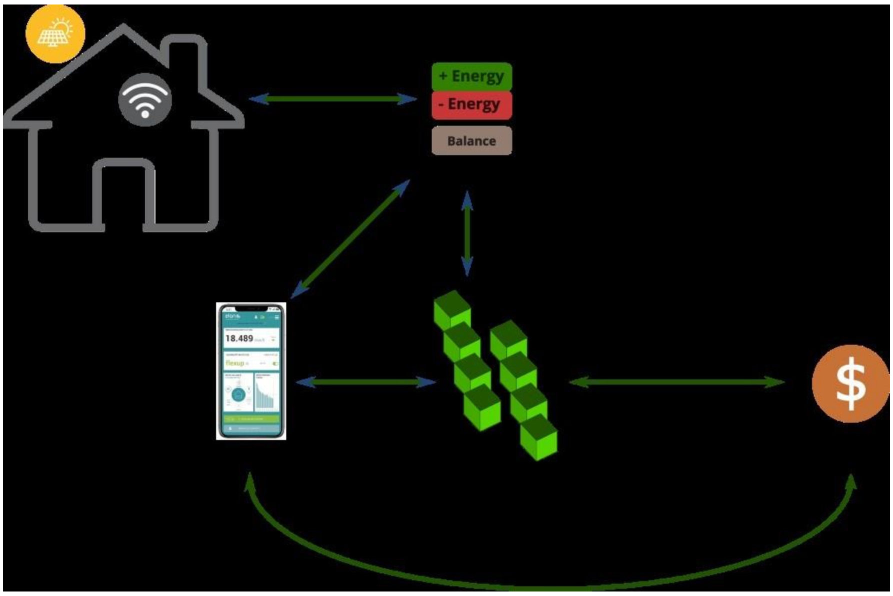
Objectives of Use Case	
Scope	Community consumers can use their community currency to pay for various services offered within the energy community and by 3rd parties.
Type of Energy Community	REC / CEC
Objective(s)	Strengthen the local economy, community building, increase benefits within the energy community and reducing operational cost to a minimum.
Connected Use Cases	

2.8.3 Narrative of Use Case

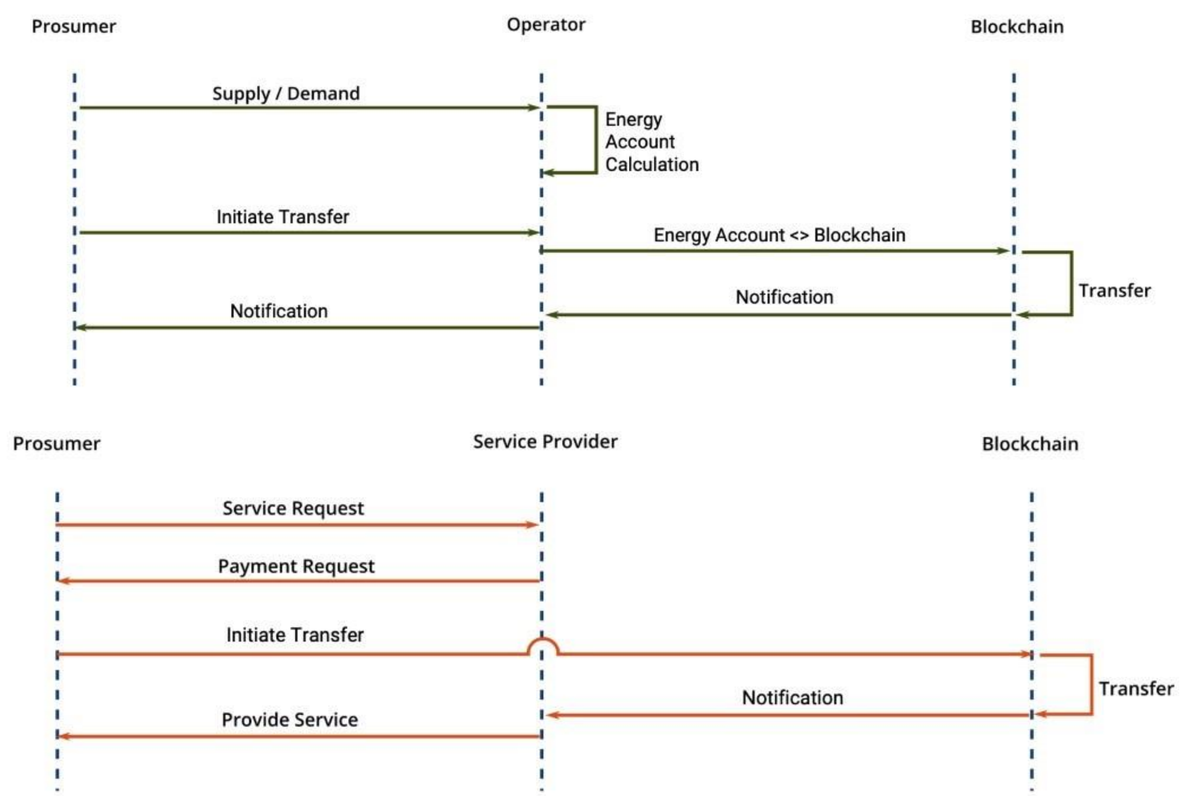
Narrative of Use Case
Short description
Energy communities are by definition non-profit organizations exchanging energy among its members. Generated energy, that is accounted by a community operator, can be expressed as a virtual community currency to be used for payments of goods and services.
Complete description
Energy communities are by definition non-profit organizations exchanging energy among its members. Independent whether it is a REC or CEC, the use of Community Currencies will increase the attractiveness of energy communities by enabling the payment of goods and services benefiting the community members, while reducing potential capital outflows when using a national currency. This works in a similar way as it is known from customer loyalty programs (e.g. frequent flyer programs like Miles-and-More), where someone can collect 'Miles' and exchange them for various goods and services. In the case of a community currency it starts with an energy account maintained by the operator of the energy community, which reflects the production and consumption of energy. To reduce hardware integration cost and scalability issues of centralized systems, the community members can now withdraw their 'Points' (e.g. PWR coin) to a blockchain system, in order to make them easily and safely transferable in the form of a blockchain token. Because blockchain token are programable, all properties – e.g. transferablility or validity, can be defined in line with national regulation and the goals of the energy community. Consequently, the use of these blockchain token can be shaped in a way the energy community members can benefit the most, while it also opens a way to provide added value to non-members. It is up to the energy community if they can and want also to allow depositing blockchain token back to the energy account or if they have to be spent, once they are withdrawn. Furthermore, an exchange into the national currency can be offered as a service from banks or entities interested to use the community currency to buy the offered goods and services.

2.8.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



2.8.5 Exchanged Information

Exchanged Information	
Type	**Information Description**
Energy Information	Power production and consumption
Billing Information	Price for provided services
Transfer Information	Blockchain activity w/ and w/o database interaction

2.8.6 Relevant Actors

Actors			
Grouping		**Group Description**	
Prosumer		Members of the energy community	
Operator		Operator of community – providing software and hardware services for community members	
Service Provider		Provider of 3rd party services, i.e. a regional business selling goods or services, not a member of the energy community	
Validators		Validators are running the software for the blockchain system and assure its integrity and the processing of transactions.	
Actor Name	**Actor Type** *cf. Grouping*	**Actor Description**	**Further information** *specific to this Use Case*
Energy Community App	Prosumer	Community customer who can pay for services via the Wallet App. Customer is connected to the system via dedicated device (energy account app).	
Energy Account	Operator	System generating and providing all the billing information (prices, sold goods or service, ..). The system is owned/operated by the community operator.	
Wallet App	Prosumer, Service Provider	Community customer uses a digital wallet app to pay service providers, utilizing a public blockchain system.	
Blockchain	Validators	Validators automatically process all transactions which are in line with the software protocol and make the result publicly available.	

3 COUNTRY-SPECIFIC USE-CASES

3.1 Austria

3.1.1 Use Case AT1- Local Self Optimization with control-based DR

3.1.1.1 Scope and Objectives of Use Case

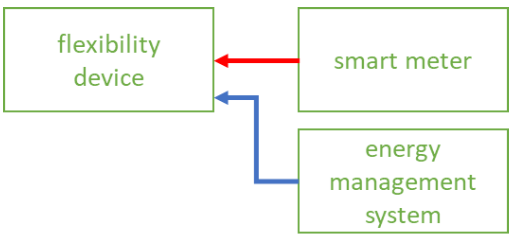
Objectives of Use Case	
Scope	Local Self Optimization with control-based DR
Type of Energy Community	REC, LEC
Objective(s)	activate flexibilities by means of direct access to the device
Connected Use Cases	Control-based DR

3.1.1.2 Narrative of Use Case

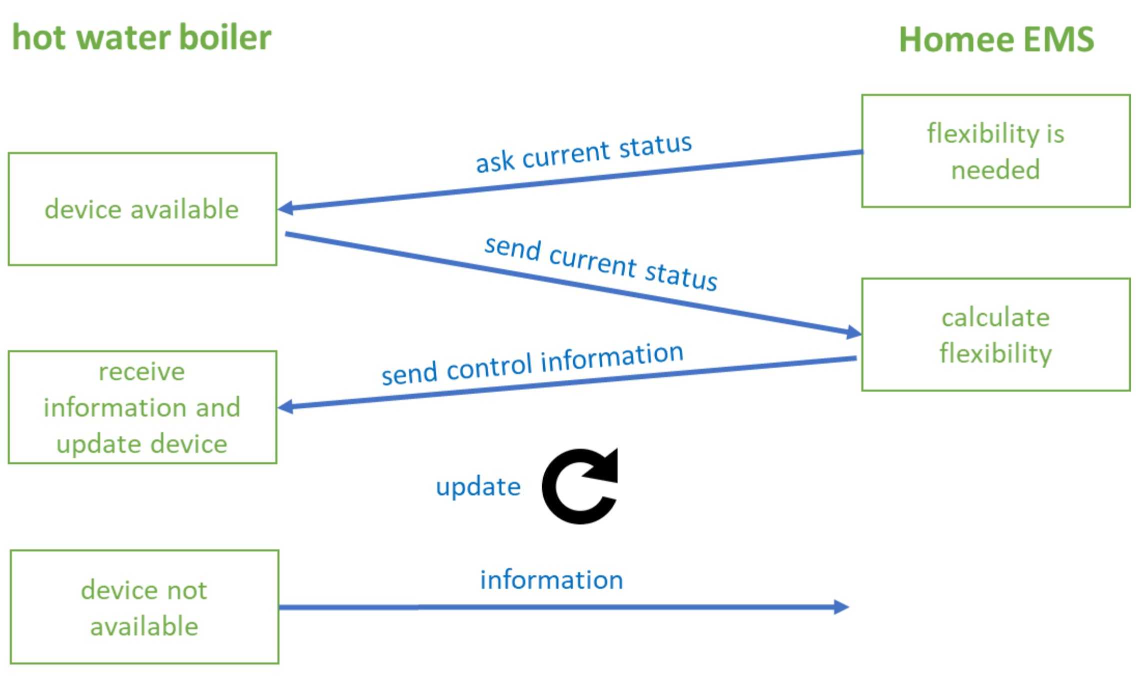
Narrative of Use Case
Short description
First of all prosumer will use their own PV generation to cover their local consumption. If an EMS is available, flexibilities (mainly hot water boiler) can be used to increase the share of self consumption (only active prosumers).

3.1.1.3 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



3.1.1.4 Exchanged Information

Exchanged Information	
Type	***Information Description***
ask current status	ask the current status of the flexibility device to calculate the flexibility potential
send current status	Send the current status of the flexibility device
send control information	send binding control information to the flexibility device (or control flexibility device in another way)

3.1.1.5 Relevant Actors

Actors	
Grouping	***Group Description***
Communication partner	Entity taking part in the communication process.
Management entity	Actor that manages a part of the use case.
Controller	Controller that can activate a certain device or behavior.
Communication infrastructure	Communication infrastructure needed for transmitting information on energy needs/provisions.

Meter	Metering equipment required for settlement process.
Indirectly involved stakeholder	Stakeholder that is affected but not directly involved in the trading process

Actor Name	***Actor Type*** cf. Grouping	***Actor Description***	***Further information*** specific to this Use Case
owner of flexibility device	Communication partner	entity that owns flexibility device	
flexibility device	Controller	consumes or feed-in energy, communicates directly or via EMS with need-owner	
energy management system (EMS)	Management entity	enables communication between flexibility device and need owner (can also be part of the flexibility device)	
Energy Meter	Meter	metering of generated/consumed energy and power	
need owner / energy management system (EMS)	Management entity	enables communication between flexibility device and need owner	
Energy Provider	Indirectly involved stakeholder	Entity that produces excess electric energy to be sold to customers.	

3.1.2 Use Case AT2 - Grid Support and Energy Trading with control-based DR

3.1.2.1 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Energy Sharing in/between (Renewable/Citizen) Energy Communities
Type of Energy Community	REC (CEC)
Objective(s)	Optimal distribution of surplus energy within an Energy Community and between Energy Communities, also using DR

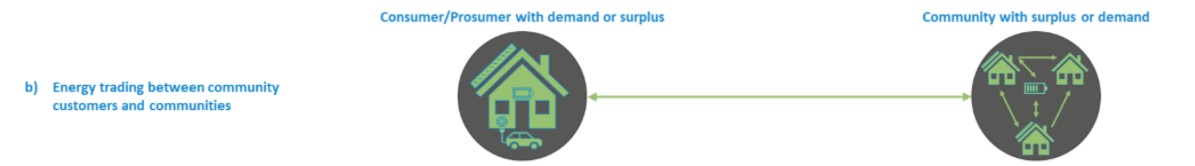
Connected Use Cases	Energy Trading Control-based demand response

3.1.2.2 Narrative of Use Case

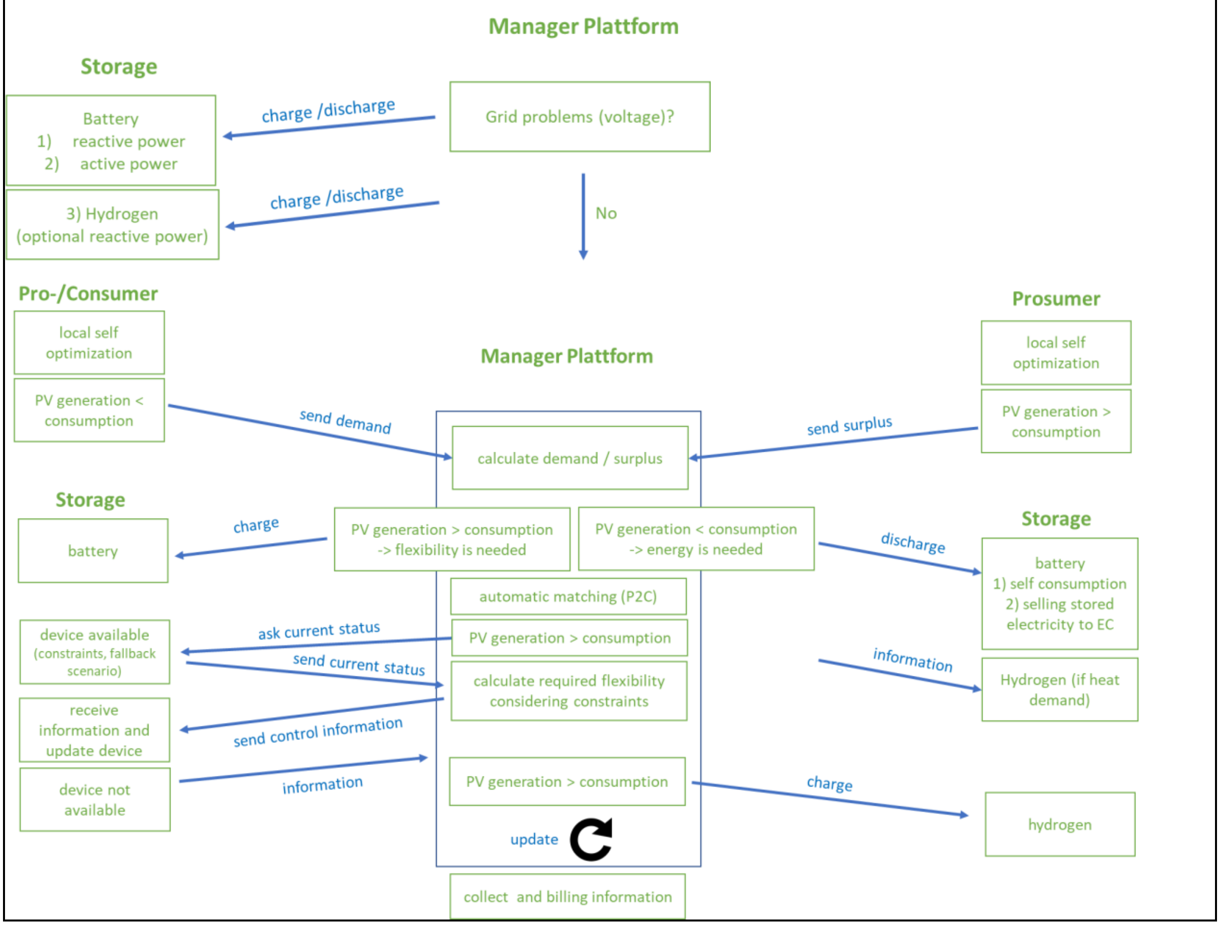
Narrative of Use Case
Short description
Simple energy sharing/trading between community customers and communities. Information about demand and surplus (including prices) are provided to the settlement system, which calculates a matching between customers and provides the billing information.
Complete description
Customers or communities with surplus will sell their energy to customers or communities with demand (controllable devices, storage systems are not considered). The sequence/structure of the use case is equal in case of customers or communities participating at the trading/sharing system. Customers or communities provide information about their demand and surplus to a settlement system. This system will calculate a matching based on the customer/community information (and preferences) and will calculate the settlement. The bill is provided to each customer/community. A customer could be a simple consumer, producer, prosumer, battery, or other energy community (REC). If the PV generation in the community exceeds the consumption, the following actions will executed: • First of all the battery storage systems will be charged and the consumption of community will be covered • If there is still PV generation left, flexibilities from active pro- and consumers will be activated (Control-based DR). • Finally, the PV surplus will be stored as hydrogen. If the consumption in the community exceeds the PV generation, first the battery storage will be discharged (up to a certain limit), after that the hydrogen storage (if there is heat demand). The usage of flexibilities of active pro- and consumers is not planned at the moment.

3.1.2.3 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



3.1.2.4 Exchanged Information

Exchanged Information	
Type	***Information Description***
send demand / surplus	Community participants send their demand / surplus
ask current status	ask the current status of the flexibility device to calculate the flexibility potential

send current status	send the current status of the flexibility device
send control information	send binding control information to the flexibility device (or control flexibility device in another way)
charge / discharge	Send command to charge / discharge battery and/or hydrogen storage

3.1.2.5 Relevant Actors

Actors	
Grouping	***Group Description***
Customer	Customers can be consumers, producers, prosumers, storage devices, CECs, RECs.
Operator	Operator of community – providing software and hardware services for community members
Communication partner	Entity taking part in the communication process.
Management entity	Actor that manages a part of the use case.
Controller	Controller that can activate a certain device or behavior.
Communication infrastructure	Communication infrastructure needed for transmitting information on energy needs/provisions.
Meter	Metering equipment required for settlement process.
Indirectly involved stakeholder	Stakeholder that is affected but not directly involved in the trading process

Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Customer device	Customer	Community customer which can participate in energy trading/sharing processes. Customer is connected to the system via dedicated device (e.g., EMS with connection to community).	
Accounting/ Settlement System	Operator	System collecting all customer information, creating matchings between surplus and demand, creating the bill, sending out	

owner of flexibility device	Communication partner	billing information to customers. The system is owned/operated by the community (operator) entity that owns flexibility device	
flexibility device	Controller	consumes or feed-in energy, communicates directly or via EMS with need-owner	
energy management system (EMS)	Management entity	enables communication between flexibility device and need owner (can also be part of the flexibility device)	
Energy Meter	Meter	metering of generated/consumed energy and power	
need owner / energy management system (EMS)	Management entity	enables communication between flexibility device and need owner	

3.1.3 Use Case AT3 - Charging payment with community currency

3.1.3.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
AT3	• Domains: Transmission, Distribution, DER, Customer • Zones: Market, Enterprise, Operation, Station, Field, Process	EV-charging payment with community currency	Community Consumers (= Energy account holders) REC CEC

3.1.3.2 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Community Consumers can pay for EV – charging at community operated charging infrastructure with a community currency. This currency is generated based on energy generation in an energy account application and transferred to a digital wallet app, where it can be used as a cryptocurrency for payments.
Type of Energy Community	REC (CEC)
Objective(s)	Generate a monetary incentive to participate in energy communities
Connected Use Cases	

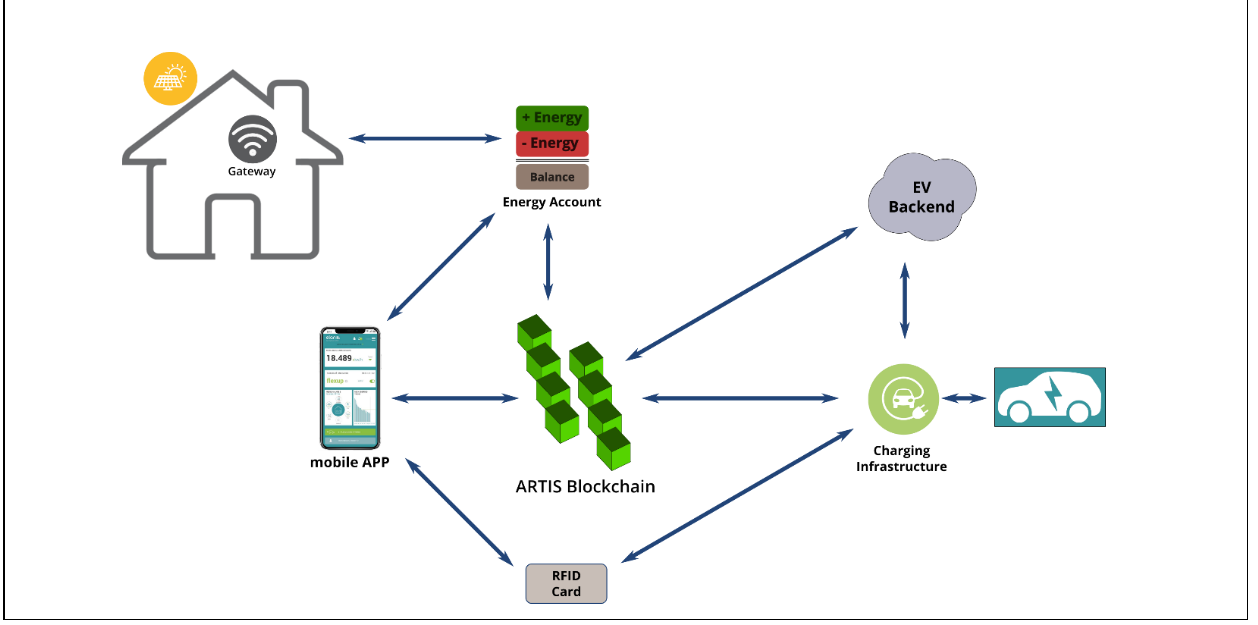
3.1.3.3 Narrative of Use Case

Narrative of Use Case
Short description
The energy account is a business model (service) for energy community members. Their energy generation and energy consumption is recorded and documented in the energy account, using a normalized energy unit (e-kWh). Once the e-kWh are converted to a community currency on the member's blockchain account that will be used to pay for EV-charging at a community owned charging station.
Complete description
The energy account is a software service that allows the users to integrate all their energy expenses and energy services and access them with an energy community app on the smartphone. This will help the Community Consumer to easily follow all of their energy consumption (electric, heat, mobility, ...) and energy generation (i.e. grid feed-in or supply to other EC members) in the mobile energy community app. The Community Consumer's energy balance between consumed energy and feed-in energy is kept track and displayed in a normalized unit, i.e. weighted in respect to different energy costs, which is called e-kWh. Every Community Consumer can decide to use these e-kWh for EV-charging in the form of a blockchain-secured community currency and manage it via a digital wallet app. The Community Customer will be guided through an on-boarding process to define his/her unique identity and provide the blockchain address for the transfer of e-kWh community currency. The energy community app is linked with the digital wallet and allows a quick login to the energy account and the configuration of e-kWh transfers from the database to the Community Consumers digital wallet account. ECs can provide a blockchain enabled EV - charging infrastructure to their respective community members and they can use their

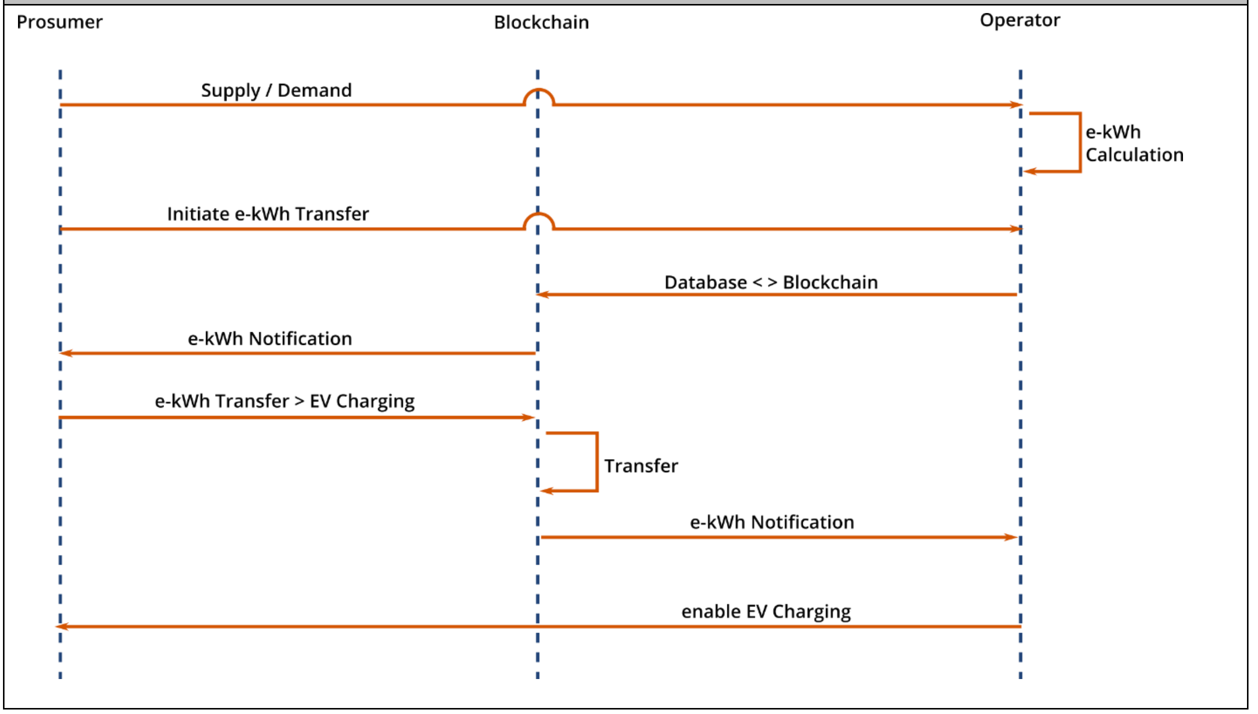
digital identity and e-kWh community currency to schedule, authenticate and pay for at these charging stations, utilizing the energy community app and the digital wallet app. Furthermore, it is possible to pay with a blockchain RFID card from the blockchain account without any necessity to use the digital wallet app.

3.1.3.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



3.1.3.5 Exchanged Information

Exchanged Information	
Type	**Information Description**
Energy Information	Charge data record: charging time, charged energy amount, charging power
Billing Information	Charging tariff, charged energy, cost in e-kWh

3.1.3.6 Relevant Actors

Actors			
Grouping		**Group Description**	
Customer		Customers are members of the energy community	
Operator		Operator of community – providing software and hardware services for community members	
Validators		Validators are running the software for the blockchain system and assure its integrity and the processing of transactions.	
Actor Name	**Actor Type** *cf. Grouping*	**Actor Description**	**Further information** *specific to this Use Case*
Energy Community App	Customer	Community customer who can pay for charging at community charging infrastructure. Customer is connected to the system via dedicated device (energy account app)	
EV-backend	Operator	System collecting all charging information (time, energy, power ...). The system is owned/operated by the community (operator)	
EV-billing	Operator	System generating and providing all the billing information (tariff, charge data records...). The system is owned/operated by the community (operator)	
Wallet App	Customer Operator	Community customer uses a digital wallet app to pay a service provider, utilizing a public blockchain system	
Blockchain	Validators	Validators automatically process all transactions which are in line with the software protocol and make the result publicly available.	

3.1.4 Use Case AT4 – Community currency payment at 3rd parties

Use Case Identification			
ID	**Domain(s)/Zone(s)**	**Name of Use Case**	**Target entity**
AT4	• Domains: Customer • Zones: Market, Enterprise, Operation, Station, Field, Process	Community currency payment at 3rd parties	Community Consumers (= Energy account holders) REC CEC

3.1.4.1 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Community Consumers can pay for services provided by 3rd parties (i.e. parties that are not in the EC), with a community currency. This currency is generated based on energy generation in an energy account application and transferred to a digital wallet app, where it can be used as a cryptocurrency for payments.
Type of Energy Community	REC (CEC)
Objective(s)	Generate a monetary incentive to participate in energy communities
Connected Use Cases	

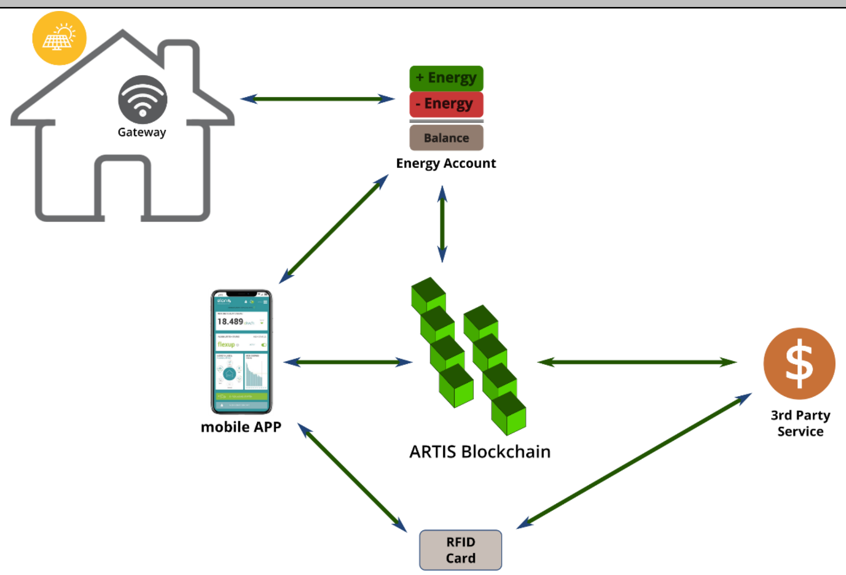
3.1.4.2 Narrative of Use Case

Narrative of Use Case
Short description
The energy account is a business model (service) for energy community members. Their energy generation and energy consumption is recorded and documented in the energy account, using a normalized energy unit (e-kWh). Once the e-kWh are converted to a blockchain-based community currency and transferred to the member's digital wallet app, it will be used to pay for services of 3rd parties, that are not within the EC.

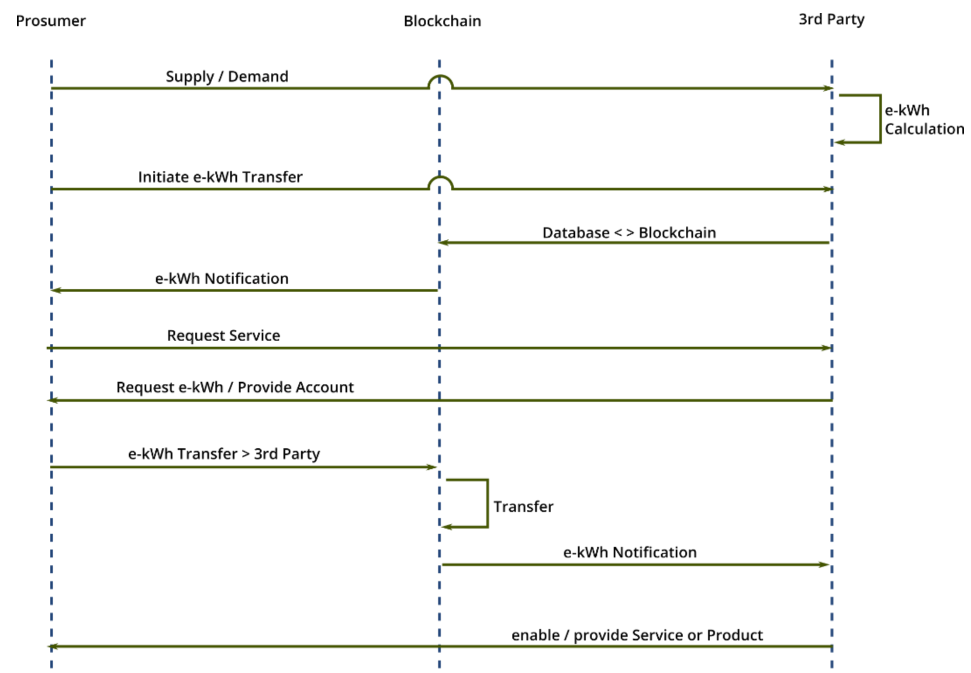
Complete description
The energy account is a software service that allows the users to integrate all their energy expenses and energy services and access them with an energy community app on the smartphone. This will help the Community Consumer to easily follow all of their energy consumption (electric, heat, mobility, ...) and energy generation (i.e. grid feed-in or supply to other EC members) in the mobile energy community app. The Community Consumer's energy balance between consumed energy and feed-in energy is kept track and displayed in a normalized unit, i.e. weighted in respect to different energy costs, which is called e-kWh. Every Community Consumer can decide to use these e-kWh for 3rd party services in the form of a blockchain-secured community currency and manage it via a digital wallet app. The Community Customer will be guided through an on-boarding process to define his/her unique identity and provide the blockchain address for the transfer of e-kWh community currency. The energy community app is linked with the digital wallet and allows a quick login to the energy account and the configuration of e-kWh transfers from the database to the Community Consumers digital wallet account. These community e-kWh can be seen similar to regional currencies and can be used to pay for goods / services within a regional economy. Third parties (local businesses, coffee and grocery shops, ...) can participate in this regional economy and accept community e-kWh as currency for their goods or services. They can use a simple QR-code or a digital wallet to provide their account address, where they want to receive the community e-kWh's. If third parties want to enable their customers also the payment with a blockchain-enabled RFID card, they will provide an RFID reader based system, capable to generate a blockchain transactions. This solution enables also not so technical people to handle the community currency in a safe way and use it for payments.

3.1.4.3 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



3.1.4.4 Exchanged Information

Exchanged Information	
Type	***Information Description***
Billing Information	Amount and description of goods or services, prices, amount of charged community e-kWh
Energy Information	Amount of generated and consumed energy, tracked as e-kWh in the energy account

3.1.4.5 Relevant Actors

Actors	
Grouping	***Group Description***
Customer	Customers are members of the energy community
Service Provider	Provider of 3rd party services, i.e. a regional business selling goods or services, not a member of the energy community
Validators	Validators are running the software for the blockchain system and assure its integrity and the processing of transactions.
Operator	Operator of community – providing software and hardware services for community members

Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Energy Community App	Customer	Community customer who can pay for charging at community charging infrastructure via the Wallet App. Customer is connected to the system via dedicated device (energy account app)	
Energy Account	Operator	System generating and providing all the billing information (prices, sold goods or service, ..). The system is owned/operated by the community (operator) and provides an interface for 3rd parties to connect to.	
Wallet App	Customer Service Provider	Community customer uses a digital wallet app to pay a service provider, utilizing a public blockchain system	
Blockchain	Validators	Validators automatically process all transactions which are in line with the software protocol and make the result publicly available.	

3.2 Germany

3.2.1 Use Case GER1 - Thermal Energy Trading

3.2.1.1 Use Case Identification

Use Case Identification			
ID	**Domain(s)/Zone(s)**	**Name of Use Case**	**Target entity**
GER1	• Domains: Generation, distribution, customer • Zones: Market, operation, process	Heat trading between community customers	Community customers

3.2.1.2 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Sharing of waste heat (and renewable heat) between customers of a local citizen / renewable energy community
Type of Energy Community	REC / CEC
Objective(s)	Increase the efficiency of the heating system by making waste heat of one community member available to other community members
Connected Use Cases	Parent use case: energy trading

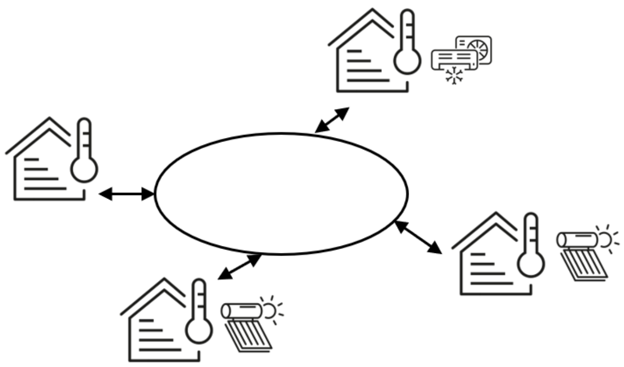
3.2.1.3 Narrative of Use Case

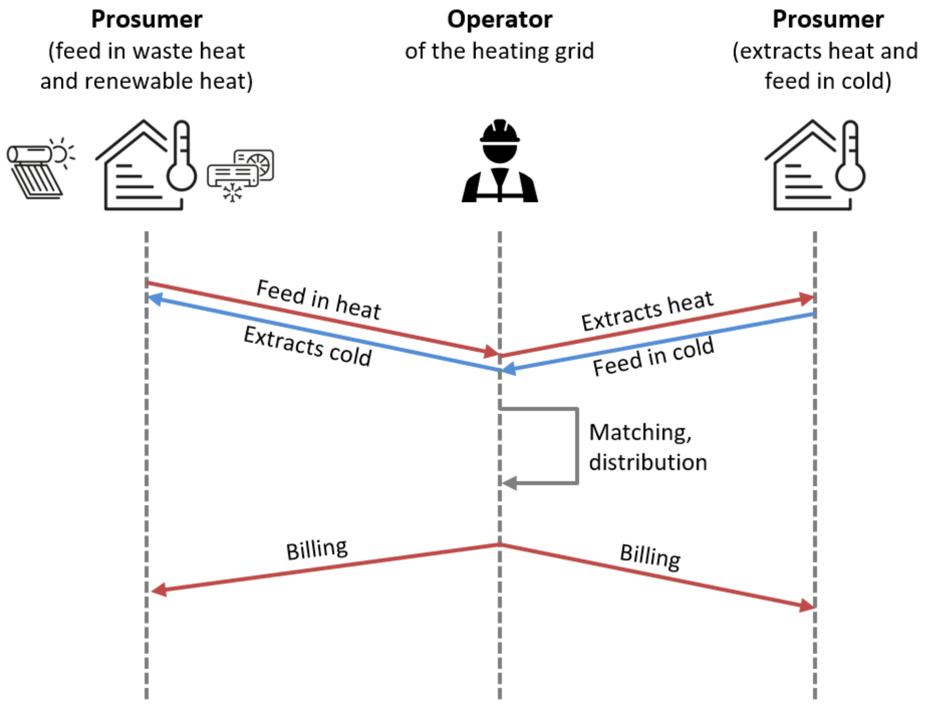
Narrative of Use Case
Short description
The members are connected to each other via a low-temperature heating network and exchange thermal energy. By using heat pumps to extract heat for heating purposes and cooling devices to extract cold for cooling purposes in a decentralised manner, thus feeding in cold and heat, synergy effects are created.

Complete description
All members of the local energy community are connected to each other via a cold heat network (e.g. with a flow temperature of 20 °C and a return temperature of 10 °C). The members extract heat as an energy source for a heat pump and thus reduce the temperature in the heat network. Members with cooling demand (supermarket all year round, offices, private buildings in summer) extract cold from the return flow of the heat network for direct cooling or as an energy source for a chiller (reversible heat pump) and feed back an increased temperature. Waste heat can also be provided from industrial processes. Furthermore, members of the LEC can feed in renewable heat from solar heating systems into the heat network. The possibility to feed in and take out heat and cold in a decentralized way results in a market place for the LEC. The particular advantage of exchanging heat is that waste heat from one member (e.g., from a refrigeration unit) is usable heat for another member (e.g., as an energy source for a heat pump). Thus, the overall efficiency can be increased by using the synergy effects.

3.2.1.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case

Remark: Some members of the thermal LEC act as prosumers and feed in heat or cold, but both types regard this as a benefit for them, therefore they are not paid for the heat or cold fed into the thermal grid. But some members feed in a large amount of heat and cover the remaining heat demand (e.g. also from waste heat sources), they will be paid for the heat

3.2.1.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Energy information	Customer information about the amount of heat or cold and the related temperature, which will be fed into the thermal grid in the next time step
Billing information	Information from the settlement system about the amount of heat and the temperature of the previous timestep.

3.2.1.6 Relevant Actors

Actors	
Grouping	***Group Description***
Customer	All actors which are connected to the thermal grid
Operator	Operator of the thermal grid (and exchange of thermal energy within the LEC)

Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Customer device	Customer	Community member that is connected to the heating network and feeds in or extracts heat or cold	
Accountin g / settlement system	Operator	Operator of the heating network who ensures a balance of the heat flows (hydraulics) and manages the financial flows.	

3.3 Scotland

3.3.1 Use Case SCOT1 - Sharing of Community Capacity

3.3.1.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
SCOT1	• Domains: Distribution, DER, Customer • Zones: *Station, Field, Process, Operation*	Capacity Sharing	Community customers

3.3.1.2 Scope and Objectives of Use Case

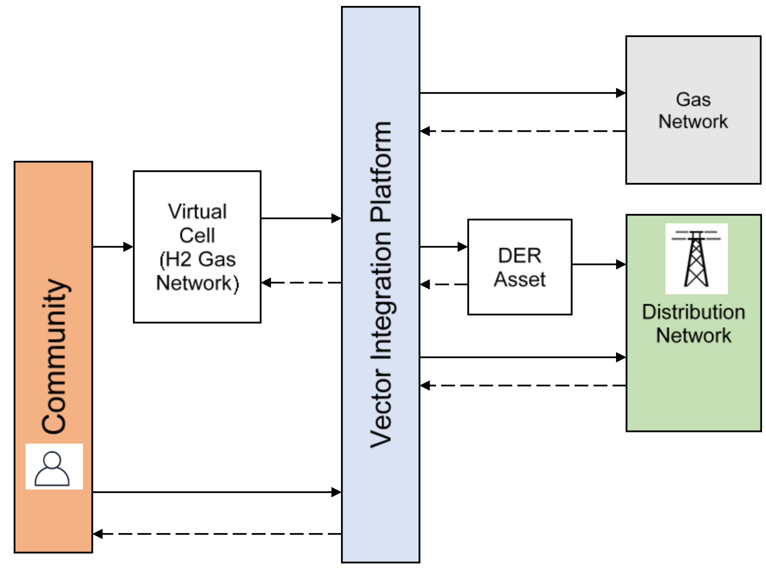
Objectives of Use Case	
Scope	Sharing of Community Capacity (via the VIP)
Type of Energy Community	REC, LEC
Objective(s)	To explore capacity sharing through energy storage and aggregated renewable generators within a local energy community in the UK. The Vector Integration Platform (VIP) developed within the project will built with the capability to share capacity of energy storage, and aggregated generation in the community and a virtual representation of the future hydrogen gas network for example Fife H100. This will aim to achieve the following objectives • Develop within the Vector Integration Platform (VIP) the functionality for the aggregation of physical and virtual energy storage assets and local generation in the community • Demonstrate a use case for Community Storage within the Fife community in the UK. This will cover the requirements to deliver services of storage via the VIP to customers the community. • Investigate the future functionalities of a green hydrogen virtual cell within the platform. This will be developed with considerations of the future hydrogen gas network in the Fife community.
Connected Use Cases	parent use case: Capacity Sharing

3.3.1.3 Narrative of Use Case

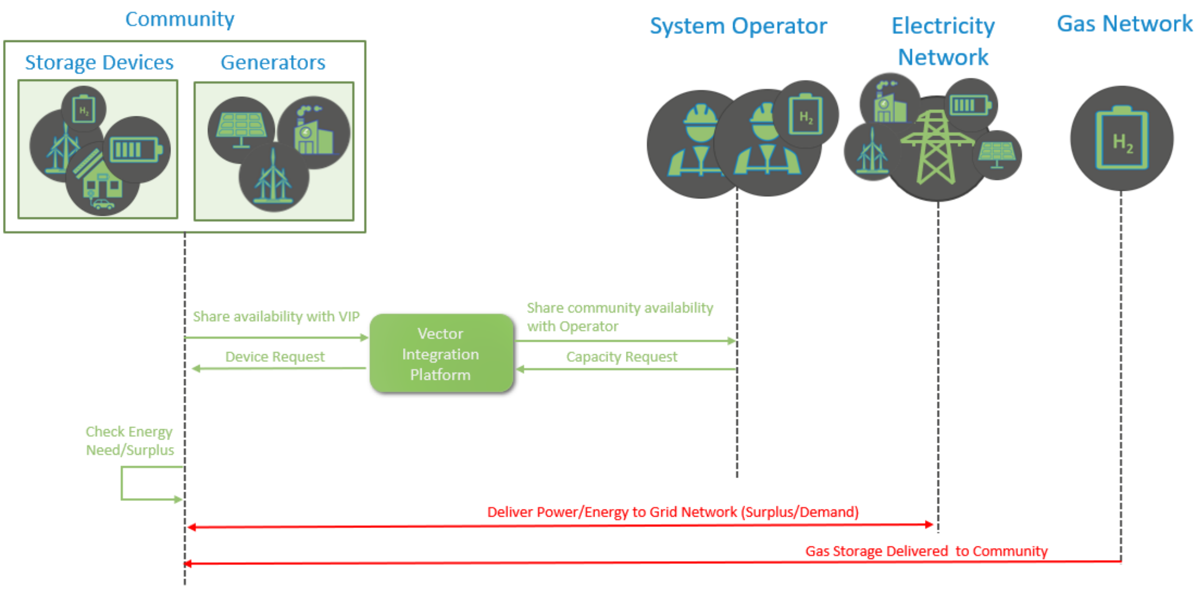
Narrative of Use Case
Short description
As part of the DER assets in the Fife UK community, energy storage (including green hydrogen) and renewable generators would be explored on how they can be used to better serve the local energy community. This will also investigate how to into integrate into the electricity network and a future gas network planned in the Fife UK community. The operation of these energy storage assets would be explored through the multi vector platform (VIP) that built to coordinate the operation of both electricity and gas energy vectors.
Complete description
This will demonstrate a use case for community storage in the local energy community considering the aggregation of 'physical and virtual cells' of energy storage within the VIP. For the physical cells, we will monitor available community energy storage assets onsite within Fife UK area and look at the possibilities for third party control. We will access real-time data (telemetry) streamed across to the VIP, as well as investigating the potential to use the VIP to control these assets for delivery of aggregated services. Smarter Grid Solutions Active Management Systems (ANM) would be deployed on some community assets within the Greener Kirkaldy region to make this possible. Currently considered community assets include: • 19.2 kW Solar PV connected with two 13.5kW Tesla Powerwall Batteries • A 7kW electric vehicle charging point This will also look at how best renewable generators in the area can better serve the community by local aggregation of their available capabilities to provide additional power/energy capacity requirements. For the virtual storage cells, this will focus on the production of "green hydrogen" through the electrolysis of water using low carbon generation sources producing hydrogen during times of excess renewable generation. A model of a hydrogen electrolyser will be implemented as part of the virtual cell based utilizing information from pre-existing hydrogen projects within ORE Catapult.

3.3.1.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



3.3.1.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Charge Request	Request from VIP to charge the community storage that connected to the distribution network.

Discharge Request	Request from VIP to discharge the community storage that connected to the distribution network.
Enable/Disable	Signal from the Storage, that it can be charged/discharged with requested power.
Power Limitation	Signal from the Storage, that it cannot dispatch requested power – but can with limited power.
Storage Capacity	Status of available storage capacity within the community

3.3.1.6 Relevant Actors

Actors			
Grouping		***Group Description***	
Controller		Controller that can activate a certain device or behaviour.	
Management entity		Managing automated procurement and distribution.	
Communication infrastructure		Communication infrastructure needed for transmitting information on energy needs/provisions.	
Actor Name	***Actor Type*** cf. Grouping	***Actor Description***	***Further information*** specific to this Use Case
VIP Management	Controller	Actor managing the control actions and interactions within all DER assets and virtual cells	
Prosumer Management System	Management entity	Actor managing the own consumption of electrical energy generated within the Electric vehicle charging stations	
Storage Management System	Management entity	Actor managing available storage capacity for within the community.	Charges/discharges if requested
Gas Management System	Management entity	Actor managing available energy in gas network via hydrogen that can be utilised by consumers.	
ANM Strata/ Element	Communication infrastructure	Enables communication between the customer, DER assets, virtual cells and distribution network, .	
System Operator	Management entity	Maintains the balance of supply and demand between the grid network and the community	

3.3.2 UseCase SCOT2 - Customer-based Demand Response

3.3.2.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
SCOT2	• Domains: Distribution, DER, Customer • Zones: Station, Field, Process, Operation	Demand Response	Electricity users, Electricity Generators, Energy Communities

3.3.2.2 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Demand Response – Customer Based
Type of Energy Community	REC, LEC
Objective(s)	To develop customer-based demand side response capability within the architecture of the web of cells and vector integration platform, This will explore the coordination of power demand and surplus within a community using active management systems utilizing physical and virtual DER assets in a grid network.
Connected Use Cases	Parent use case: customer based DR

3.3.2.3 Narrative of Use Case

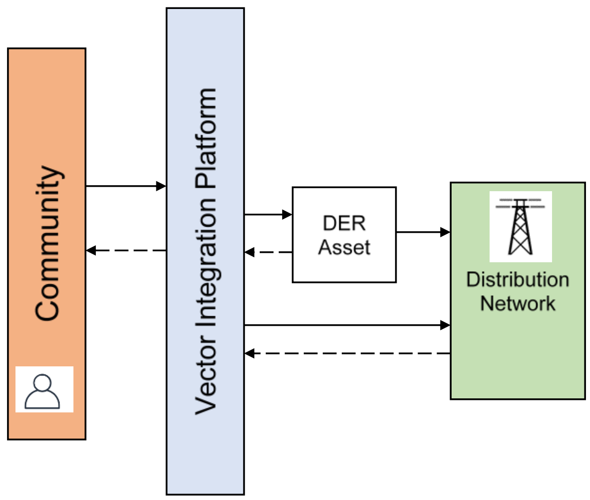
Narrative of Use Case
Short description
This use case explores a customer-based scenario for providing demand response service where the distributed energy resources (DER) within the community are able to provide services to the grid network systems operator. The use case would explore the coordination of physical cells (i.e. with DER assets) in the community and virtual cells (simulations) to represent a scenario for demand side response
Complete description
For the physical cells, we will monitor available community DER assets onsite within Fife UK area. This use case will capture the demonstration of this area within wider Vector Integration platform (VIP) design. We will access real-time data (telemetry) streamed across to the VIP, as well as investigating the potential to use the VIP to control these assets for delivery of aggregated services. Smarter Grid Solutions Active Management Systems (ANM) would be deployed on some community assets within the Greener Kirkaldy region to make this possible. DER assets that can't be physically demonstrated would be

represented by virtual cells with University of Strathclyde taking lead with the modelling. Both physical and virtual cells will operate under a web-of-cells optimizer which aims to select the optimal dispatch strategy for DER assets within a cell.

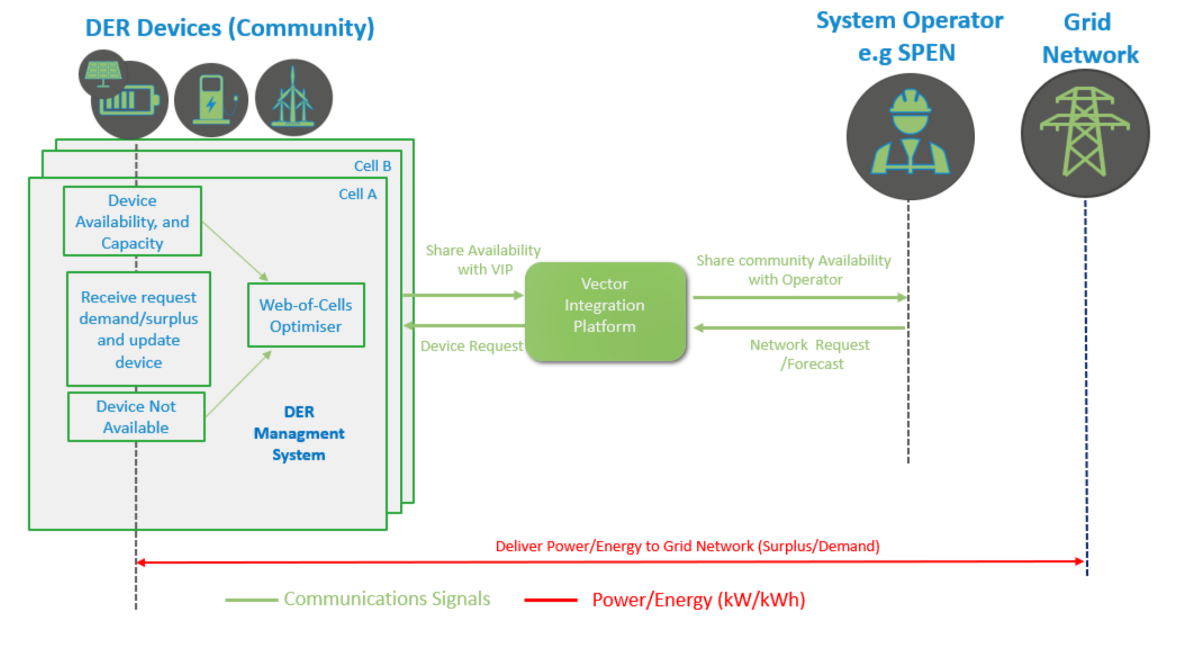
Currently considered community physical assets include:

- Levenmouth Demonstration Turbine in the Fife area in Scotland
- 19.2 kW Solar PV connected with two 13.5kW Tesla Powerwall Batteries
- A second Solar PV array (capacity tbc)
- A 7kW electric vehicle charging point

3.3.2.4 Diagrams of Use Case

Functional Diagram of Use Case


Sequence Diagram of Use Case



3.3.2.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Availability	Availability of the DER assets within community to provide requested demand/surplus through the vector integration platform.
Device Request	Requested energy (demand/surplus) from the vector integration platform to the community DER assets.
Network Request	Requested energy (demand/surplus) from the electricity network operator to the vector integration platform to the community based in network requirements
Energy Delivered	Customer information about its energy surplus/demand in kWh for the next timestep
DER Capacity	Available capacity within the DER assets in the community.
WoC Strategy	Operational dispatch strategy of the web-of-cells optimiser

3.3.2.6 Relevant Actors

Actors	
Grouping	***Group Description***
Management entity	Actor that manages a part of the use case.

Controller	Controller that can activate a certain device or behaviour.
Communication infrastructure	Communication infrastructure needed for transmitting information on energy needs/provisions.

Actor Name	***Actor Type*** cf. Grouping	***Actor Description***	***Further information*** specific to this Use Case
System Operator	Management entity	Maintains the balance of supply and demand between the grid network and the community	
DER Management	Management entity	Manages the operation of DER assets within community exploring optimal strategies to dispatch assets between cells whilst updating the Vector Integration Platform on the energy availability	
VIP Management	Controller	Actor managing the control actions and interactions within all DER assets	
ANM Strata/ Element	Communication infrastructure	Enables communication between the customer, DER assets, virtual cells and distribution network.	
System Operator	Management entity	Maintains the balance of supply and demand between the grid network and the community	

3.3.3 Use Case SCOT3 - Energy Trading

3.3.3.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
SCOT3	• **Domains:** Generation, Distribution, DER, Customer • **Zones:** Market, Enterprise, Field, Process, Operation	Energy Trading	Electricity users, Electricity Generators (Energy Communities)

3.3.3.2 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Access to community energy trade markets
Type of Energy Community	REC, LEC
Objective(s)	Providing the energy community access to the market to facilitate the trading of energy
Connected Use Cases	parent use case: Energy trading

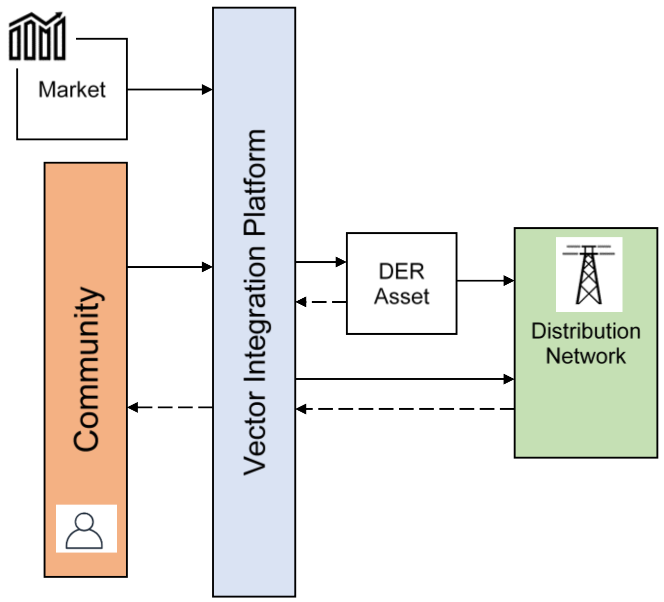
3.3.3.3 Narrative of Use Case

Narrative of Use Case
Short description
This use case explores trading scenarios between energy communities with the focus on building the capability within the vector integration platform (VIP) to access current and future community energy trade markets. Possible scenarios that would be explored to work with the VIP are: • Peer – Peer • Peer – community – peer • Peer – community – generator (sale of flexibility alongside energy) • Peer – community – Market Operator
Complete description
Customers in a community will be grouped into cells based on the energy they produce/consume (prosumers) and the DER assets located within the cell area. The capability of the VIP to provide access to energy trade markets would then be explored based on the following scenarios. • **Peer – Peer:** This will cover trading flexibilities within a cell with the use of smart metering, potentially alongside storage and/or control equipment, to enable properties generating net surplus generation from onsite microgeneration to sell their energy in real time to other energy users behind the same primary substation. • **Peer – Community – Peer:** This will cover both trading within a cell and between cells. The VIP can act as community aggregator to facilitate local peer to peer co-ordination of the energy trading markets. • **Peer – Community – Generator trading (including flexibility):** This will cover both trading within a cell and between cells with a focus on where a constrained generator pays local users to flex their demand in order to maximize headroom for increased local generation. The VIP in this case, may act as community aggregator to facilitate trades. Energy Community could also act as end deliverer of flexibility, e.g. via flexible charging for car club cars.

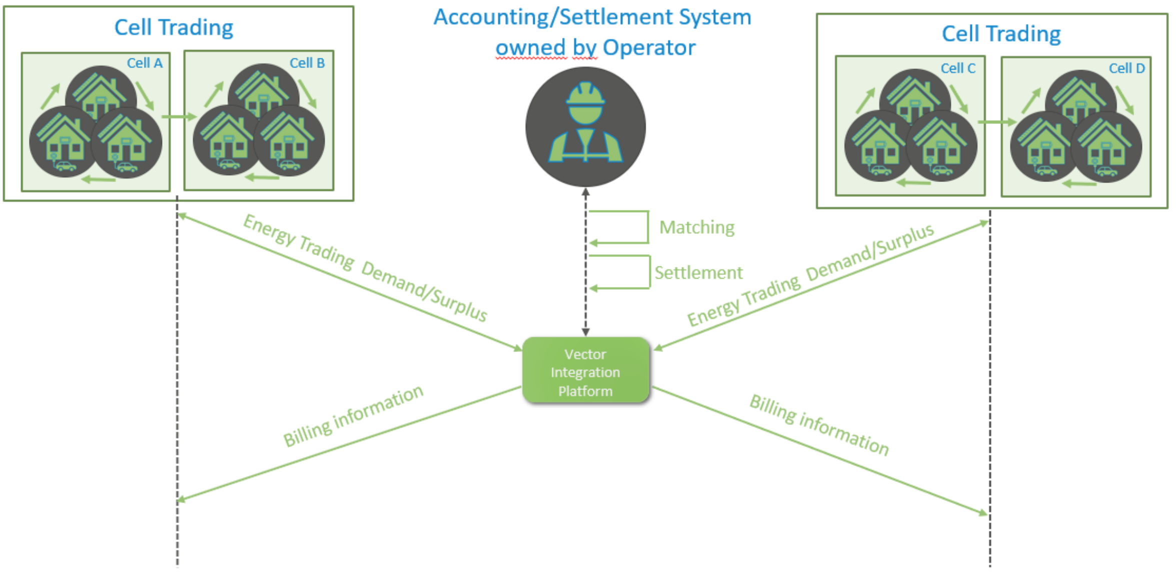
- **Peer – Community – Market Operator:** This will cover scenario for the possibility of linking the community to wider electricity market operators e.g. National Grid Balancing Markets, Nord Pool (Day-Ahead and Intra-day markets). In such situation, flexibilities within the community can be traded as market services and the community can benefit financially from services provided.

3.3.3.4 Diagrams of Use Case

Functional Diagram of Use Case



Sequence Diagram of Use Case



3.3.3.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Availability	Availability of the community to provide requested demand/surplus from the market through the vector integration platform.
Device Request	Requested energy (demand/surplus) from the vector integration platform to the community DER assets.
Market Request	Requested energy (demand/surplus) from the electricity and/or gas operator to the vector integration platform to the community based on market prices
Energy Delivered	Customer information about its energy surplus/demand in kWh for the next timestep (and price)
Billing information	Information from the settlement system about the energy trading process of the previous timestep (from/to other customers, kWh, €)

3.3.3.6 Relevant Actors

Actors			
Grouping		***Group Description***	
Controller		Controller that can activate a certain device or behaviour.	
Management entity		Managing automated procurement and distribution.	
Communication infrastructure		Communication infrastructure needed for transmitting information on energy needs/provisions.	
Actor Name	***Actor Type*** cf. Grouping	***Actor Description***	***Further information*** specific to this Use Case
Market Manager	Management entity	Manages the accounting and settlement process between the market and the community	
Community Manager	Management entity	Manages the generation of electric energy and gas energy across the community and feed-in the available energy to the Vector Integration Platform.	

VIP Management	Controller	Actor managing the control actions and interactions within all DER assets and virtual cells	
ANM Strata/ Element	Communication infrastructure	Enables communication between the customer, DER assets, virtual cells and distribution network, .	

3.4 Sweden

3.4.1 Use Case SE1 – Controlled E-Mobility Charging

3.4.1.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
SE1	• Domains: Distribution, DER, Customer • Zones: Market, Enterprise, Field, Process, Operation	Controlled E-mobility Charging	Parking company (grid owner)

3.4.1.2 Scope and Objectives of Use Case

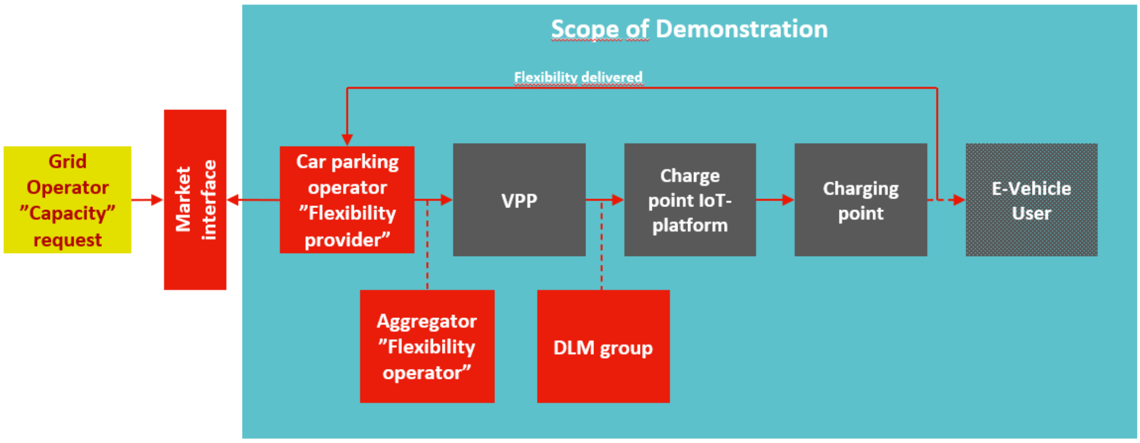
Objectives of Use Case	
Scope	Electric flexibility
Type of Energy Community	REC
Objective(s)	Investigate DSO flexibility potential in parking garage when using Demand Side Response (DSR) of the charging of electricity vehicles due to capacity limitations in electricity grid.
Connected Use Cases	Customer-based demand response (Parent Use Case)

3.4.1.3 Narrative of Use Case

Narrative of Use Case
Short description
Use case 1 Reduce charging output for the selected chargers during peak hours without any considerations on individual needs or history. Control of all chargers per location or certain groups of chargers per location should be enabled. **Use case 2** Reduce charging output at peak hours if the following requirements are fulfilled: 1. Time requirement - charging at a particular station is started at least X hours before the peak load period, the charge is reduced, not otherwise. 2. Energy requirement - the actual charged kWh is more than Y kWhs, the charge is reduced, not otherwise.

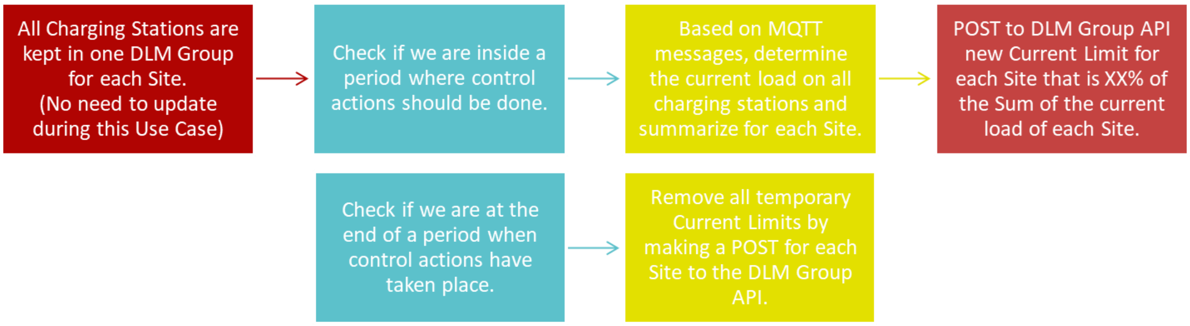
Use case 3
Analyze the car's average charging (and parking) time and base the load management potential at peak hours on this data, with minimal influence on the user needs. There are 2 different separate use cases (values will be agreed during the project): 1. If customer's average charging time is longer than X hours and current charging has lasted at least Y hours, charging will be controlled. 2. If customer's average charging energy is more than X kwh and with current charging at least Y kwh have been charged, charging will be controlled. Historical data is needed around all individual cars that are to be included in the use-case based on historical customer data. Analytics on users in the customer database will be the basis for execution considering average charging time and charged energy.
Complete description
See short description.

3.4.1.4 Diagrams of Use Case

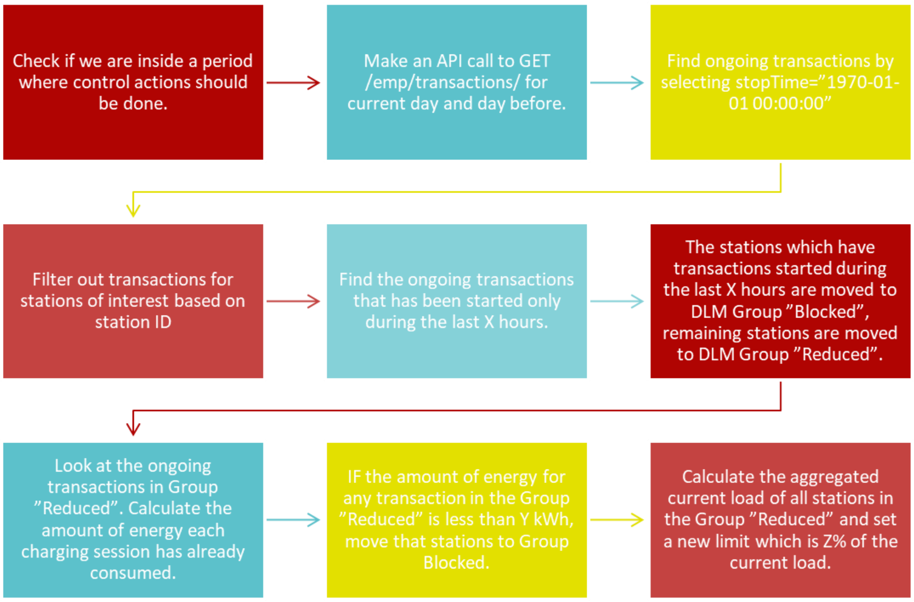
Functional Diagram of Use Case


Sequence Diagram of Use Case

Use case 1:



Use case 2:



Use case 3:

3.4.1.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Capacity request	Request from grid operator (via capacity market) to car parking operator and/or offer from flexibility provider to make capacity available.
Estimate demand response potential (based on steering logic including analytics (use case 1-3))	Request from flexibility provider (parking company and/or aggregator) to Charging point IoT-platform (via VPP) on possibly available capacity.
Execute demand response	Execute demand response on available DLM-group according to estimated flexibility from VPP.
Back to normal rate of charging	When demand for flexibility is fulfilled and/or no flexibility can be delivered from charging points.

3.4.1.6 Relevant Actors

Actors	
Grouping	***Group Description***
Communication partner	Entity taking part in the communication process.
Management entity	Actor that manages a part of the use case.
Controller	Controller that can activate a certain device or behaviour.
Communication	Communication infrastructure needed for transmitting

infrastructure	information on energy needs/provisions.
Meter	Metering equipment required for settlement process.
Indirectly involved stakeholder	Stakeholder that is affected but not directly involved in the trading process

Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Grid operator	Management entity	Provides the infrastructure needed to transmit the electric energy, manages the distribution grid.	
Market place	Communication infrastructure	Provides communication platform where grid operator can offer incentive to parking company to enable flexibility.	
Parking company	Management entity	Makes decision on whether flexibility should be enabled or not.	
Aggregator	Communication partner	Acts on the decision of the parking company and communicates with the VPP.	
VPP	Management entity	Calculates possible charging flexibility and decides on charging scheme. Communicates with IoT-platform of the charging point.	
Charging point IoT-platform	Controller	Acts on the command from the VPP and communicates with charging point.	
Charging point	Controller	Charges E-vehicle at speed according to limitations from charging point IoT-platform.	
E-vehicle user	Indirectly involved stakeholder	Gets E-vehicle charged.	

3.4.2 Use Case SE2 – Flexibility on City Building Site

3.4.2.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
SE2	• Domains: Distribution, DER, Customer • Zones: Market, Enter-prise, Field, Process, Operation	Flexibility on city building site	Developer SERNEKE (partner)

3.4.2.2 Scope and Objectives of Use Case

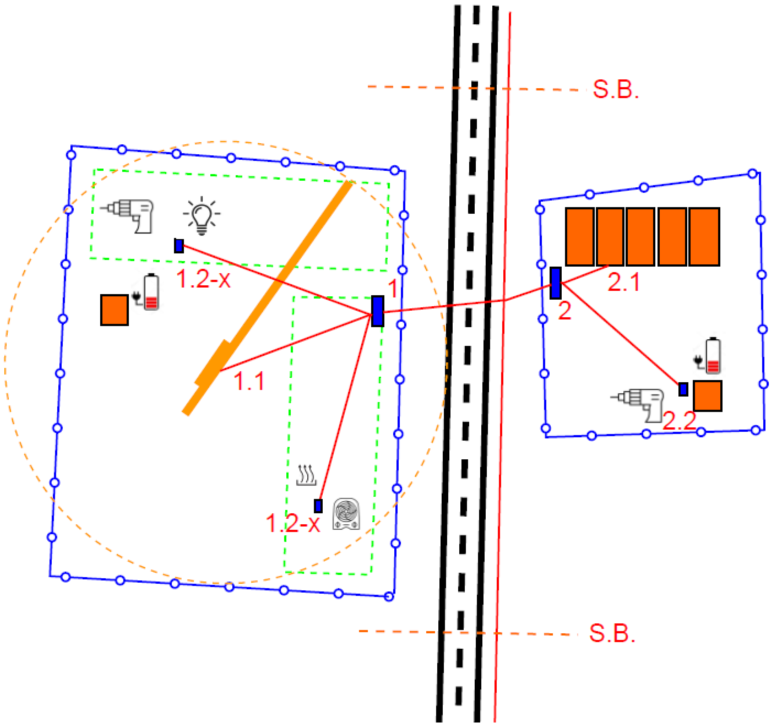
Objectives of Use Case	
Scope	Electric flexibility
Type of Energy Community	REC
Objective(s)	Investigate DSO flexibility potential on construction site based on analyzes of load profiles and different activities and needs during the construction of a Long Stay Hotel.
Connected Use Cases	Customer-based demand response (Parent Use Case)

3.4.2.3 Narrative of Use Case

Narrative of Use Case
Short description
Target is to measure and look for potential to level out the electricity capacity at a construction site.
Complete description
The construction site is the Long stat Hotell "Kosterbåten" in the city district Västra Hamnen, in Malmö which started in Q2 2020 and go on for two years The plan is to measure the total electricity usage at the construction site with installed sub metering on selected places on-site. The metering data will by analysed combined with the log of the construction site complemented with questionnaire and interviews to understand the short- and long-term capacity peaks and their origin. Evaluation will be done in order to estimate potential for flexibility and peak-shaving.

3.4.2.4 Diagrams of Use Case

Functional Diagram of Use Case
Sub-metering program includes high granularity metering of 1.1, 1.2, 2.1 and 2.2



Sequence Diagram of Use Case
Not relevant at this stage Metering – Analyses – Follow-up

3.4.2.5 Exchanged Information

Exchanged Information	
Type	**Information Description**
Power meter data	Capacity usage on different sub-groups

3.4.2.6 Relevant Actor

Actors	
Grouping	**Group Description**
Construction company	Customer, flexibility provider
DSO	Supplier, bidder for capacity and marketplace provider

Subcontractor / equipment renter (Indirectly involved stakeholder)		Provider of constructions site equipment and infrastructure	
Unions (Indirectly involved stakeholder		in relation to working methods and everyday work to understand what "flexibility" there is in flexible processes that could affect the working day	
Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Grid operator	Management entity	Provides the infrastructure needed to transmit the electric energy, manages the distribution grid.	
Market place	Communication infrastructure	Provides communication platform where grid operator can offer incentive to parking company to enable flexibility.	
Construction company	Management entity	Makes decision on whether flexibility should be enabled or not.	

3.4.3 Use Case SE3 – Flexibility in a Facility with heat pumps & DH

3.4.3.1 Use Case Identification

Use Case Identification			
ID	***Domain(s)/Zone(s)***	***Name of Use Case***	***Target entity***
SE3	• Domains: Distribution, DER, Customer • Zones: Market, Enterprise, Field, Process, Operation	Flexibility on city building site	Building owner Vasakronan (partner)

3.4.3.2 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Electric flexibility
Type of Energy Community	REC
Objective(s)	The objective is to demonstrate and extrapolate results from a number of tests in order to thereby understand the flexibility potential in commercial buildings with different heating solutions.

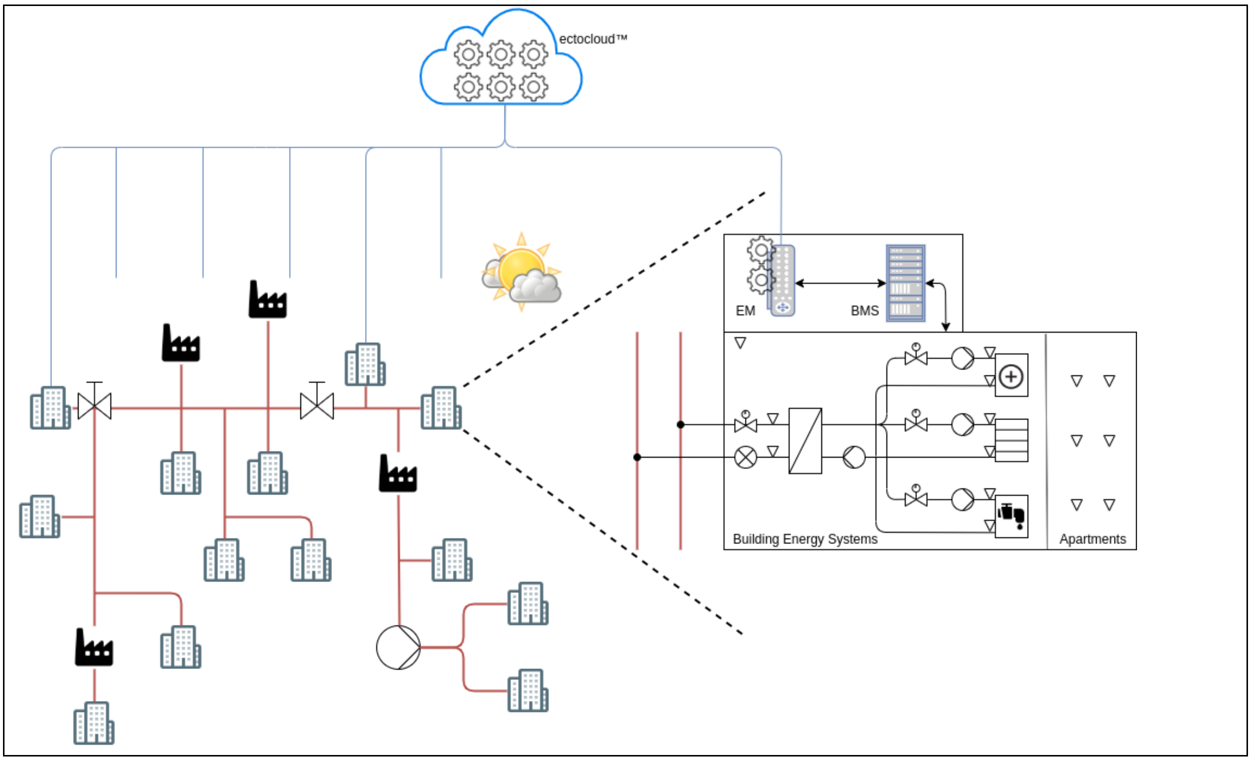
Connected Use Cases	Control-based demand response (Parent Use Case)

3.4.3.3 Narrative of Use Case

Narrative of Use Case
Short description
The demonstrations will be held at Vasakronan's property Triangeln in central Malmö. The property has a number of different tenants with offices, restaurants, shops and residential areas. The property is supplied with heat through both heat pumps (connected to aquifers) and district heating.
Complete description
There are mainly two tests for flexibility that will be carried out. 1. Flexibility by utilizing the thermal inertia in a building to enable load control (without affecting comfort). Through E.ON's Digital District Heating (CESO), the building's control system (BMS (Siemens and Bastec) will be able to influence so that heat is controlled reactively and / or proactively to cut power peaks and thereby reduce instantaneous power output from the heat pumps. 2. Flexibility by switching energy source for heat between supply from the heat pump to district heating. If the load in the electricity grid is high but power is available in the district heating system and the logic is to relieve the electricity system through this, production can be prioritized against district heating.

3.4.3.4 Diagrams of Use Case

Functional Diagram of Use Case
The digital optimization and control platform **CESO** (Customer Energy and System Optimization) utilized to generate benefits from a production and distribution context, providing manually and automatically activated control capabilities to DSOs. CESO-based control is applied to circumvent needs of operating peak plants during shorter periods of high demand, thus decreasing the needs to use fossil fuels, while having a neglible impact on customer comfort achieved through activation of building inertia. CESO-based control is achieved through cloud and IoT-based technology, computing system-wide steering in the cloud which is transmitted to Energy Manager IoT gateways. The Energy Managers integrate with the building heating loads (District heating and heat pump) through the local BMS (Building Management System) and apply local control logic to influence the heating loads power outtake. Through Machine Learning technology, decision support information is generated and presented to the user to understand the benefit and impact of applied steering.



3.4.3.5 Relevant Actors

Actors			
Grouping		***Group Description***	
Building owner		Customer, flexibility provider	
DSO-Power		Supplier, bidder for capacity and marketplace provider	
DO-District heating		Supplier of DH and supporting customer to be flex. provider	
Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Grid operator	Management entity	Provides the infrastructure needed to transmit the electric energy, manages the distribution grid.	
Market place	Communication infrastructure	Provides communication platform where grid operator can offer incentive to parking company to enable flexibility.	
Aggregator	Communication partner	Acts on the decision of the building owner and communicates steering suggestions to the BMS.	

3.4.4 Use Case SE4 – Increasing utilization with Local Balancing

3.4.4.1 Use Case Identification

Use Case Identification			
ID	**Domain(s)/Zone(s)**	**Name of Use Case**	**Target entity**
SE4	• Domains: Distribution, DER, EMS, Customer • Zones: Market, Enterprise, Process, Operation	Flexibility on residential multi-family building site	Building owner MKB (partner)

3.4.4.2 Scope and Objectives of Use Case

Objectives of Use Case	
Scope	Electric flexibility, EMS, ancillary services
Type of Energy Community	Multi-famaly buildings and building clusters.
Objective(s)	The objective is to demonstrate and the potential for batteries to lower running costs for owners of residential buildings along the mutual benefits for grid owners with distributed flexible grid resources and EMS.
Connected Use Cases	Incentive-based demand response (Parent Use Case)

3.4.4.3 Narrative of Use Case

Narrative of Use Case
Short description
The demonstration has shifted focus from utilization of batteries to steer on industrialized level to multi residential buildings. The building is owned by MKB and is located in Malmö. The goal is to possibly influence the overall running costs by implementing a battery. Furthermore, to induce a sustainable and innovation brand at the site, with the hope of increasing utility over the project period.
Complete description
A battery is being installed there several possibilities and their feasibility at the site examined in steps. The first step is to lower costs related to the type of grid subscription at the site, power subscription plan. Using the battery and power managers to decrease the highest power demands on monthly basis will cause a direct decrease of the monthly fee. Future steps include steering of the battery to supply a wider span of functions, using more input factors. Phase balancing will provide another value for owners. Improved power control will also be added to enable ancillary services to the grid, thus also create another revenue stream for the owners

3.4.4.4 Diagrams of Use Case

Functional Diagram of Use Case

By introducing an EMS (Energy Management System) alongside the battery hardware will the owner (MKB) have increased control of their reliance on the power grid. By reducing peak-loads and smoothening the power consumption over a larger period will the peak strain on the grid decrease. While they are also improving the potential utilization use of PV in the local area that increasingly becoming a dimensioning factor during summers high production periods

The functions of the entire EMS will be an integrated software-based solution which utilizing both EONs Energy Manager and functionality found natively in the battery. Control is achieved through cloud and IoT-based technology, computing system-wide steering in the cloud which is transmitted to Energy Manager IoT gateways. By including more impact factors and better understand the need during the project runtime will there be a steady improvement of control and functionalities.

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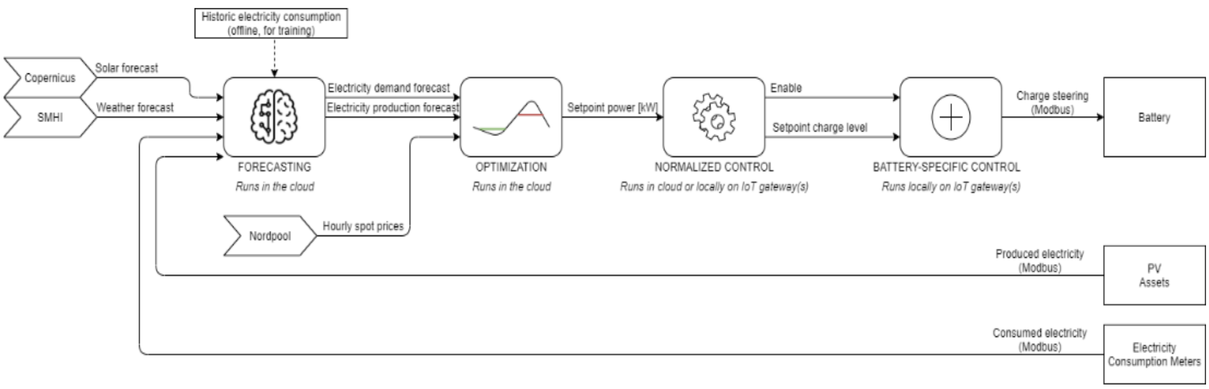


3.4.4.5 Exchanged Information

Exchanged Information	
Type	***Information Description***
Shift of scale	Moved from industrial size to smaller multi-family residential buildings.

3.4.4.6 Relevant Actors

Actors	
Grouping	***Group Description***
Building owner	Battery customer, flexibility provider
DSO-Power	Supplier of BMS and platform control
TSO	Buyer of ancillary services

Actor Name	***Actor Type*** *cf. Grouping*	***Actor Description***	***Further information*** *specific to this Use Case*
Grid operator	Management entity	Provides the infrastructure needed to transmit the electric energy, manages the distribution grid.	Develops the EMS
Aggregator	Communication partner	Acts on the decision of the building owner and communicates steering suggestions to the BMS.	

4 DEMO SITES

4.1 Austria

4.1.1 Testbed AT1 - Suedburgenland

4.1.1.1 General Description

One of the demo sites for the project CLUE will be in the Austrian province Burgenland within the innovation lab act4.energy. The innovation lab act4.energy is a living lab initiative that is initiated and managed by Energie Kompass GmbH and is supported by the Austrian Federal Ministry of Climate Action within the innovation program “City of Tomorrow”. The initiative is located in the districts Oberwart and Güssing in south-east Austria and encompasses 10 municipalities that all work together and cooperate in a public-private partnership.

The innovation lab act4.energy builds and operates experimental environments and creates framework conditions for innovations. It enables and supports research and innovation projects for development and testing of new products, solutions and services in the energy sector and has a focus on improving the use of renewable energies. The region Oberwart-Stegersbach (10 municipalities in total) operates as a living lab test-bed for demonstrating and evaluating new technologies and services for regional renewable energy systems. Based on open innovation processes a cooperation of science, politics, research, companies, local representatives and the civil society develops new solutions with a strong focus on practical application and functional business models.

The innovation lab region in short:

- The Oberwart-Stegersbach innovation laboratory region comprises 10 municipalities with 20,000 inhabitants
- An exemplary geographic and demographic Structure enables good duplicability to other regions
- Dynamically growing business location in the heart of Europe with tourism, commerce, trade, strong municipal infrastructure (trade fair location, schools, cultural institutions) and cheap transport connections
- Renewable energy utilization already well developed (initiative “Sonnenkraftwerk Burgenland” with more than 400 PV plants, biomass and biogas plants and geothermal applications).
- Available user access for Co-creation processes
- Comprehensive partner network as well as a well established R&D infrastructure

Within project CLUE:

The innovation lab act4.energy has a strong expertise in open innovation and co-creation processes and will focus on the question of usability and end-user experience for the demonstrated project solutions.

In the demo region, at least one energy community (renewable energy community) will be established with the goal of utilizing flexibilities from electric-mobility in combination with contact-less automatic charging and payments supported by blockchain technology for clearing. During the preparation and execution of the demonstration phase there will be strong emphasis on user engagement, and experiences in forming and administrating energy communities beyond the mere technical aspects will be gathered.

The legal framework for the establishing of Energy Communities in Austria is laid out in the new EAG (i.e. Erneuerbaren Ausbaugesetz - Renewable Energies Expansion Act), which is expected to be passed by the parliament in December 2020 and be in effect in Q1/2021. As soon as legally possible it is planned to establish two Renewable Energy Communities in the region and equip the participating households with the necessary technical infrastructure to measure the produced (via PV) and consumed energy and record these in an Energy Account.

4.1.1.2 Implemented Use Cases

In the testbed Sueburgenland two use cases will be implemented. One is "virtual energy currency payment at 3rd parties" where community consumers can pay for services provided by third parties (i.e. parties that are not in the EC), with a virtual energy currency. This currency is generated based on energy generation in an energy account application and transferred to a digital wallet app, where it can be used as a cryptocurrency for payments. The goal of this use case is to generate a monetary incentive to participate in Energy Communities.

The second use case is "payment for EV – charging with a virtual energy currency" where community consumers can pay for EV – charging at community operated charging infrastructure with a virtual energy currency. This currency is (as in the other use case) generated based on energy generation in an energy account application and transferred to a digital wallet app, where it can be used as a cryptocurrency for payments. The goal is again to generate a monetary incentive to participate in Energy Communities.

For the implantation of these 2 use cases the Energy Account application, which has been developed within the scope of another project, is utilized to record the energy generation and energy consumption of the participating households (prosumers and consumers). The Energy Account records the energy in a normalized unit e-kWh (taking into account different tariffs and costs for purchased, self-consumed and feed-in energy) and allows the user to easily keep track in a dedicated app.

As part of the CLUE project, this energy balance expressed in e-kWh, will be transferred to a public blockchain, thus generation an "e-kWh – Token" or in other words a cryptocurrency. This virtual energy currency can then be used for payment for services within the REC or with 3rd parties, as detailed in the respective use case descriptions.

In order for these use cases to be implemented, the participating households of the energy communities will be equipped with dedicated smart meters that record the respective energy consumption and PV – energy generation and are connected to the Energy Account database (a cloud server application). An interface between this cloud data base and the selected public Blockchain system will be developed that allows to "book out" e-kWh from the Energy Account and generate the same amount of "e-kWh token" on the blockchain. A digital wallet maintaining this cryptocurrency will be developed to manage payment procedures for services within the REC (i.e. payment for e-Mobility services) or services of 3rd parties.

4.1.2 Testbed AT2 – Municipality Gasen

4.1.2.1 General Description

The Municipality Gasen within the „Klima- und Energiemodellregion Naturpark Almenland" (KEM) will serve as testbed for CLUE Austria. KEM is a program of the Austrian climate and energy fund and aims at implementing regional climate protection projects in different thematic areas reaching from renewable energy and energy efficiency over sustainable building and mobility to agriculture and awareness raising. The KEM Almenland comprises six municipalities, which collaborate in these projects leading to a close network within the region. As the KEM Almenland is member of several projects dealing with renewable energy, there is not only strong personal contacts and understanding of region's inhabitants, but also strong knowledge on participatory processes.

The KEM Almenland and the municipality Gasen in short:

- The Naturpark Almenland comprises 6 municipalities with approx. 12.500 inhabitants
- Geography and demography enables transferring results for other rural areas
- Well-grounded network within the region in the areas of renewable energy, economy, agriculture, Leader projects and tourism.
- Comprehensive network of partners and professional players
- The biomass heating plant in Gasen serves as a focal point for renewable energy. It is run with regional biomass and a PV and a CHP unit generate renewable electricity.

Within project CLUE:

In the municipality Gasen, a renewable energy community will be established aiming at streamlining the consumption of renewable energy produced within the community. For this purpose, a lithium-ion battery and a hydrogen storage are deployed. The implementation of the renewable energy community is accompanied by strong involvement of the participating citizens in order to also gain knowledge and experience about organisational and social aspects of energy communities. Once the regulatory framework for energy communities within Austria is set, the renewable energy community will be officially founded and participating households will be equipped with the necessary technical equipment to meter production and consumption of the (renewable) energy within the community.

From a technical point of view there are four different types of participants:

- passive consumers (no generation, no EMS)
- active consumers (no generation, EMS)
- passive prosumers (generation, no EMS)

- active prosumers (generation, EMS)

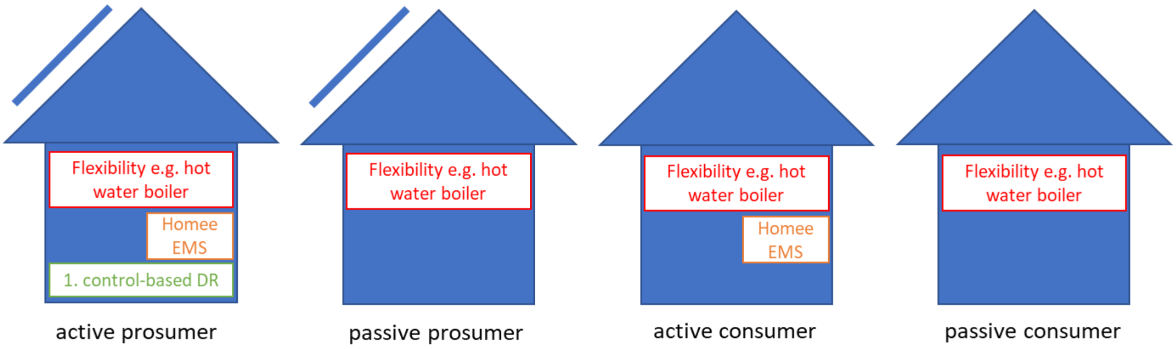


Figure 1: Possible types of participants in Testbed Austria 1

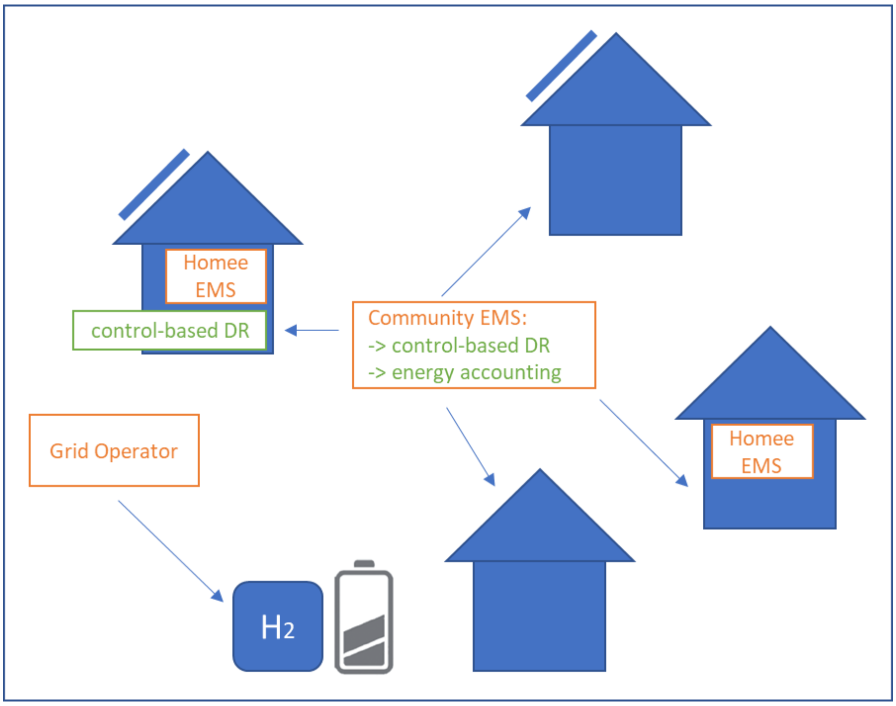
Flexibilities (mainly hot water boiler) may be available for every type of participant, but can only be controlled in households, where an EMS is available.

4.1.2.2 Implemented Use Cases

In the testbed Gasen three use cases will be implemented:

1) Local Self Optimization (Control-based DR): First of all prosumer will use their own PV generation to cover their local consumption. If an EMS is available, flexibilities (mainly hot water boiler) can be used to increase the share of self-consumption (only active prosumers).
2) Energy Trading between community participants and community: If the PV generation in the community exceeds the consumption, the following actions will executed:
   a) First of all the consumption of community will be covered
   b) If there is still PV generation left, flexibilities from active pro- and consumers will be activated (Control-based DR).
   c) Then the battery storage systems will be charged.
   d) Finally, the PV surplus will be stored as hydrogen.

   If the consumption in the community exceeds the PV generation, first the battery storage will be discharged (up to a certain limit). The usage of flexibilities of active pro- and consumers is not planned at the moment.
3) Grid Support will be done with battery storage system and hydrogen.



4.2 Germany

4.2.1 Testbed GER

4.2.1.1 General Description

The Testbed "Shamrockpark" in Germany is located in the city of Herne. It was created on the site of the former headquarters of the coal company RAG AG in Herne, Germany. The various office buildings are being extensively refurbished and complemented by several new buildings to form the new mixed-use area. State-of-the-art communication technology and an IT infrastructure that meets today's requirements will enable efficient work. New living space, a kindergarten and a senior residence will be created on the site. The project partner FAKT AG will develop new high-rise buildings that will bring new impetus to Herne. The World Center will attract international companies as tenants on 17 levels and inspire them with offers such as a business hotel, a sky bar and interpreting services. The Future Center is the counterpart to the World Center and is intended to offer space for start-ups, innovative research and educational units and much more.

CLUE supports the planning, implementation and the operation of the ectogrid energy system at the Shamrockpark quarter. The ectogrid energy system is based on a low-temperature LowEx-district heating network with variable temperatures and a smart electric grid and supplies 27 new and existing buildings. Ectogrid enables the exchange of heat between the buildings and the use of low temperature industrial waste heat as energy source. Bidirectional flow of heat is possible in the pipes of the network. The integrated energy system includes several types of sector coupling between the heating, electricity and e-mobility sectors by heat pumps, combined heat and power plants and electric vehicles charging infrastructure. Within CLUE, a planning tool will be developed to optimize the design of such integrated energy systems. The operation of the energy system will be optimized based on detailed monitoring. The flexibility options within the district, which could be provided by storage, sector coupling and demand-side management, will be evaluated. The energy services, which could be provided by the quarter to the surrounding energy system, will be researched including the related business models. The ectogrid energy system allows a high share of local or regional renewable energy in the energy system and is therefore a raw model for climate neutral districts. Possible reservations of the citizens and other stakeholders against the new, sustainable technologies will be evaluated and their acceptance improved by citizen participation measures, which will be supported by social scientists. CLUE-Shamrockpark is part of the European ERA-NET project CLUE, which develops solutions for Local Energy Communities in four European Countries

4.2.1.2 Implemented Use Cases

The implemented use case is in the area of trading thermal quantities that are fed into the cold heat network (ectogrid) in a decentralized manner by the prosumers and thus made available to other prosumers. Both waste heat from chillers and waste heat from industrial processes are used to supply the decentralized heat pumps with a primary heat source. At the same time, the heat pumps reduce the temperature level in the cold part of the heat network so that this low temperature level can be used to cool buildings. Thus, by harnessing thermal sources at different temperature levels, synergy effects and a win-win situation are created within the Local Energy Community. The use case is designed in principle and the trade works physically as described, but the establishment of a separate legal entity for the Local Energy Community is not necessary for this business model and is therefore not implemented.

4.3 Scotland

4.3.1 Testbed SCOT - Levenmouth

4.3.1.1 General Description

In the Scotland demo site, the aim is to develop a Vector Integration Platform (VIP), that can control supply and demand assets of different energy vectors (heat, electricity and gas etc.) within a local energy community in Levenmouth Fife Scotland UK.

Levenmouth, the trial area for the ScotCLUE project, has local energy assets including several wind turbines, a solar PV park, electric vehicles, hybrid diesel-hydrogen refuge collection vehicles and an industrial CHP network within a community of circa 10,000 households suffering from fuel poverty.

The ScotCLUE project plans to build in the capability within the VIP to utilise this asset base to help create and study the effects and benefits this will bring to the community.

To achieve this, our focus at the first instance is to trial this out with some existing assets we have access to and that are available within this project. These are listed below:

1. The Levenmouth demonstration offshore wind turbine (owned by ORE Catapult) which will act as electricity generator representing integration of wind power generation. We aim to monitor generation profiles and potentially demonstrate the functionality of the VIP performing third-party control.
2. A community owned electric vehicle charging station which would be a prosumer asset which we aim to use monitor its usage and utilise this within the context of other assets in the VIP.
3. Community energy storage located within the Fife community. This will demonstrate a use case for community storage in the local energy community considering the aggregation of energy storage within the VIP. In this case, we will monitor available community energy storage assets onsite within Fife UK area and look at the possibilities for third party control.
4. Virtual Simulated and future cells that replicates other aspects of assets within the community that cannot be physically demonstrated. In this case, we look to simulate a representation of a future hydrogen gas network. This be done using available information around a future hydrogen project e.g. Fife H100. This will look to use excess electricity from the wind turbine to produce hydrogen gas (green hydrogen) for the community.

The Scottish demo site will implement and validate these within a web of cells architecture; a cell defined as a managed group of, one or more, related and fixed assets, which are operated to achieve an objective or series of objectives. This will allow balancing of the power grid through communication and interfacing between local cells of minimal complexity to alleviate local problems within each cell. The University of Strathclyde would be leading with the development of the model for the web of cells with Smarter Grid Solution (SGS) leading distributed energy resource management system (DERMS) software will be utilized to provide state of the art control within the Levenmouth Fife area in the UK.

The demo will seek to address communication and resilience challenges within local energy systems at a local level, and then develop the identified solution to ensure its scalability and replicability at a national and regional level. This would also look at possibility of the building in the capability and flexibility for current and future energy trading markets in the community.

Scottish partners are closely working with the local government agency (Fife Council) and Community Energy Scotland (CES) via stakeholder engagement to define how a flexible energy system would fit the energy strategy of current and new assets within the community area.

At the end, we expect the Vector Integration Platform to have future testbed potential, which provides opportunities for SMEs to test their products and drive growth at local and regional level. The figure below show a high-level description of the system architecture.

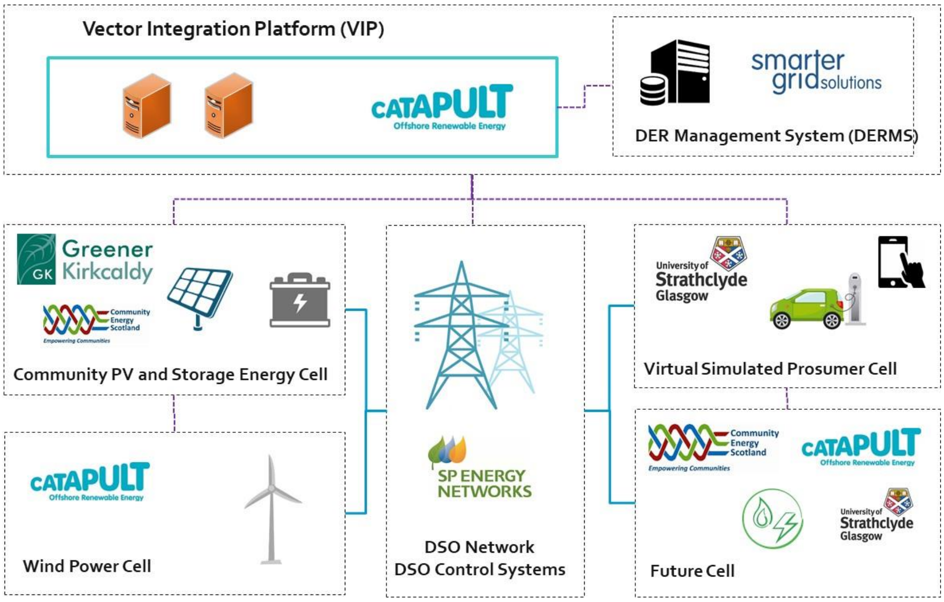


Figure 2: high-level description of system architecture of Testbed Scotland 1

4.3.1.2 Implemented Use Cases

The following parent use cases will be explored during the project. The descriptions have been presented within section 3.3

- Capacity Sharing
- Demand Response
- Energy Trading

4.4 Sweden

The demonstrations in Sweden is utilizing four different testbeds in the city of Malmö to show the flexibility potential in load management representing four different user segments. Malmö have had periods where the capacity limitation to the TSO have been overdrawn and there is a need to find ways to manage the load outtake in the Malmö grid in order to limit these occasions.

An investigation of fluctuations in power consumption in Malmö shows that peaks occur during 8-11 am and 5-7 pm and that 76% of the peaks are between 1-5 h long

The testbeds will give 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.

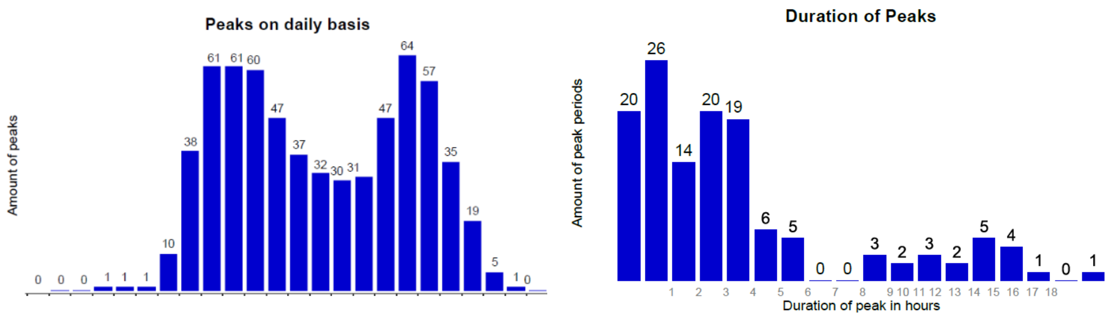


Figure 3: fluctuations in power consumption in Malmö

4.4.1 Testbed SE1 - Car park Anna and Hyllie

4.4.1.1 General Description

The Swedish demo for smart charging utilizes the car parks Anna and Hyllie as testbeds. These car parks represent two good references for both a city center car park and a car park including commuters in the transportation node Hyllie with the concept park´n ride. The car parks offer both public and hired parking lots with 670 parking lots in Anna and 1400 parking lots in Hyllie. This includes 12 parking lots in Anna and 16 parking lots in Hyllie equipped with charging points for electric vehicles that is the focus of the demonstrations.

The public parking company Parkering Malmö operates a total of 50 000 parking lots, in 9 self-owned car parks as well as parking facilities owned by 65 other property owners. They manage approximately 170 charging points and the ambition for Parking Malmö is to continuously further equip the parking lots with charging infrastructure, including a plan to further develop car parks. The plan is to have at least 650 charging points until 2025.

In order to meet the needs driven by electrification we will see a continuous increase in load and power demand on both building and system level and smart management of charging is important to solve many of the challenges. From a building perspective, we need to find ways to manage the increased demand in load without driving high investments and operational costs. On system level, the capacity limit in the power grid drives a need on aggregated scale to manage peak hours for better balancing of load and capacity restrains. Therefore, the testbed aims at understanding the flexibility potential provided in the smart charging functions developed and deployed in the CLUE project and to assess the potential if the functionality is aggregated, including all of Parkering Malmö's current and future charging infrastructure.

4.4.1.2 Implemented Use Cases

The use cases that are implemented in the testbed targets the public available chargers in the car parks with the aim to understand the flexibility potential and the different use-cases' interference with the level of "comfort" for the charging point user. The overarching target is to aggregate the result to understand the flexibility potential that could meet the DSO needs mitigating e.g. capacity limitations in the electricity grid.

In use case 1 the charging output is reduced in the testbed for the selected chargers during peak hours without any considerations on individual needs or history. Control of all chargers per location or certain groups of chargers per location should be enabled.

In use case 2 we reduce charging output at peak hours if a time and energy requirement are fulfilled. If charging at the individual charging point is started at least 1 hour before the load management or that the charged kWh is more than 2 kWh, the charge is reduced, not otherwise.

In use case 3 we analyze the car's average charging (and parking) time and base the load management potential at peak hours on this data, with minimal influence on the user needs. If the customer's average charging time is longer than X hours and current charging has lasted at least Y hours, or if the customer's average charging energy is more than X kwh and with current charging at least Y kwh have been charged, charging will be controlled.

For use case 3, historical data is needed around all individual cars that are to be included in the use-case based on historical customer data. Analytics on users in the customer database will be the basis for execution considering average charging time and charged energy.

4.4.2 Testbed SE2 – Construction Site Kosterbåten

4.4.2.1 General Description

The second demonstration in Sweden, Malmö utilizes a construction site as a testbed. Malmö is no exception from the ongoing urbanization and construction sites drive substantial needs of capacity with a varying demand over the different phases of the construction period. Massive new build city districts and densification drives challenges for the grid operator (DSO) and potential cost for the developer. In the second demonstration, we gather detailed empirical data from the testbed "Kosterbåten", which is an ongoing construction site that will be developed to a Long stay Hotell in the city district Västra Hamnen, in Malmö. The construction started in Q2 2020 and will go on for two years. Kosterbåten consists of two establishments, one for the construction site (250A) itself and one for the construction site office and sheds (125A), see figure below. When finalized the building will hold 6324 m2 heated gross floor area.

4.4.2.2 Implemented Use Cases

The use case is to measure the total electricity usage at the construction site with installed sub metering on selected places on-site. The metering data will be analyzed combined with the log of the construction site complemented with questionnaire and interviews to understand the short- and long-term capacity peaks and their origin. Evaluation will be done in order to estimate potential for flexibility and peak shaving by taking different actions in the construction process e.g. rescheduling processes and other low-tech solutions.

There will also be a number of meter readings that will provide further understanding of the construction sites impact on various supply quality parameters when analyzed. Assessment will be done to understand alternatives to manage the high short-term capacity needs for the construction sites and work as a benchmark adding electrification of various tools that are used over the process.

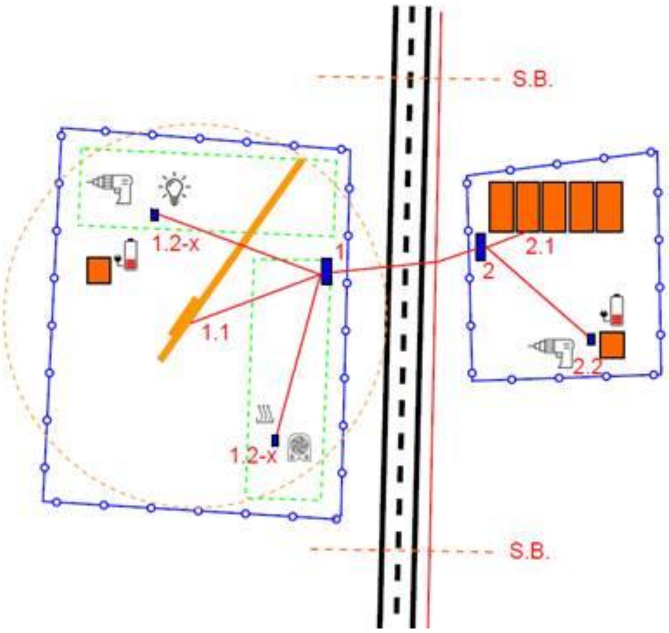


Figure 4: Sub-metering program includes high granularity metering of 1.1, 1.2, 2.1 and 2.2

4.4.3 Testbed SE3 – The building complex "Triangeln"

4.4.3.1 General Description

The third demonstration in Malmö utilizes the building complex Triangeln as a testbed to understand the flexibility potential in building energy demand including alternative heating solutions. Triangeln provides great prerequisites as a testbed for showing the flexibility potential. The property has a few different tenants with office spaces, apartments and stores, which have various energy needs over time. Triangeln is owned and managed by the property owner Vasakronan and is located in central Malmö. The property is supplied with heat through both heat pumps (connected to aquifers) and district heating.

4.4.3.2 Implemented Use Cases

There are mainly two use-cases with the target to manage capacity demand that will be carried out in the Triangeln testbed.

The first use case will utilize the thermal inertia in a building to enable load control (without affecting comfort). Through E.ON's Digital District Heating (CESO), the building's control system (Siemens and Bastec) will be able to influence so that heat is controlled reactively and / or proactively to shift power peaks and thereby reduce instantaneous power output from the heat pumps.

The other use-case will explore the potential by switching energy source for heat between supply from the heat pump to district heating. If the load in the electricity grid is high but power is available in the district heating system and the logic is to relieve the electricity system through this, production can be prioritized against district heating.

4.4.4 Testbed SE4 – MKB Residential building

In and around the village of Simris E.ON created a microgrid that have been used for testing of different Local Energy System functionalities and solutions. Local Balancing was the steering intelligence and algorithms balancing the microgrid through peak shaving of the loads based on forecasted data on local consumption and production. The aim is to take the intelligence used to balance the village and microgrid and adapt to city district and energy communities where the same logics can be applied on residential buildings and urban environments. To use it for real live environment applications instead of a research and development project and continue to improve the EMS capabilities which remains at the core. This testbed is constituting of a residential building owned by the public housing company MKB in Malmö and was chosen due to the high peaks relative to the ordinary consumption that also lasted for a few hours at the most. The peaks could go as high as 200 KW while the mean consumption was 84 KW. This pattern makes the chosen site a good candidate for this type of demonstration while in the same time it is not unique in the consumption pattern, making the results and learnings replicable to other sites as well.

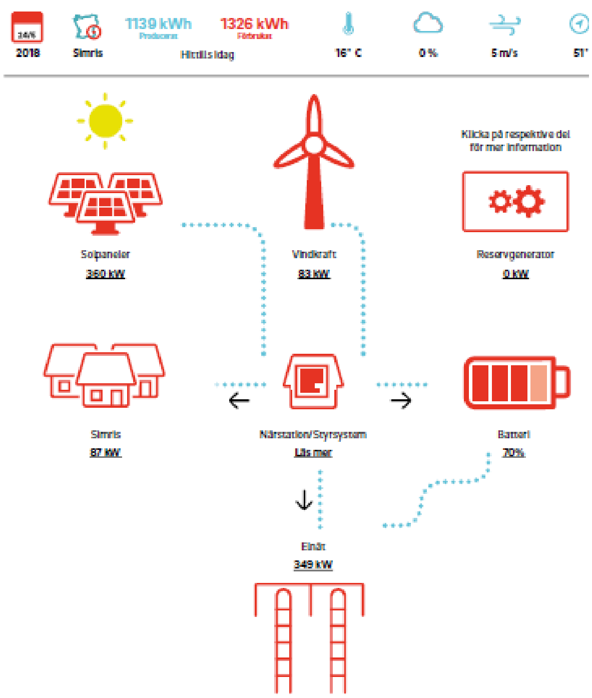


Figure 5: Local energy system of Simris, as model for MKB testbed

In the figure below, the data flow steering architecture for Local Balancing peak shaving and cost optimization is shown as multiple collaborating software modules. This is the general approach that is to be further evaluated at the Simris microgrid and adapted for urban settings for which different asset configuration scenarios may be relevant (e.g. battery and PV or battery-only).

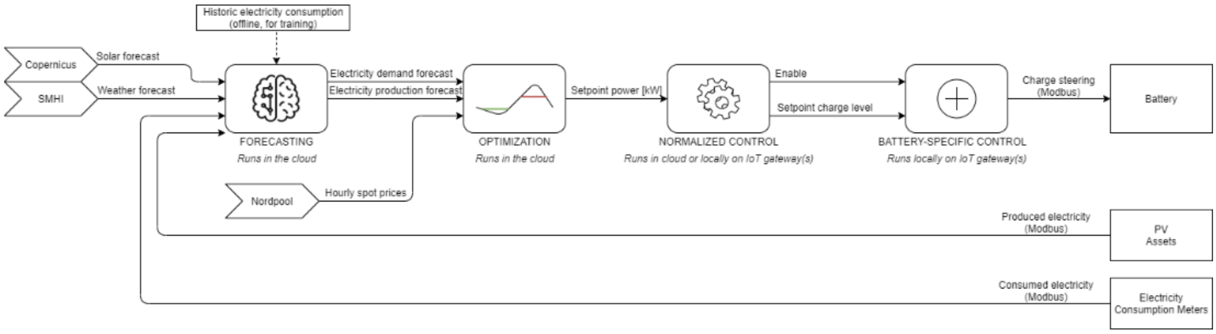


Figure 6: Architecture of local balancing to be developed, evaluated and demonstrated in the project

The solution is intentionally created scalable both horizontal and vertically to make it possible to extend usability of an existing site or to interact with other sites. On top of this could new markets interact with the EMS through communications protocols, thus adding new functions. Connectivity to ancillary services, power flexibility markets are examples that are being looked at for their possibilities to add value to the battery owner and thus the Local Balancing concept as a whole.

5 BUSINESS MODELS

As a baseline for testbed specific business model development, which will take place in country-specific work packages, existing (research) projects were investigated. The non-exhaustive research revealed so far 19 projects dealing with Energy Communities and the like. Business models of these 19 projects/communities vary widely and reveal a great range for Business models to be developed and applied within CLUE.

5.1 Bioenergy village Jündhe (DE)

Location: Germany

Website: http://www.bioenergiedorf.de/en/home.html

5.1.1 Short Description

This EC has around 1089 members, and was set up in the year 2005.

The community consists of a 700kW CHP generator that runs on biogas to produce electricity which would be supplied to the public grid. A 550kW woodchip boiler is also used during the winter for heating which circulates around the local district heating network. During summer, the excess heat from the CHP-plant is used for drying of wood chips or log-wood which will be used by the heating boiler in winter.

Use case: Capacity and Energy sharing

Organization type: co-operative

Objectives:

- *Climate and resource protection* – Use of biomass resource compensates the overall CO2 emissions.
- *Protection of soil and water*- Contamination of oil and water could be reduced through environmentally friendly concepts for cultivating bio-energy crops ('double-cropping' with maize, triticale and sunflowers).
- *Diversity of plants* - A sufficient diversity of plants can be tolerated, as these can be utilized in the fermentation process for the production of biogas.
- *Effects on Regional business cycle* – generation of a new income base for local farmers by selling plants and wood for energy use, possibly leading to higher employment levels.
- *Participation of locals* – Involvement of the village inhabitants is fundamental for a shift from traditional to renewable energy, mainly for investments for a connection to the grid. Encouraging the inhabitants to participate would promote the collective opinion-building and would then support a high orientation towards the community.
- *Decentralization of energy supply* - The energy generation plants will be operated by a local cooperative which would meet the several local needs. The minimization of technical, environmental and economic risks comes along with the shift to local energy sources.
- *Quality of life* - The experience of common decision-making and problem solving could start a new self-confidence and improve the quality of life within the community.

5.1.2 Business model description:

The generation facility is owned collectively and locally by the residents of Jündhe – who are able to buy shares in the established co-operative company that owns the facility. Around 75 percent of the village's inhabitants are members.

The members are able to purchase electricity and heat from the company – the consumers of the generated energy are also the members of the co-operative. The electricity however, is completely fed in to the public grid of the local public utility – the inhabitants rely on the local distribution grid.

Costs: The investment costs amounted to an approx. 5.4 M €. For the biogas and electricity generation needed approx. 2.9 M €, the heating plant approx. 0.9 M €, and the local heating network approx. 1.6 M€. Around 0.5M € came from the investments by the villagers, 1.3M € from a grant, and the remaining 3.4 M € loaned to the community by the bank.

The conditions for the heating customers is definitely better than a case with heating oil including ancillary costs (maintenance, chimney sweep, etc.). The cost structure was achieved through the following stipulations:

- Basic fee: € 500
- heating price: € 0.049 / kWh (except adjustment clauses)
- Connection fee: € 1000
- Conversion costs: € 2500 (on an average)
- Participation in the cooperative: a minimum of 1500€

In total, the connected households would save around € 75,000 (€ 441 per household) in heating costs in each year, in comparison with the current heating oil prices

Expectations from the project:

Table 2: Actors and expectations in the Jündhe Bioenergy village

Actor	Expectation	Speaking for 'publics'
Funding Ministry	Implementation of biomass technology	Societal welfare, underpin biomass strategy, economic welfare of rural areas
University – IZNE (7 different disciplines)	Academic qualification, acquisition Empirical evidence on hypothesis regarding life-style shifts, sense of community, ecological diversification	Applied research in agriculture, ecology and (cultural) life sciences
Mayor	Economic and environmental welfare, getting funds, future oriented decision (self-sufficiency)	Economic and social welfare, stabilization of the farming structure (safeguard employment)
Cooperative	Business success	Climate protection, independency
Construction firms	Ensure know-how	Ensuring employment
Inhabitants	Cheap energy, strengthening the local position	Environmental protection, supporting sustainable future, stabilization of the farming structure
Members of the cooperative / investors	Saving money in the long-term	Independent energy producers
Engineering	Image building	Ensuring employment
Committee of external experts	Professional information transfer	Scientific community

Distribution of energy within the community:

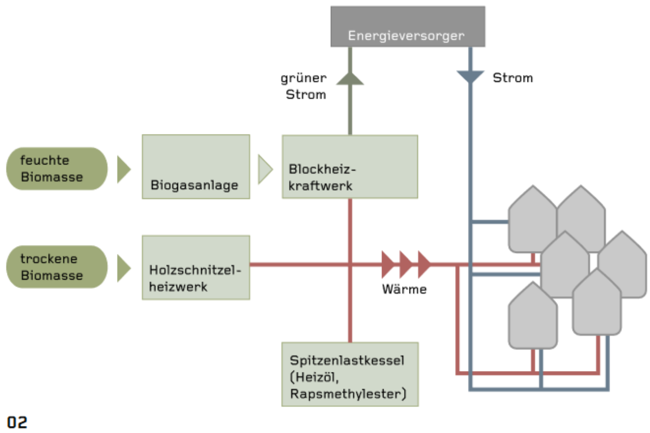


Figure 7: Heat and power distribution concept in the Jündhe energy system (source: Eigner-Thiel, et.al)

Only shareholders or members of the Cooperative company can purchase electricity generated by the common generating station. District heating is carried out with a locally owned district heating grid.

Challenges:

- The capital costs are high.
- The system would only work when a large majority of the villagers participate, and can be then attached to the local heating network.

- The amount of gas generated by the facility is not constant, it may actually differ due to insufficient raw materials. The needed raw materials would then be bought additionally

Benefits: A drastic reduction of 60 percent in the CO_2 emissions of the village was observed, and a relatively cheap and reliable source of local energy was procured.

Lessons learned:

- *Participation:* the foundation of a co-operative allowed equal participation in the decision making process. Several functions were partially taken by the same person, with personal closeness to planning and economic know-how (the mayor). The feeling of self-efficacy could be further strengthened by the involvement and participation in decision making.
- *Communication, Multiplier and Promoter:* success could be ensured by promoters with a high level of trust in the community – the key person here was the mayor of the village.
- Festivals and contests with children were used to disseminate the positive and emotional context of the project. A visible 'label' for participants to improve participation in the neighbourhood was also implemented. A constant communication with the local media, and word of mouth to disseminate trusted information within the community was also effective.
- *Know-How exchange:* Several joint learning sessions, and the improvement of know-hows within the working group successfully increased self-confidence. Research, personnel training and skill development in all the involved businesses also increased the local know-how and created new market opportunities. The chosen structure of the working groups facilitated a high level of exchange of information and acquisition of participatory knowledge.
- *Interdisciplinary cooperation:* support from administration of the university group was required, and their extensive consultative work had to be funded. Interdisciplinary cooperation based on three main categories – understanding of perspectives, methods and goals of each discipline and agreed objectives, regular meetings of the project group and a separate coordination of the whole project.
- *Social acceptance of Renewable Energy:* The villagers and others in southern Lower Saxony were already ambitious with Renewable Energy (RE). Innovation can be linked with the traditional use of RE with a step-by-step approach. Visits to demonstration projects was also described as one of the key activities to motivate and promote the technological approach.

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http://www.bioenergiedorf.info/index.php?id=startseite

http://www.bioenergiedorf.info/index.php?id=144

5.2 Sprakebüll Village eG (DE)

Location: Germany

Webpage: http://co2mmunity.eu/wp-content/uploads/2019/02/Factsheet-Sprakeb%C3%BCll.pdf

5.2.1 Short description:

With the primary objective of self-sufficiency and to avoid fossil fuel based energy, the Sprakebüll village eG was set up North Frisia in 1998. Initially, the eG started with the investment for a wind farm (5x1.65 MW) with only 22 citizens, and subsequently a second wind farm with 183 citizens soon followed. In the year 2011, an additional wind park was established (3 X 2.65 MW). Later, in the year 2014, a repowering for the first wind farm was conducted, and each turbine repowered to 3.6 MW. Overall, around 130 MW of generating capacity from wind (and biomass) with an annual production of 1878110 kWh (just from wind) exists in the eG.

The eG has over 20 years of experience with citizen participation models, and is also now the village with the highest density of electric cars in Germany. The activities of the community include the generation of electricity from RE, the supply of renewable heat and to enable district heating in the community.

Organization type: Energiegenossenschaft – cooperative company, GmbH & Co. KG

Use case: Capacity and Energy sharing

5.2.2 Business model description

The Gmbh and CO. model is normally suitable for larger community projects, with higher investment volumes that require a limitation of liability. The voting rights for the members in the eG depend on the proportion of capital invested by the member, not on the traditional "one member, one vote" cooperative principle. The allocation of shared ownership was important, the shares were not sold via a 'first come – first serve' principle, but mainly on a geographical criterion i.e. preference for local citizens investing in wind power over others.

Increased profits resulted in increased trade and income tax. The revenue from the project is distributed according to the level of investment by each member (i.e., number of shares owned). Limited partners have to pay income tax for the revenue generated, while the limited commercial partnership (KG) pays the trade tax. The local municipality acquires 25 – 30 percent of the taxes for its own use.

Challenges:

- Strict environmental laws create problems with wind power plant planning.
- The change of German Renewable Energy Sources Act – the renewable electricity produced will have to be directly marketed to the consumers.
- Selecting a suitable energy storage system for the community

Benefits: The municipality is doing economically well because of the increased trade tax revenues from the wind power. This proved to be a strong catalyst and motivator for further community projects and the utilization of other low-carbon energy systems.

Lessons learned:

- Keeping up to date on the topic new technological developments and the legal frameworks is crucial in keeping up with the dynamic energy market conditions.
- Qualities such as mental determination and willingness to take risks is very important.
- Inclusiveness, with transparent and open dialogues with the community is critical in providing the citizens a feeling of belonging.

References:

https://www.h2-international.com/2018/06/05/communities-discover-their-love-for-electric-carsharing/

Caramizaru, A. and Uihlein, A., Energy communities: an overview of energy and social innovation, EUR 30083 EN, Publications Office of the European Union, Luxembourg, 2020,ISBN 978-92-76-10713-2, doi:10.2760/180576, JRC119433.

5.3 Virtual citizen plant Schönau (DE)

Location: Germany

Webpage: https://www.ews-schoenau.de/die-ews-solaroffensive/modellprojekt/

5.3.1 Short description

Elektrizitätswerke Schönau (EWS) initiated this project in the year 2017, in which around 30 participants with 30 Photovoltaic systems, several battery systems, electric cars and small scale combined heat and power plants take part together. The overall aim of the project is to develop a climate-friendly, decentralized and citizen supported energy supply.

With a community demand of 41 kW, a generation of 162 kW, and a grid feed in of 39 kW, the community of 30 participants have achieved a 100% autarky in the community.

Based on digital solutions like energy management systems and intelligent measurement systems, the energy components of the participants are all grouped into a virtual citizen power plant. The several energy flows can be traced by the users via a mobile application or an internet portal. On a small scale, it is being tested how the current digital technology can regulate the flow of electricity, in a way that benefits the network. The medium-term goal is to combine e-mobility, electrical heat generation via heat pumps or heating rods with solar power generation, and to couple the energy sectors of electricity, heating and transport.

Use case: Virtual power plant, capacity sharing, peer to peer trading

5.3.2 Business model description

The consumer becomes the prosumer in the community who generates, consumes, temporarily stores and trades electricity by himself. The supply chain then becomes a local energy community; whose members supply each other with the energy. In the model project Schönau, research and exploration on how these ideas can work in practice together with their customers is being conducted.

EWS is developing products and offering community-based solutions including peer-to-peer trading using automated platforms

Energy trading: Peer-to-peer electricity trading

Challenges:

- Development and implementation of energy management within the community and app development require time and co-operations.

Lessons learned:

- A digital citizen energy workshop where the group's prosumers and the energy transition enthusiasts discuss the development of new technological solutions via newsletters and surveys would improve understanding with new participants.

References:

https://www.ews-schoenau.de/die-ews-solaroffensive/modellprojekt/

'Customer participation in P2P trading: a German energy community case study', Behind and Beyond the meter - Digitalization, Aggregation, Optimization, Monetization, Chapter 4, 2020, Pages 83-104 https://doi.org/10.1016/B978-0-12-819951-0.00004-9

5.4 Sustainable Energy Village Feldheim (DE)

Location: Germany

Webpage: https://nef-feldheim.info/the-energy-self-sufficient-village/?lang=en

5.4.1 Short description

In cooperation with a start-up company 'Energiequelle' and the local residents of Feldheim, the Feldheim local council installed four wind turbines in 1997. By the year 2015, the number had expanded to 47 wind turbines with a total capacity of 74MW. A battery storage system was installed to save the surplus energy, more than enough to supply electricity to the village for two days. In the year 2008, the community decided to build a biogas plant to further reduce the overall energy costs by providing district heating services. The biogas-fired thermal power station covers the total heating demand of the village and the surplus heat is also used to generate electricity. Additionally, a solar PV farm was added to the energy system of the community, producing electricity for over 600 households. The rapid growth in renewable energy development led to the establishment of the Feldheim Energie GmbH & Co. KG by local citizens. Feldheim achieved its energy independence through local generation, energy storage and even a private energy network. The energy system is gradually increased to the size of 81.1 MWp Wind, 2.25 MWp Solar PV, 500 kWe/ KWt biomass plant and 10 MWh energy storage.

Energiequelle GmbH designed the various components of this concept – which includes cutting-edge, state-of-the-art wind power systems and biogas plants –, installed them as turnkey systems and linked them via the new heat and power distribution system to form a regional energy supply grid.

Organization type: GmbH & Co. KG

Use cases: capacity sharing, shared local energy storage, load balancing

5.4.2 Business model description

The energy community meets all its energy demand locally and sells the surplus generation to the national grid. The energy community had to build its own parallel electricity network, after the initial attempt to lease the network from the official utilities failed. Hence, it owns a community electricity and heating network, and is independent on demand side from the national electricity network. This alternative arrangement led to one third lower energy prices which is independently determined by the energy co-operative irrespective of the retail prices at the centralized energy system.

German wind turbine manufacturer, Enercon, Energgiequelle and Feldheim energy community jointly developed a 10 MWh energy storage facility for local balancing and to stabilize the electricity network of German transmission system operator 50 Hertz. In other words, this community energy storage facility also provides frequency regulation for the transmission system operator. The coordination and the interaction between the energy system actors and the energy community has led to this new business model and its application. Feldheim is a good example for the potential role of local energy initiatives and energy system actors to develop the community energy systems.

Challenges:

- Establishing a local parallel power and heat grid required the pooling of financial resources from the community members. However, the municipality and the local residents were unable to put up the investments needed to build the separate electricity and district heating grids. Additional funding from the regional government and from EU programmes were therefore tapped into.
- The major roadblock to the Feldheim community becoming entirely energy self-sufficient: Utility company E.ON refused to sell or lease its electrical grid to the village

References:

Binod Prasad Koirala, et al, 'Community energy storage: A responsible innovation towards a sustainable energy system?', Applied Energy, Volume 231, 2018, Pages 570-585, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2018.09.163

NEFF. New Energies Forum Feldheim 2016 <http://nef-feldheim.info/?lang=en > [accessed August 17, 2016].

https://www.energiequelle.de/content/map_projekte/feldheim/

5.5 Next Kraftwerke – Virtual Power Plant (DE)

Location: Germany

Webpage: https://www.next-kraftwerke.be/en/technology/next-pool/

5.5.1 Short description

Next Kraftwerke is the operator of Next Pool, one of Europe's largest Virtual Power Plants. Next Pool aggregates different types of renewables as well as industrial and commercial power consumers and power-storage units. Electricity and the flexibility of the connected power plants and power consumers is traded various European electricity and balancing power markets.

Currently Next Kraftwerke operates in Belgium, Netherlands, Germany, France, Poland and Austria and represents 6,412 units of the total capacity of 5,406 MW. In 2016, the annual volume trade was 10,2 TWh. Next Kraftwerke also trades guarantees of origin.

Use cases: Energy trading, Control-Based Demand Response and Capacity sharing, Virtual Power Plant pool

5.5.2 Business model description

The connected plant owners benefit from the economies of scale by acting jointly and get their share of the revenues based on their service provisions in the pool. The member's electricity and flexibility is offered at the day-ahead and intraday markets of the EPEX Spot power exchange, the balancing energy market and other international electricity markets such as EXAA in Austria. Next Kraftwerke also offer portfolio and balancing group management.

Table 3: General information on the Next Kraftwerke business model

Membership	Open to anyone
Locational limitation	No
Type of energy	Electricity, CHP
Purpose	Sell power, Balancing, energy sharing
Electricity sharing	yes
Imbalance responsibility	yes
Market access	yes
DSO status	no

Energy trading: aggregate, monitor and manage client energy resources via virtual power plant, and trade on the electricity market

Challenges:

- Grid bottlenecks result in immense costs.
- Unified pricing area in Germany, a large amount of money is lost to keep the electricity prices same.
- Energy policy has to be changed to keep up with the technical and economic development of renewable energy
- Storage would be required with an increase in Electric Vehicle share and with regional grid bottlenecks.

Lessons Learned:

- Keeping up with technological developments and meteorology helped better manage decentralized generation resources.
- Interesting for clients to combine flexible power supply with the avoidance of extreme peak loads, as it was analysed that the value of flexibility on the spot market slightly decreases when there is a reduction in peak load.

- Since the introduction of the mixed price system 'Mischpreisverfahren' in 2018, the reservation prices have gone up drastically, and the activation prices have dropped considerably. Interested parties would have lesser incentive to invest in performant forecasting and are not eager to trade away imbalances in the intraday market.

References:

Tounquet F., De Vos L., Abada I., Kielichowska I., Klessmann C., Energy Communities in the European Union - Revised final report, ASSET 2019

Lettner, Fleishhacker, 'An assessment of the economics of and barriers forimplementation ofthe improved business models' BestRES, Septmeber 2017

https://www.cleanenergywire.org/news/start-next-kraftwerkes-renewable-virtual-power-plant-stabilises-grid

5.6 SonnenCommunity (DE)

Location: Germany

Webpage: https://sonnen.de/sonnencommunity/

5.6.1 Short description

The sonnenCommunity operates in Germany, Austria, Switzerland and Italy and is a community of sonnenBatterie owners who share their self-produced energy. Members are exclusively using energy from the community and have no need for a conventional energy provider. Combined with a photovoltaic system the sonnenBatterie is used to maximize the member's self-consumption. Surpluses are fed into a virtual energy pool that serves other members. A central control system monitors all sonnenCommunity members and balances energy supply and demand.

Organization type: Virtual Power Plant Pool

Use cases: Energy trading, Energy sharing, Control and Re-dispatch

5.6.2 Business model description

The sonnenCommunity is the first decentralized energy community in Germany. It connects people who produce their own electricity into a large, independent network. All sonnenBatterie owners are virtually and intelligently connected to one another in the sonnenCommunity and can - depending on requirements and weather conditions - feed excess electricity into the community or draw the electricity they need from it.

The members share their excess energy via online application with one another - there is real independence from the electricity supplier, which also pays off, because those who sell their self-generated electricity surpluses to other members of the sonnenCommunity will even get better prices than selling them to large electricity companies. Members who obtain electricity from the sonnenCommunity also pay lower average prices for community electricity - because the profit margin of the energy companies does not apply.

In the background, the central software recognizes how much electricity is being produced and how much is being used at all times in the SonnenCommunity. This facilitates to keep supply and demand in balance and ensure that there is always enough energy available.

The sonnenCommunity completely replaces the electricity supplier and makes its members 100% independent.

Community membership costs 19.99 €/month. Anyone can join and profit from the low electricity cost. When purchasing electricity from the community, the costs are 0.23€/kWh, which results in a saving of atleast 0.0616€/kWh regarding an average electricity price of 0.2916€/kWh in 2017. Membership additionally comes with a discount of €1875(gross) on the "sonnenBatterie", the Li-ion battery storage system of Sonnen. Members who do not produce their own electricity with a PV system can also purchase the battery. The batteries serve as temporary storage units for the electricity trading.

The technical data sheet recommends the "eco8/6" battery (capacity: 6.0kWh) for an electricity consumption of up to 4400kWh/a. The battery life time is designed for 20 years, although only ten years and 10,000 cycles are guaranteed.

The cost of the "eco8/6" is around €10,990 for non-members, and around €9100 (1519€/kWh) for community members. Community members with a battery storage unit from Sonnen can book an electricity flat-rate tariff called "sonnenFlat" (For the "eco 8/6" the tariff "SonnenFlat 4250" can be booked, which includes a maximum annual free electricity supply of 4250kWh. The 4250kWh/a includes direct PV self-consumption and electricity consumed from the battery storage). With this concept, the storage owner has no negative impact from cuts in self-consumption, while Sonnen applies the storage capacity for marketing and trading.

Table 4: General description of the Sonnen Community project

Country	Start year	Objectives	Network size	P2P Layers	Outcomes	Shortcoming
Germany	2015	P2P energy trading with storage system	National	Energy network, Business	An online P2P trading platform	No discussion on local markets

Control energy

All members who make their sonnenBatterien available to the public power grid as short-term intermediate storage receive permanent electricity in return for 0 euros to cover their own needs.

Redispatch

In cooperation with Germany's largest transmission network operator TenneT, sonnenBatterien were used for redispatch for the first time. The decentralized battery storage systems networked with blockchain technology help to stabilize the power grid.

Redispatch measures are necessary interventions in the electricity production of conventional power plants and renewable energy sources. If the forecasts for the following day predict a storm and thus a lot of wind energy, the network operators can prepare their plans accordingly. Electricity from wind power is largely produced in northern Germany, while the industrial centres with high electricity requirements are located in the south. What is missing is sufficient capacity to transport this electricity. If so much wind power is generated in the north that the existing transmission grids can no longer transport it to the south, redispatch measures must be taken to intervene in electricity production. This can mean that wind turbines in the north are limited or even switched off so that the power grid does not collapse.

To ensure that this valuable electricity from renewable energies is preserved, sonnen's battery pool offers the solution. If the situation arises again that the grids can no longer transport the energy produced, the electricity is stored in the sonnenBatteries.

Participating sonnenCommunity members help to integrate renewable energies even better into the electricity mix. In addition, the network expansion, and thus costs for society, can be reduced.

Challenges:

- There has not been any discussions or intentions to participate in the local markets

Lessons learned: This business model is possible when renewable energy or electricity supply costs are lower than the existing electricity rates. The model utilizes structures that can benefit prosumers, brokers, and consumers in areas where the electricity market is deregulated. In the future, P2P electricity trading will continue to expand as the number of areas where electricity brokerage business is permitted increases and renewable energy and storage devices costs decrease.

References:

Vonsein, S., Madelener, R., 'Li-ion battery storage in private households with PV systems: Analyzing the economic impacts of battery aging and pooling', Journal of Energy Storage, Volume 29, June 2020, https://doi.org/10.1016/j.est.2020.101407

Zhang, C., The 8thInternational Conference on Applied Energy –ICAE2016 'Review of Existing Peer-to-Peer Energy Trading Projects', Energy Procedia 105 (2017) 2563 – 2568

5.7 Lichtblick SchwarmBatterie (DE)

Location: Germany

Webpage: https://www.lichtblick.de/zuhause/solar/schwarmbatterie/

5.7.1 Short description

SchwarmBatterie, is a service provided by the energy supplier Lichtblick to control and optimize the purchase, storage and feed-in of solar power.

The LichtBlick Schwarm Batterie regulates the user's solar power - it controls whether the user feeds in, stores or draws power. The SchwarmBox ensures the safe and smooth operation. It distributes the solar power in the household and monitors its feed into the grid. The Schwarmbox also helps to relieve the public grid: If too much has been fed in, it draws electricity from it and stores it in the battery storage system. The users will also benefit, as they can use the stored energy without any cost.

Organization type: Virtual Power Plant network

Use cases: Peer to Peer Trading, Grid managemen, Energy sharing

5.7.2 Business model description

'Schwarm Energy' is a set of services provided by energy supplier Lichtblick. The 'SchwarmDirigent', which is a part of the Schwarm Energy services, is a unique IT-based platform. Through this platform, the processes of an increasingly complex energy system and market to consumer-friendly products and services to residential and business consumers are combined together. The local power plants owned by the consumers and their storage capacities are optimized. Schwarm Energy facilitates a meaningful and useful interaction of the distributed and renewable energy sources in the network. The company Lichtblick uses the main utility distribution network for the different Peer to Peer (P2P) energy transactions.

Table 5: General description of the Lichtblick project

Country	Start year	Objectives	Network size	P2P Layers	Outcomes	Shortcoming
Germany	2010	IT Platform for energy markets and customers	National	Energy network, ICT	Plenty of services provided by the energy supplier	No discussion on local markets

Activities:

Lichtblick has developed the SchwarmDirigent, which is a technology and IT platform which accounts for the different controlling needs in a context of decentralized energy. SchwarmDirigent provides several services for inter-related activities such as energy supply, decentralized power supply, forecasting and optimization, grid management, plant operation, trade and logistic or even the management of customer relationship. For these activities, the SchwarmDirigent platform deals with several components and actors such as renewable energy capacities, mobile and stationary storage facilities, combined heat and power units, decentralized consumer loads, power exchange, energy reserve markets, smart grids, external market partners, household and commercial consumers.

References:

Moritz, L., 'Unlocking the value of digitalization for the European energy transition: A typology of innovative business models', Energy Research & Social Science Volume 69, November 2020 https://doi.org/10.1016/j.erss.2020.101740

K.Kusana, 'Optimal peer-to-peer energy management between grid-connected prosumers with battery storage and photovoltaic systems', Journal of Energy Storage, Volume 32, December 2020, https://doi.org/10.1016/j.est.2020.101717

5.8 Energienetz Hamburg eG (DE)

Location: Germany

Webpage: https://www.energienetz-hamburg.de/

5.8.1 Short description

With a vision of a 'democratically controlled fairly priced and renewable energy supply' for Hamburg's residents, Community energy co-operative Energienetz Hamburg eG was founded in 2010. Since they were founded, the group has been campaigning for energy independency in the city of Hamburg, encouraging greater energy efficiency in the city, selling cheaper electricity directly to the community members, and decide for itself how much renewable capacity is to be connect to the local distribution grid.

Organization type: eG, registered cooperative company

Use cases: Capacity sharing

5.8.2 Business model description

Energienetz Hamburg began an ambitious campaign to recruit fellow 'Mitstreiter' – brothers in arms/ members, in their campaign for a 100% community-owned and run energy industry in Hamburg. Each member in the growing collective have some financial stake in the project, but the same voting rights depending on the size of their respective investment in the project. The immediate goal of the cooperative was the purchase of Hamburg's electricity distribution grid previously owned by the Swedish energy giant Vattenfall.

The future plans of the cooperative include investments in distributed generation along with energy storage facilities, to move Hamburg towards a total independence from the national transmission grid – and away from any dependence on fossil fuels.

Energy distribution: through locally owned distribution network and community renewable energy generation

Challenges:

- The energy distribution networks in Hamburg were profiteering from its residents and decisions about local energy matters were not transparent.
- The purchase of distribution grid and achieving independency from national grid required several years of campaigning and a referendum.

References:

OVO energy, Communtiy Energy White paper April 2014
https://www.ovoenergy.com/binaries/content/assets/documents/pdfs/community_energy_whitepaper.pdf
https://solaroffensive-hamburg.de/

5.9 Heimschuh: Grid-friendly self-consumption and trading of PV electricity (AT)

Location: Styria, Austria

Webpage: https://www.energy-innovation-austria.at/article/blockchain-grid-2/?lang=en

5.9.1 Short description

In the southern Styrian municipality of Heimschuh, one of Europe's first 'Citizens Energy Communities (CEC)' was implemented. Heimschuh is a local energy community aiming to consume locally generated energy, and to be largely independent of any external power sources.

The energy networks in the province of Styria implemented a 100 kW/100 kWh district storage system, which was to be used by 9 households with PV generation facilities. The storage system increased the self-consumption rate of the photovoltaic systems from 30 to over 70 percent.

Within the scope of the "Blockchain Grid" project of the Green Energy Lab, the simultaneous use of storage and trading of PV electricity within the community is being tested using blockchain technology, in which over 20 households are participating.

A control system will be implemented that facilitates transactions only while ensuring network stability. Additionally, a mechanism for trading local network capacities between end customers is also being developed and tested, in order to optimize the network utilization especially in the context of charging electric vehicles.

The Blockchain Grid reverses the approach for congestion management in distribution networks: It should generate the optimal use of free, temporally changing network capacities to generate income for the users (prosumers).

Activities from the project description:

The development of a blockchain-based platform, that enables free energy resources to be shared for the provision of system flexibility (generation of surplus or activation of loads).

- Operation under real conditions in the Heimschuh test network with around 200 passive and 15 active participants.
- A proof-of-concept of the blockchain for energy, storage and network management with the control of flexibilities.
- Legal and technical framework for the use of the blockchain in cooperation with other sub-projects in the model region Green Energy Lab.
- An analysis of the scalability and replicability of the use cases.

5.9.2 Business model description

To implement the Energy Community with active citizen participation, the following concepts are implemented using distributed blockchain technology, which also enable a high degree of automation:

- *P2P trading* enables the local exchange of generation surpluses between customers, which means that locally generated electricity is marketed locally. So far, the surplus electricity has been taken from energy suppliers at comparatively low prices, without taking the local needs and peculiarities into account.
- *Shared storage*: If locally produced electricity is not currently being used locally, this excess energy can be temporarily stored by the customer in a shared storage and consumed again at a later point in time.
- *Dynamic distribution of network capacity*: The aim is the optimal use of free, temporally changing network capacities for both producers and consumers. This enables the customers to make free network capacities available in a network section in a non-discriminatory manner. The network operator acts as the provider of the platform.

Energy trading: P2P trading

Challenges:

- Technical challenges: a pure worst-case analysis for the infrastructure dimensioning no longer makes sense in all cases. Modern charging stations with a maximum output of 22 kW significantly exceed the typical output assumptions of 2- 4 kW for residential complexes in Central Europe.
- The control of user flexibilities is still to be checked, and the legal and technical framework for the use of the blockchain to be further improved
- A high degree of automation is required for the operation of the system.

References:

https://www.e-netze.at/Strom/Projekte/Blockchain/Default.aspx

https://www.meinbezirk.at/leibnitz/c-lokales/oesterreichweites-energie-leuchtturmprojekt-in-heimschuh-eroeffnet_a2265527

https://www.energy-innovation-austria.at/article/blockchain-grid-2/?lang=en

https://www.e-steiermark.com/pressemitteilungen/premiere-20-haushalte-testen-in-heimschuh-den-insel-handel-von-sonnen-strom

5.10 Svalin co-housing complex (DK)

Location: Denmark

Webpage: http://the-energy-collective-project.com/context/

5.10.1 Short description

Svalin is a sustainable co-housing community with over 50 households in Roskilde, Denmark. The houses and the shared infrastructure were designed to accommodate solar panels, geothermic heat pumps and electric cars. The project is functioning as a live laboratory for the research project Energy Collective of the Technical University of Denmark (DTU). The project experiments trials with the local self-sufficiency and the sharing of economy. The community is energy positive, it produces more renewable energy than it consumes on a yearly basis. Each household consumes its own generated electricity, while the surplus is transferred to the electric grid under the current Danish regulatory framework.

Organization type and use case: Energy collective project (Co-housing community), Community based energy sharing, peer to peer energy trading

Objectives and activities:

The objectives are to collectively consume 100% renewable and local renewable energy by sharing their energy generation, while avoiding the traditional intermediary parties. The aim is to be the first demonstration site in Denmark, of a community consuming and sharing electrical energy collectively among community residents. Also, the other aims are to promote Environmental consciousness about the use of electricity and be an inspiration to other municipalities. Activities include generation of renewable electricity and consumption; Energy services; electro-mobility; energy sharing

5.10.2 Business model description

Through the designed shared infrastructure, renewable energy generation is shared between several houses in the community. The project investigates consumer-centric electricity markets in several forms like community-based, peer-to-peer etc., with the main goal to redesign the production, consumption and the exchange electric energy. Another main objective of the business model is to avoid the traditional intermediary parties between the generator and the consumer.

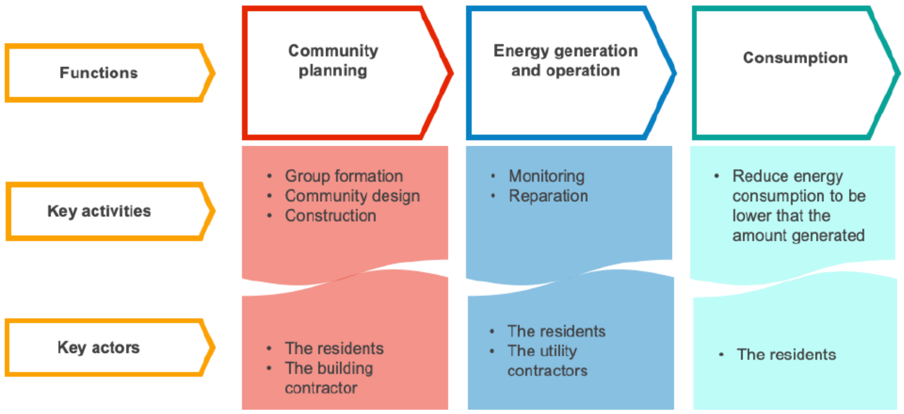

Figure 8: Value constellation for district heating (source: Chau Tran Thi Minh 2020)

Designed to be a positive energy community, the actual revenue comes from the surplus solar power generated. Within the government's Feed-in-premium (FiP), the surplus electricity fed in to the grid is paid for EUR 8 cents per kWh. The costs associated with the energy generation includes maintenance and other possible reparation expenses.

The income from energy generation is considered in the form of lower annual electricity and heating costs, while the maintenance costs are paid annually, so in the case of the community, no net profit is generated on a yearly basis.

Energy distribution and trading: peer to peer trading of locally generated electricity from renewable resources using a P2P trading online application (https://p2psystems.shinyapps.io/ShinyApp_Project/). There is still discussion on how to optimally share the electricity generated, mainly within the community than outside of it.

Challenges:

- The establishment of new regulations for a sharing economy within the power sector - Danish regulation forbids a household from directly using the electricity generated from its own solar installations; the power generated must be fed into the regional power grid and sold to the respective local energy utility, while the residents consume power from the wholesale market.
- The cost of setting up the designed system infrastructure in the community – could be high, and pooling of resources by the residents could be difficult.
- Social challenges – there is a lack of social cohesion among the residents, referring to the sense of being less connected among themselves.
- Improving the energy efficiency of each household to remain net positive.

Lessons learned:

- Discussions with the households to improve the number of community participants and acceptance really helped.

References:

E. Sorin, L.A. Bobo, P. Pinson (2018). Consensus-based approach to peer-to-peer electricity markets with product differentiation

T. Baroche, P. Pinson, R. Le Goff Latimier, H. Ben Ahmed (2018). Exogenous approach to grid cost allocation in peer-to-peer electricity markets

Chau Tran Thi Minh, ‚Social business model for sustainable energy Danish community energy ‘, Masterthesis, Universität Utrecht, July 2020

5.11 Heat Smart Orkney (HSO) – smart community energy (UK)

Location: Scotland

Webpage: https://www.communityenergyscotland.org.uk/projects-innovations/heat-smart-orkney/

5.11.1 Short description

Though the island of Orkney has high wind generation capacity, it loses the possible revenue due to grid curtailment. For the islands of Rousay and Eday, an average generation greater than 45 % was impeded and curtailed. The project Heat Smart Orkney, which is funded by the Local Energy Challenge Fund of the Scottish Government, provides a solution by connecting the community owned wind turbines to the heating of local homes. An aggregator platform is implemented to monitor the signals from the distribution system operator's Active Management System to control the demand-side management for the load of 264kW of the local hot water storage heaters. Over 70 properties have already benefited from the project. With replacement of resources and the implemented efficiency measures, a total of 4.700 litres of oil, 8.000kg of coal and wood and 20,4MWh of electricity could be saved. Due to the success of the project, the rebate to compensate the residents for the additional power used in their home, at a higher cost than the alternative provision of heat was doubled, to promote further incentive for project participation

Use cases: control based demand response

5.11.2 Business model description

The aggregator signs up the multiple small additional loads into large enough bundles so they can participate in the markets for different revenue streams. In the UK, OVO energy have been involved in trials in the Orkney Islands where excess generation from onshore wind farms is diverted into domestic heat storage rather than being curtailed, due to unavailability of demand.

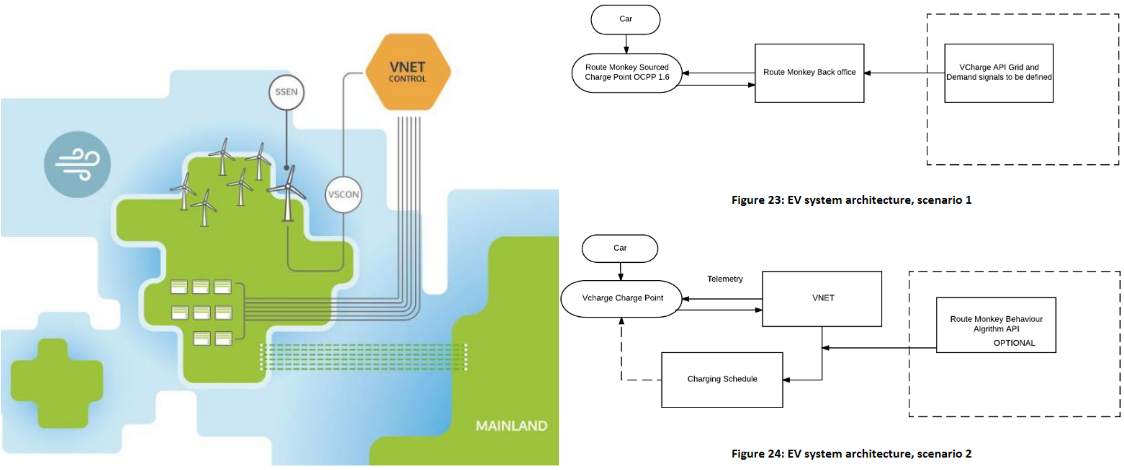

Figure 9: General description of the Orkney project (left, source Pakenham 2019) and system architectures of two analysed scenarios with EV (right, source: SMILE 2017)

Challenges:

- Energy poverty in the island residents was high
- Domestic heating required expensive fuels

Lessons learned:

- Experience in the implementation of new smart grid architectures in preparation for the deployments in large scale
- The project enabled the grid operators and suppliers to understand the requirements for smart grid systems and improve their existing designs
- The project helped to propose new innovative business models and regulations to enable the deployment of smart grid systems at affordable costs for device owners, energy suppliers and operators.

References:

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5.12 Surf 'N' Turf (UK)

Location: Scotland

Webpage: https://www.surfnturf.org.uk/

5.12.1 Short description

The concept behind the Surf 'n Turf project is to enable Orkney island to both generate and consume more electricity locally, to reduce the import of fossil fuels and curtail energy related CO2 emissions, and to support Orkney communities and businesses to harness locally sourced renewable energy.

Surplus electricity is locally generated from renewable energy sources than consumed, and the surplus zero-carbon power is exported to the UK National Grid. There are even times when so much surplus energy is generated, that the interconnecting power cables reach full capacity, meaning the production of electricity has to be capped and a large share of possible generation should be curtailed. Some turbines must be switched off, and clean energy goes unharnessed.

Use cases: capacity sharing

5.12.2 Business model description

Community Energy Scotland and partners founded the project Surf 'n Turf to enable Orkney to locally generate more electricity and to decrease CO2 emissions with the use of an electrolyser to produce hydrogen from surplus power from the installed community wind turbine. The produced hydrogen is stored and shipped to Kirkwall, where the hydrogen is used to generate electricity, which is used to power facilities in the Harbour area and to the ferry ships when they are docked.

The funding required by the project was primarily received through the Local Energy Challenge Fund (Scottish Government) and is led by the Community Energy Scotland, in partnership with the EMEC, Orkney Islands Council, Eday Renewable Energy and ITM Power. The project was launched in September 2017, and is laying the foundations for hydrogen as a fuel to be used at sea. The use case also involves proving the technology on dry land, and enabling potential users to get hands-on experience. The fuel cell used is designed to marine standards, so it can act as a training rig for ship engineers and crew members

Challenges:

- Potential significance to shipping and other industries involves the training and exploration of new opportunities with clean fuels, and also to communities that are have a rich potential in renewable energy resources, but have grid issues of their own.

References:

https://www.communityenergyscotland.org.uk/projects-innovations/surf-n-turf/

http://www.seafuel.eu/wp-content/uploads/2019/10/Orkey.pdf

5.13 Jokkmokk: community owned district heating energy plant (SW)

Location: Sweden

Webpage: https://leco.interreg-npa.eu/events/show/leco-study-visit-solar-energy-jokkmokk-sweden/

5.13.1 Short description

The Jokkmokk municipality has about 5,000 inhabitants and is situated in the inland of Norrbotten, Northern Sweden, close to the Arctic Circle. Jokkmokk is a Swedish Eco-Municipality and a signatory of the EU Covenant of Mayors. The municipality has developed its own Sustainable Energy Action Plan and is committed to further reduce its greenhouse gas emissions by at least 20% until the year 2020, compared to the year 2005.

The community district heating supplies public buildings in Jokkmokk and also private households and companies. In the year 2017, around 34 GWh of heat was delivered from the facility to consumers. A 17 MW wood chip boiler is used for the major share of the year, and a pellet boiler of 3 MW is used in the duration between end of May to mid-September. The district heating company currently has just eight employees. Up to 99% of the delivered energy is produced by bioenergy, however, successfully increasing the energy efficiency is important both economically and ecologically.

Additionally, a 11 kW solar PV capacity in central Jokkmokk has been installed, with an objective of increased self-consumption, as the Swedish funding system rewards a higher self-consumption with PV installations. In this case, electricity is used by a restaurant in the building and to charge electric cars. The surplus generation if any, is fed in into the grid and sold to the electricity company Vattenfall.

Organization type: municipality owned company

Objectives:

- A 15% reduction of energy consumption per capita until the year 2015, a reduction of 20% until 2020.
- A 3% reduction of energy consumption within the municipal sector per year
- Increased connection to the community biomass district heating system with 1% increase per year
- Increased use of renewable energy sources within the municipal sector, at least 10% until the year 2020

Use cases: community district heating, capacity sharing

5.13.2 Business model description

Jokkmokk district heating is 100% owned by the Jokkmokk municipality. The investment costs for material were around 1200 €, and the labour costs around 9000 €, while the expected cost saving is about 14815 €/year. Subsequent projects will most likely be less profitable.

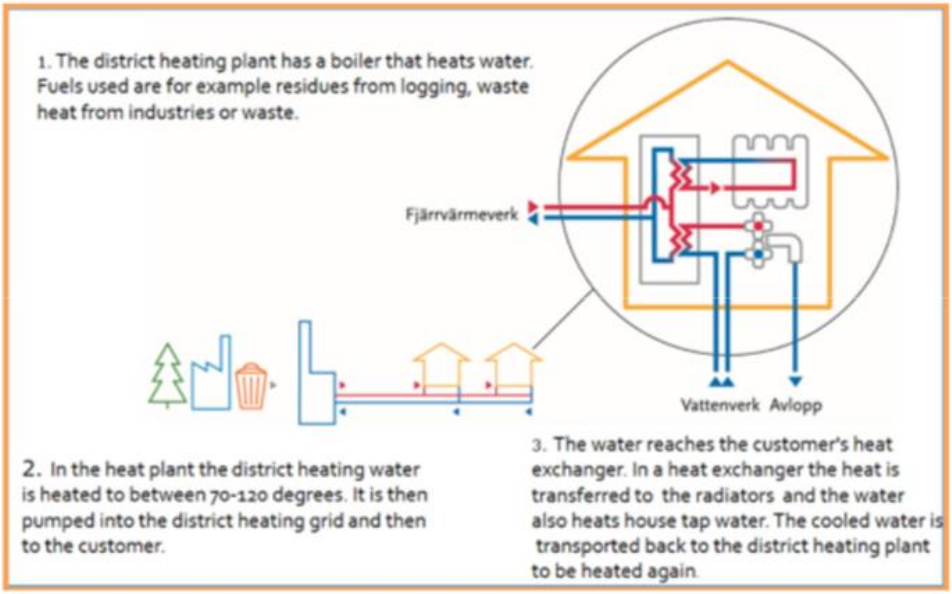

Figure 10: Illustration of the district heating network in Jokkmokk

Challenges:

- Conducting network activities with other municipalities and the regional economy
- The recruiting of highly educated staff capable of developing and implementing this type of projects successfully
- Non-functional infrastructure: Some substations were not working properly. These needed to be checked, overhauled or possibly changed.

Lessons learned:

- In the long term, proper and continuously working control system and a strategic efficiency plan are required.
- Energy efficiency projects have short payback period and economic, environmental and social benefits.
- A higher efficiency will lead to lower fuel costs, and will protect the forests. It will preserve biodiversity in forests and forests also function as CO2 sink.

References:

https://localenergycommunities.net/wp-content/uploads/2019/05/SWEDEN-CASE-STUDY-1.pdf

http://www.recentnpa.eu/wp-content/uploads/2016/03/Jokkmokk_CaseStudy.pdf

https://localenergycommunities.net/wp-content/uploads/2019/05/Jokkmokk_PilotFeasibilityStudy_Vuollerim_Final.pdf

5.14 Kagu Energy Cooperative (ET)

Location: Estonia

Webpage: http://co2mmunity.eu/wp-content/uploads/2018/10/Factsheet-kagu.pdf

5.14.1 Short description

Kagu Energiaühistu (Kagu energy cooperative) is a unique model of a non-profit organisation operating in Estonia. Kagu energy cooperative is not yet involved with any renewable energy projects, but is in the process of completing feasibility studies for two solar plants in the town of Värska.

Organization type: Commercial association

Use cases: Feed in Tariff

5.14.2 Business model description

The association aims at ultimately supporting and advancing the economic interests of its members through collective entrepreneurial activities. The members of the commercial association join either as a consumer or supplier. To establish a commercial association, there is a minimum requirement for a capital of 2,500 € and there must be at least two founders. Moreover, if the annual turnover of the association exceeds 40,000 €, the association must register as a VAT payer with the Tax and Customs Board in the country.

The financing model has not yet been designed but the association is expected to offer shares in the project to the local residents for investments in the solar PV plants. The power plant will sell electricity to the grid, as the possibility to sell locally generated electricity directly to the members of the association is prohibited under the Estonian Law.

Another alternative considered by the association is finding a company that could buy the electricity generated by the association. In this case, the solar PV plant should be installed on the property of the company, as the electricity generated can be either consumed on-site or injected into the grid, according to Estonian law. The project is economically viable thanks to a 5,37 ¢/kwh feed-in tariff offered by the Estonian government. However, the payback time of 11 years is still considered long, and might not attract a large number of investors.

Some of the other options also considered is to wait for a decline in the overall costs of PV technology, or for investment grants making the investment more convenient for the association members. The motivated project leaders are willing to proceed already with their initiative, even with such a long payback period to set an example for others in Estonia.

Challenges:

- Electricity generated by the association facilities cannot be directly sold to its members, as per regulation.
- Comparatively low Feed in Tariffs in Estonia – not really an incentive for investors
- The costs of connecting to the national grid is entirely the responsibility of the power plant owner.
- The upgrade of transmission grid in several identified areas for Solar PV installations is an absolute requirement.

Lessons learned:

- It is important to start something collectively, even not related to the project, to improve social reach of the association
- Learning from the experience by installing a small communal PV for feasibility
- Goals should be set optimally and as realistic as possible, a very high goal could be counter-productive.

- Access to people with technical knowledge and experience in energy projects is important, especially when starting a project from scratch.

References:

http://co2mmunity.eu/wp-content/uploads/2018/10/Factsheet-kagu.pdf

Ruggiero, et.al., 'Context and agency in urban community energy initiatives: An analysis of six case studies from the Baltic Sea Region', Energy Policy, 2021

5.15 Som Energia(ES)

Location: Spain

Webpage: https://www.somenergia.coop/

5.15.1 Short description

Som Energia was the very first energy cooperative established in Spain. The cooperative was founded by 150 members in the year 2010, who were inspired by the community project Ecopower in Belgium and the community project Enercoop in France. Som Energia cooperative offered the possibility for the members to work together to support renewable energy from regional sources to make renewable energy more affordable. The non-profit organisation began by purchasing locally generated renewable energy from existing sources, so members had access to affordable clean electricity. Subsequently, Som Energia built its own solar PV installations and worked on several new renewable generation projects with its local member groups. The aim was to produce enough electrical energy to meet 100% of the members' consumption.

Organization type: Cooperative

Use case: renewable energy supply and energy sharing

5.15.1 Business model description

Som Energia has currently nearly 68.000 members. More than 6000 members invested a total of €15,000,000 in the project. After the Spanish government suddenly stopped providing financial support for Renewable energy generation projects, Som Energia came up with an innovative new financing system called 'Generation kWh', to set up new projects against market price.

The Generation kWh price to be applied for the electricity that the consumers receive, will be calculated based on the real cost of generating this electricity in the associated generation plants. Thus, the allocated kilowatt-hours are not free. They have a price that will be equivalent to the cost of generating the electricity. This price is calculated based on the operating costs of the associated facilities, and which may also be subject to adjustment by the Som Energia General Assembly, according to the objective criteria established in the general conditions of the contract. The adjustments could be made with respect to:

- Maintenance costs.
- Generation tax.
- Management costs.
- Linear amortization of the investment over 25 years.

Challenges:

- Som Energia has been facing difficulties (together with other groups) to bring down a new government law which subjects all operators of PV installations in Spain to pay a kind of "sun tax"
- There appears to be a link between the regional freedom movement in Catalunia and Som Energia's movement to become "independent" of the oligopoly.

Lessons learned:

- the developers and local authority used existing educatory institutions provided schools with a multitude of materials, such as posters and promoting school research projects, mainly in order to allow young children to research and engage further with wind farms, to increase awareness.
- Dissemination of project experiences and expertise with other co-operatives and progressive organizations lead to further progress of the cooperative.
- The creation of local jobs is one of the most effective incentive (more than improvements to local infrastructure) to promote community acceptance.
- Several measures, which minimise the visual impact on the landscape have been identified and proven to be more successful at promoting community acceptance than those measures which compensate for the impact.

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5.16 Enercoop (FR)

Location: France

Webpage: https://www.enercoop.fr/

5.16.1 Short description

Enercoop was the only renewable energy supplier in France, and their customers were mainly companies. It was founded in 2005 before the liberalization of the French electricity market. After the Fukushima Daiichi disaster in the year 2011, Enercoop saw a large increase in the number of clients and members, from 3000 to 11000. By the year 2014, Enercoop had over 20000 clients, and presently, over 100000 clients. Around 49% of the overall capacity installed throughout the operating region of cooperative is wind power, 45% of centralized hydro power, 5% PV installations and 1% of centralized Biomass facilities. In total, the number of members in the collection of regional cooperatives is up to 50000, out of which there are more than 300 generators. Enercoop operates 100 hydro power plants, 25 windfarms, 104 solar farms and 3 biomass generators, generating a total 249 GWh of electricity in the year 2017.

The aim of Enercoop is to create many regional cooperatives around France where local members can be in charge of all sections of the energy process from generation to consumption. Enercoop intends to make the citizens responsible for the energy they consume through this way. Enercoop is a network of cooperatives which covers the whole of France, up to 11 regional cooperatives and members can chose which regional cooperative they want to belong to.

Organization type: cooperative community-oriented enterprise

5.16.2 Business model description

Enercoop generators are individuals, citizens and communities at the same time. For each kWh of electricity consumed by its customers, Enercoop buys one kWh directly from renewable electricity generators throughout France, mainly possible due to the 'direct contracts' signed (107% direct contracts signed in the year 2019). The articles of association of the cooperative impose that at least 57% of the profits must be reinvested in the means of generation of electricity.

51% of the capital in Enercoop belongs to employees and almost all of the profits are reinvested in the infrastructure. The remaining profits can either be reinvested or can be rewarded to the investors. The network of local Enercoop cooperatives is owned by its 50,000 members.

Due to its cooperative status, the offered price by Enercoop to its consumers are still steady since the last 10 years; unlike in the energy market where price fluctuates, with EDF (EDF Energy, France) prices going up slowly but regularly. The proposed price is a fair price for the consumer, who pays the generator and the distributor through buying the electricity.

The consumers, producers, employees, partners, founders and communities, united in their local cooperative, decide together and make all decisions related to the cooperative. Each member elects their representatives to the Board of Directors on a 1 person = 1 vote basis. The collective interest takes more priority over profit, meaning more than half of the profits are reinvested in the development of the Enercoop project. As the only national supplier in cooperative form, Enercoop also allows their members to understand, participate and take ownership of energy issues, in particular to achieve energy savings. The clients of Enercoop consume 20% less than the French average. Every year, members are consulted at a General Meeting during which they can make their voices heard: they validate the accounts for the previous year and take part in major decisions.

Challenges:

- The French electricity sector is highly centered and centralized around the EDF. The high centralisation has resulted in a very low citizen involvement, as people have been led to believe that they have no role to play in the system.
- Nuclear energy is very well established in France, and an Anti-nuclear cooperative needed a large amount of propaganda. Furthermore, as nuclear power is already carbon free energy resource, no motivation at the national and regional level towards renewable energy technologies like solar PV and Wind exists, in regards to climate change activities.

- Highly difficult to generate interest within the populace, with limited access to information on community renewable energy.

Supporting activities:

- The 'energy saving wiki', which is made available free of charge and is directly accessible from the Enercoop website is a collection of resources and tips for saving energy, including a forum for members to openly discuss energy efficiency issues.
- The 'Dr Watt' training is a personalized support which aims to train individual consumers on energy efficiency through self-diagnosis in a definite and an educational way.
- The 'Support to businesses' is another strategic and tailor-made coaching for businesses, which combines theoretical training and dedicated support for energy-saving actions.
- Surveys to collect its consumers' points of view on energy efficiency were made to increase awareness.

References:

Caramizaru, A. and Uihlein, A., Energy communities: an overview of energy and social innovation, EUR 30083 EN, Publications Office of the European Union, Luxembourg, 2020,ISBN 978-92-76-10713-2, doi:10.2760/180576, JRC119433.

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5.17 Amelander Energy Cooperative (NL)

Location: Netherlands

Webpage: https://www.amelandenergie.nl/

5.17.1 Short description

AEC is an island cooperative which realizes sustainable energy projects in the region of Ameland in Netherlands. AEC is also an active local contributor to increasing the awareness of energy consumption and the promotion of energy-saving measures.

A total of 23,000 solar panels, connected to the island's electricity grid, cover a ten-hectare area and generate enough electrical energy to cover the needs of over 1,500 households per year (approximately 5.6 mio. kWh, i.e. around 20 % of the Ameland's total electricity demand). The remaining 80 % of electrical demand is from local businesses in the island. Ameland has also more than 40 fuel cells (of 2 kW each) that serve as back-up facilities and generate electricity from natural gas. Two holiday parks with a swimming pool on the island are equipped with a gas-fired co-generation system, the Nature Center building uses a gas heat pump, and over100 households have electrical heat pumps. A number of residents have added hydrogen as fuel to their gas heating, and almost all of the street lights use energy- efficient LED bulbs.

The aim of the AEC is to motivate the reduction of energy consumption on Ameland (through behavioural and energy-saving measures), and to generate the electricity for consumption that is still necessary sustainably via solar energy and if possible, other options such as geothermal and tidal energy.

Organization type: Cooperative Company U.A.

Use cases: demand side management and capacity sharing

5.17.2 Business model description

The AEC is a member cooperative for every person with a connection to Ameland. The members of the AEC together form the cooperative. A member can contribute ideas, participate in discussions and also in the decision-making process (about the local future). The meaning of the cooperative is: with each other, for each other and from each other.

The partnership typology which is adopted by the AEC can be said to be the most elaborate co-development and co-ownership partnership. Here, the energy company is involved in all the development phases of the project, from orientation, planning and construction, and to operation and exploitation of resource. The energy company and cooperative now share the ownership of the installations of generation facilities, and often create a separate legal project entity in which both parties have equal (in most cases) or otherwise divided shares. The AEC offered the residents of the island and the owners of recreational homes to participate in the solar park investment via a bond loan, which resulted in many interested people.

- Financing: A mix of private (energy company) and public funding was used as financial structure. The local residents were also able to invest in the park as well, but are not granted any decision making power within the cooperative.
- Actors Involved: Amelander Energie Coöperatie, ENECO and the Ameland municipality
- Participation Structure:
    - Open to all natural or legal persons with a socio-economic connection with Ameland (50 EUR share to become a member)
    - Voluntary leaving (only possible at the end of the financial year, subject to a notice period of at least two months)
    - Voting rights: one member one vote

Challenges:

Disproportionate requirements for supply license

The license which was required for electricity supply is linked to several technical and financial conditions (public service obligations, security of supply, and balancing services).

- The obligations apply at a national scope, i.e. the supplier must be able to fulfil all obligations towards all small businesses and households in the country.
- The technical and financial obligations which are linked to the supply license are related to the national scope, which would mean that small organizations such as AEC are unable to obtain such a license.
- The organizations such as 'RED II' and 'EMD' have the right to formulate the proportionally fair and non-discriminatory procedures, including licensing procedures

Lessons learned/ key Action drivers:

- Grants from the government: the grants for the project were obtained from the European Agricultural Fund for Rural Development, from the the province of Friesland and the municipality of Ameland.
- The partners: ENECO's technical know-how and the co-operation of the city of Ameland considerably accelerated the installation of the proposed solar park.
- An example of a replicable model: The AEC has completely adopted the business model of the energy cooperative "Sustainable Energy Cooperative Schiermonnikoog U.A." on the nearby island of Schiermonnikoog.
- 'Postcode roos' scheme: the members of a cooperative receive an energy tax discount on their energy bills for the locally and sustainably generated electricity.

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5.18 Schoonschip Energie Coöperatie (NL)

Location: Netherlands

5.18.1 Short description

The small group which started the project in the year 2008 to investigate possibilities to set up an energy community expanded to a total of 47 households. The households decided to jointly set up a new floating neighbourhood, independently generating their own energy, and cover their own water and food needs to the most possible extent. The members of this 'Schoonschip community', now generate, store and share their self-generated renewable electrical energy, operate their own local grid and participate in the different electricity markets.

Schoonschip is located in Amsterdam North, within the innovative new neighbourhood of Buiksloterham. It includes 47 households on 30 floating villas, which is home for a total of around 150 residents.

Organization type: energy cooperative

Use cases: capacity sharing, storage sharing

5.18.2 Business model description

Schoonschip is registered as a cooperative of 46 members. Each member operates its own private electricity system with solar installations. Every houseboat has a battery, which is owned and operated by the community. The community also operates on their own, the local grid and the community energy management system. The management system activities include the optimum operation of the batteries, demand side response and surplus electricity exchange with the distribution system.

Decision making bodies in the cooperative:

- The Board: these are cooperative members, appointed by the cooperative (by voting)
- The Supervisory Board: these are members proposed by the board, appointed again by the cooperative (by voting)
- The General Assembly: all members of the cooperative are part of the Gerenal assembly
- The board makes decisions after consulting with the general assembly

Financing: the cooperative receives its financial support from several public and private partners

Participating structure: Schoonschip is a closed local cooperative, consisting of only citizen households in the cooperative.

Challenges:

- Little transparency in the legislation, mainly regarding energy taxes, and real estate legislation.
- Several problems with the City administration, regarding land use and allocation of the parking spaces for the cooperative's shared transport means (electric vehicles).
- Tax issues resulting from the electricity trading are not covered under the 'Experiments Electricity Law' –regime, these issue are a major problem for the feasibility of renewable electricity based local energy communities.

Key Action Drivers:

- Financial support received from City administration and Province for feasibility studies
- Experiments Electricity Law –Regime motivated the project realization
- Example of the fully autarkic ship 'Gewoonboot' made it possible to design the floating himes.

Lessons learned:

- The purchasing of inventory on a collective basis would have been less expensive
- The necessary requirements if documented during the designing stages of the project would have been really useful.
- Documentation and clear instructions on the installation of components to technicians, for connection to the smart grid and batteries in the right way – should have been included in the contracts for the technicians.

References:

Task Force Energy Communities, 'European Union Bridge Horizon 2020 – Energy Communities in the EU', December 2019 https://www.h2020-bridge.eu/wp-content/uploads/2020/01/D3.12.d_BRIDGE_Energy-Communities-in-the-EU-2.pdf

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https://www.metabolic.nl/projects/schoonschip/

https://www.cirkelstad.nl/inspiratie/schoonschip/

5.19 Ecopower CVBA (BE)

Location: Belgium; **Webpage**: https://www.ecopower.be/

5.19.1 Short description

Ecopower CVBA was established in1982. Today, it is one of the most successful energy cooperative in Belgium, acting as a generator and supplier of green electricity. The capital raised by the cooperative is used to finance new projects, in collaboration with other existing cooperatives or otherwise.

The cooperative is an electricity generator and supplier of green electricity and renewable fuels in the region of Flanders. The cooperative also invests in biomass heating with wood pellets for small-scale heating of buildings and for domestic hot water. Its 'Ecotrajet' project aims to assist citizens in the process of energy renovations in their homes.

The cooperative aims and objectives are investments in 100% renewable energy, supply of clean energy to its members from local renewable sources, and the promotion of energy efficiency in the energy system. Ecopower also provides energy services to its members like free check-ups for energy saving, tips and tricks for energy saving, a guide for buying more energy-efficient appliances, a mobile application that assists the user to manage energy saving, rental of power meters, subsidies for the insulation and the replacement of heat pumps, energy auditing support, and consumption monitoring.

Organization type: Cooperative Limited Liability Company (CVBA)

Activities: Generation, supply renewable electricity; Supply renewable heat (biomass); Energy efficiency (Ecotrajet services)

Use cases: capacity sharing and energy saving

5.19.2 Business model description

Ecopower cvba is a Belgian Renewable Energy Sources cooperative (REScoop) with over 48,000 members. The cooperative issues shares to its members and invests the capital generated in renewable energy generation installations such as wind turbines and solar PV.

Every citizen is eligible for membership in the cooperative: by purchasing a share they become a co-owner of the generation installations and are thus entitled to a share in the resulting profits. The members are also given the opportunity to purchase green electricity from local sources at a fair price.

Financing: Ecopower gathers its financial resources from as many cooperative members (shareholders) as possible and uses these funds to invest in its renewable energy projects.

Participation structure:

- Participation is open to every natural and legal person, regardless of their geographical location, and membership is obtained by purchasing a share worth EUR 250, with a limit of maximum 50 shares per member.
- Semi-Voluntary termination (6 months before every 6-year period ends, the members are given the opportunity to cancel their membership. The Board of Directors may allow some exceptions, but may also refuse if this threatens the stability of the cooperative).

Challenges:

"Unfair" competition regarding building rights

- Requirement of a legal agreement regarding permission to build a structure on someone else's property for a mutually determined but potentially unlimited point in time.
- Potentially rich geographical locations for wind turbines is usually being contracted at generous fees to large companies
- Competitive advantage exists only for the larger players.

Disadvantage in the calculation of the profitable peak for PV:

- The Profitable PV peak is used as the basis for calculating the value of the green energy certificates.
- The calculation method for PV peak states that an economic advantage is already gained due to the local self-consumption, so that the value of the green energy certificates is lower - this undermines the overall economic profitability of projects where PVs are placed on the roofs of schools or military barracks, for example, and the generated electricity is supplied to a nearby village, not self consumed.
- Highly difficult to build a business case for PV projects and resulting in suitable roofs not used to the maximum possible extent.

Lessons learned/ Key Action Drivers:

- Subsidies were obtained from the former monument care service for initial investments of the first project and renovation of water mills (4.5 million Belgian francs).
- Ecopower signed an agreement with Iverlek/Electrabel in 1995 to sell their electricity for 2 Belgian francs per kWh. The profits because of the selling price enabled Ecopower to reinvest in new production facilities.
- The establishment of the Organization for Sustainable Energy Flanders (ODE-Vlaanderen) to carry out active lobbying for support mechanisms.
- The introduction of the green power certificates in 2003 made it possible for Ecopower to build more generation facilities and to increase their generated electricity.
- Ecopower becoming an energy supplier in 2003, and improved self consumption has led to an steep increase in the number of members.
- The story of Ecopower focuses on attaining energy democracy, social justice and sustainability. By promoting this message in the community so early and consistently, the cooperative has become successful in comparison to other cooperatives.

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