Empowering local renewable energy communities for the decarbonisation of the energy systems

D1.2 – Definition of the Use Cases

09 June 2023

This project has received funding from the European Union's Horizon 2020 Programme under the Grant Agreement no. 957819

<table>
<tr><th></th><th colspan="5">LocalRES</th></tr>
<tr><td>Project title</td><td colspan="5">Empowering local renewable energy communities for the decarbonisation of the energy systems</td></tr>
<tr><td>Grant Agreement No.</td><td colspan="5">957819</td></tr>
<tr><td>Project Duration</td><td>48 months</td><td>Start date</td><td>01/05/2021</td><td>End date</td><td>30/04/2025</td></tr>
<tr><td>Work Package</td><td colspan="5">WP1 - EU energy market framework for Renewable Energy Communities (RECs)</td></tr>
<tr><td>Task</td><td colspan="5">Task 1.2 - Definition of REC-driven services and Use Cases</td></tr>
<tr><td>Deliverable No.</td><td colspan="5">D1.2</td></tr>
<tr><td>Deliverable title</td><td colspan="5">Definition of the Use Cases</td></tr>
<tr><td>Dissemination Level</td><td colspan="5">PU (Public) / CO (Confidential)</td></tr>
<tr><td>Lead beneficiary</td><td colspan="3">CARTIF</td><td>Deliverable author</td><td>Alberto Belda,
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<tr><td>Due date</td><td colspan="3">30/04/2022</td><td>Version date</td><td>09/06/2023</td></tr>
<tr><td>Status</td><td colspan="5">Working version / Under revision / Final version</td></tr>
<tr><td>Description</td><td colspan="5">Definition of LocalRES project Use Cases in each of the demonstration sites based on the characterisation of the most representative aspects of each of the LocalRES pilots and on the analysis of REC-driven energy market services. The resulting Use Cases will constitute fundamental guidelines for the remaining WPs, and will be used to identify and evaluate potential new scenarios to</td></tr>
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		be implemented after the project, both in the demonstration sites and in other locations with similar conditions.	
Date	**Version**	**Author**	**Comment**
17/08/2022	V1.0	CARTIF	ToC
13/09/2022	V1.1	CARTIF	Integration of methodology, state of the art
28/10/2021	V1.2	CARTIF	Integration of first version of services
21/12/2022	V2.0	CARTIF	First version of use cases
31/01/2022	V2.1	Demos site leaders & technical partners	Review of use cases & services
13/04/2022	V3.0	CARTIF	Integration of use cases, completion of services and consolidation of the whole document
22/04/2022	V3.1	CARTIF	Integration of comments from demo sites partners
25/04/2022	V3.2	CARTIF	Integration of inputs from TECNALIA, ARTELYS and CENTRICA
27/04/2022	V3.3	CARTIF	Integration of inputs from University of Passau, AIT, GridAbility, as regards the Blackout strategies and P2P energy trading services
29/04/2022	V3.4	VTT, ARTELYS	Peer review
30/06/2022	V4.0	CARTIF	Final consolidation (first submitted version)
09/06/2023	V4.1	CARTIF	Revised version

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Executive summary

This document is the result of the work carried out within *Task 1.2, Definition of REC-driven services and Use Cases,* in *WP1, EU energy market framework for renewable energy communities,* and constitutes LocalRES project milestone MS1.

The aim of the present document is to obtain a set of use cases (archetypes) of the Renewable Energy Communities (REC) that will be demonstrated in the LocalRES project pilot sites. According to the norm EN/IEC PAS 62559, a *Use Case* is a *specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system*. Adapting this concept to RECs and the context of LocalRES project, a use case is understood *as a set of one or various services provided by a REC which yields a benefit to the community in a specific context (resources, related regulation, local aspects, etc.) under specific conditions or characteristics (RES technologies, stakeholders, objectives)*. Differently said, a use case can be considered as a system analysis of the REC cases study in which the stakeholders, resources and, technologies are mapped and linked to achieve specific goals.

To develop the archetypes or use cases, a specific methodology has been followed (section 2/), including a thorough literature review of services to be potentially implemented in RECs, the preparation of a questionnaire to map and analyse the types of technologies, available assets, local conditions, needs and strategic objectives, and a collaborative process with local stakeholders to define the use case of each demo. For this process, different sessions and iterations have taken place to identify those services that may contribute to the creation of added value for themselves and opportunities in the EU market.

A thorough literature review has been performed as starting point (section 3/) to identify common practices associated to RECs and related services targeting the EU energy market and the empowerment of consumers, leading to decarbonization and sustainability. For this review, different EU-funded projects have been analysed, as well as other relevant sources. As part of this review, the REC concept has been addressed and compared against the Citizen Energy Communities concept to highlight the different activities and services that each of these figures can perform according to the current EU directives.

The services listed during the literature review to be potentially deployed and delivered by RECs have been analysed in detail from the particular perspective of a REC, considering functional and non-functional requirements, objectives, relevant stakeholders, or specific local aspects. These services have been classified as technical (subdivided into thermal and electrical) and non-technical. Furthermore, they have been categorized by scope or layers of analysis: i) member-focused services; ii) REC services to the markets and the grid in the normal operation mode; iii) REC grid services in the grid alert state. This analysis (section 8/) has been performed using the methodology from EN/IEC PAS 62559 as a reference, but adapting it and simplifying both the structure and the contents to allow non-technical actors interested or involved in RECs to know more about REC-driven services.

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Together with the demo teams, and after several exercises to map and characterise the local conditions in the demo sites, the services of highest interest for the community have been selected for each of the demo sites. These services have been linked between each other and with stakeholders involved in the community to constitute each of the project use cases. Many of the services will be physically implemented along LocalRES project execution, mainly through their integration within the Multi Energy Virtual Power Plant (MEVPP). As a result, four detailed project use cases have been defined, one for each of the demo cases, which reflect the local conditions of each community and can be considered as the foreseen projection of the REC that the demo sites aim at become by the end of LocalRES project (section 4/).

The identification of these project uses cases and services will help Task 1.4 and Task 1.5 in the identification of financing schemes and business models to engage additional consumers and unlock new investments.

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List of acronyms and abbreviations

aFRR	automatic Frequency Restoration Reserve
mFRR	Manual Frequency Restoration Reserve
AWHP	Air-to-Water heat pump
BRP	Balance Responsible Party
BESS	Battery Energy Storage System
CE4EUI	Clean Energy for EU islands
CEC	Citizen Energy Community
CHP	Combined heat and power
DER	Distributed energy resources
DHN	District Heating Network
DHCN	District Heating and Cooling Networks
DR	Demand Response
DSO	Distribution System Operator
EMS	Energy management system
ESSs	Energy storage systems
EU	European Union
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FCR	Frequency Containment Reserve
H2P	Heat-to-power
H/CaaS	Heating / Cooling as a Service
ICT	Information and Communication Technologies
JRC	Joint Research Centre
KPI	Key Performance Indicator
LEC	Local Energy Community
LFM	Local Flexibility Market
MEVPP	Multi Energy Virtual Power Plant
OCPP	Open Charge Point Protocol
ORC	Organic Ranking Cycle
P2H	Power-to-heat
P2P	Peer-to-peer
PNE	Polar Night Energy (Kökar Demo)
PV	Photovoltaics
PT	Planning Tool
REC	Renewable Energy Community
RES	Renewable Energy Sources
RTO	Research and Technology Organisation
TESS	Thermal energy storage system
TRL	Technology Readiness Level
TSO	Transport System Operator
V2B	Vehicle-to-building
V2G	Vehicle-to-grid
VAWT	Vertical-Axis Wind Turbine
WH	Waste Heat

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1/ Introduction

1.1. Purpose of the report

Deliverable D1.2 within LocalRES project reports about the activities performed in *Task 1.2. - Definition of REC-driven services and Use Cases*, that aim at setting the overall approach and framework of LocalRES use cases. According to the norm EN/IEC PAS 62559, a *use case* is a *specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system*. This concept has been adapted to the context of the project and of Renewable Energy Communities (RECs). Thus, in the scope of LocalRES project, ***a use case is understood as a set of one or various services provided by a REC which yields a benefit to the community in a specific context (resources, related regulation, local aspects, etc.) under specific conditions or characteristics (RES technologies, stakeholders, objectives)***.

Consequently, within task 1.2, the REC-driven energy market services have been analysed in detail to support the definition of the project use cases, focusing on the LocalRES demonstration sites by considering the regulation, local aspects, physical resources, technologies, and commitment and desire of the local citizens.

The services that could be potentially provided by RECs have been reviewed based on **three different layers** of analysis:

I. **Member-focused services**, understood as the provision of an added value for the members of the community (e.g. community-based optimization of self-consumption, energy sharing and trading);
II. **REC services offered to the markets and the grid** in the normal operation mode
III. **REC grid services in the grid alert state** (e.g. during a high risk of a blackout).

The services contained within these three analysed levels form the basis for the definition of the project Uses Cases, which will in turn serve as fundamental guidelines for the remaining Work Packages (WPs). Within this document, the functional and non-functional requirements of the use cases have been established by identifying the services to be exchanged, the role of the stakeholders in each service and how they would function and could be implemented in the demonstration sites.

As a result, a set of use cases has been defined, taking into a special consideration the identification of options for customer flexibility, the mapping of energy demand and the distributed energy source potential in each of the demonstration sites, with the aim of studying future scenarios after the implementation of the actions of LocalRES project. These use cases have been designed in cooperation with local stakeholders, who have been involved in different stages of the definition process including interviews, workshops and specific task meetings to receive their feedback and ensure the feasibility of the proposed use cases. The resulting use cases will become the basis for the development process in the following tasks.

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The methodology from EN/IEC PAS 62559 has been consulted as a reference to describe the services constituting the use cases for each demonstration site. Additionally, different Key Performance Indicators (KPIs) have been defined for each of the identified services, connected with the KPIs of Task 4.1, related to the demonstration actions.

1.2. Structure of the report

The present document is structured as follows:

- Section 1/ introduces the purpose of the report, and highlights the contribution of participating partners and main relations to other activities.
- Section 2/ presents the methodological process that has been followed in Task 1.2, including the characterisation and mapping of resources, technologies, commitment of citizens and other local aspects in each of the demo sites. Additionally, a glossary of frequent terms and concepts is also presented in this section, for their consideration both in this task and in the broad scope of LocalRES project in regards to use cases.
- Section 3/ summarizes the literature review which was carried out as starting point of the task to identify the common practices in relation with services in the scope of RECs targeting the EU energy market, and the empowerment of consumers, leading to decarbonization and sustainability. Additionally, the *Renewable Energy Community* concept has been addressed and compared with the *Citizen Energy Community* concept.
- Section 4 includes the characterisation of the most representative aspects of all demonstration sites, and present the four use cases built from the specific sets of services identified as suitable and of interest according to the local context in each demo site.
- Section 5/ presents some general conclusions from the work performed in the task.
- Finally, after the bibliography in section 6/, two annexes have been included:
    - Annex A (section 7/) including both a template of the questionnaire which was prepared in the scope of the task and the summary of results from the questionnaire.
    - Annex B (section 8/) where all the main REC-driven services identified in the task are assessed.

1.3. Relation to other activities of the project

Table 1 shows the main relations of the present report with other tasks of LocalRES project and their associated deliverables, which should be considered along with this document for a proper understanding of its contents.

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Table 1: Relation of current report to other tasks and deliverables

Task/Deliverable	Relation
Task 1.1 / D1.1	Assessment of regulatory frameworks associated to RECs in the countries where the pilot sites are located. Regulation in force and regulatory conditions have been checked for the services identified for the use cases and listed in 0 Annex B.
Task 1.3 / D1.3	Assessment of decarbonization scenarios in each of the case studies. The services and use cases identified within D1.2 for their potential implementation in the future in the demo sites have been inputs for D1.3, for the definition of potential mid- and long-term scenarios.
Task 1.4 / D1.4	Performance of a Cost-Benefit Analysis (CBA) of each of the use cases defined in this report (D1.2).
Task 1.5 / D1.5	Definition of business models and financing instruments in connection with the use cases defined in D1.2.
Task 2.2 / D2.2	Definition of specifications of the Planning Tool (PT), which has included the analysis of the services defined in D1.2 from the perspective of the PT, considering and its capabilities. Review of the services and associated KPIs to promote the alignment with those used in the PT.
Task 3.1 / D3.1	The definition of the REC digitalisation requirements has considered the sets of services included in the use case of each demo site, e.g. for the identification and classification of datapoints.
Task 3.2 / D3.2	Modelling of sector-coupling technologies and reference typologies of buildings considering the preliminary mapping of technologies and local context performed within Task 1.2.
Task 3.3 / D3.3	Development of the REC trading strategy and optimal dispatch of different markets and services separately, which considers the different services (defined in D1.2) aimed at being integrated in each of the demo sites for their inclusion in the work of the task.
Task 3.5 / D3.5	Identification of KPIs relevant to the use cases (D1.2) to be potentially considered in the joint models developed in the task.
Task 4.1 / D4.1	Definition of the KPI-driven evaluation framework and baseline, as well as the contribution to the implementation of pilots' demonstrations. The KPIs identified in D4.1 and those defined to assess the REC-driven services within D1.2 will be considered together to pursue their alignment.

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1.4. Contribution of partners

The structure and main contents of this report have been prepared by CARTIF as lead partner of Task 1.2. Demo site representatives have provided the needed information to characterise the demo sites and have proposed a first list of services that could be potentially applied to their corresponding demo site through a questionnaire. Local stakeholders and associated partners constituting the demo site teams have contributed in the design of the use cases and application to the local conditions of each demo site. Finally, technical partners from *WP3 Digitalisation and management of local energy systems* have checked the suitability of services from a technical perspective, and have helped to complete them. Table 2 summarizes the main contributions from participant partners in the development of this deliverable:

Table 2: Contribution of participant partners

Partner	Contribution
CARTIF	Preparation of questionnaires for the characterisation of the four demo sites, included in section 7/, Annex A. Design of general structure of the report, definition of the methodology, literature review and analysis of services, collection of contributions and writing of the deliverable. Final consolidation.
CENTRICA, TECNALIA, AIT, PASSAU	Overall review of proposed services from CARTIF, included in section 0, Annex B of this report.
Demo site teams	Contribution to the definition of the use cases. Overall review and validation.
DOWEL	Contribution to the regulatory aspects of the services
VTT, ARTELYS	Internal peer review of the report.

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2/ Methodology

This section describes the different steps of the methodological process that has been followed in the scope of Task 1.2, as well as a glossary including relevant terms and definitions associated to the use cases.

2.1. Methodological process followed in Task 1.2

The methodology followed in Task 1.2, *Definition of REC-driven services and Use Cases,* namely for the definition of the use cases in LocalRES project, is represented schematically in Figure 1:

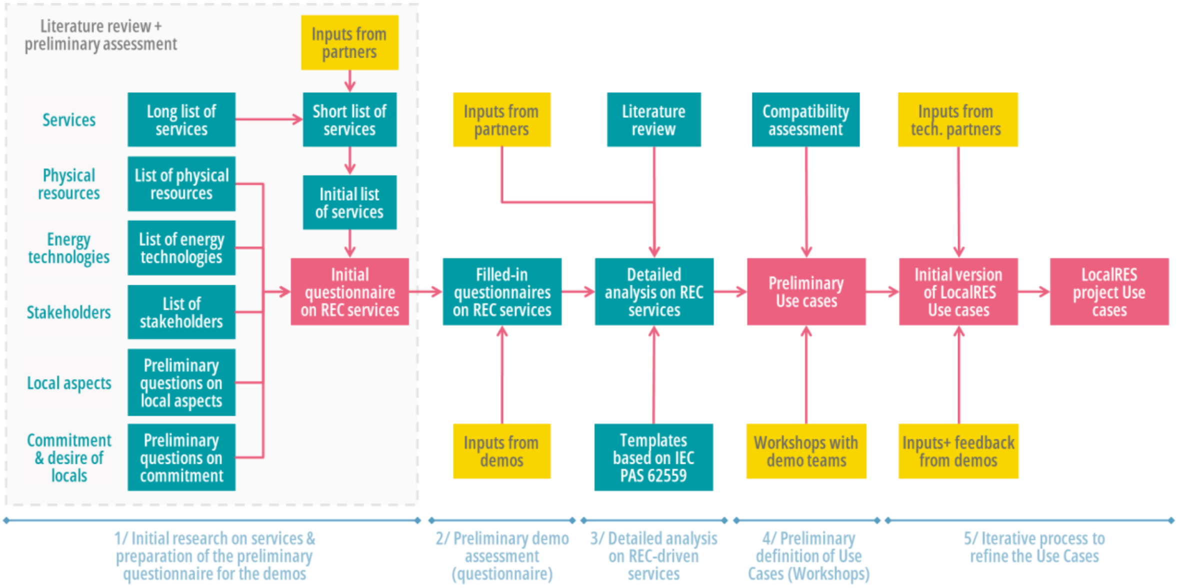

Figure 1: Applied methodology for the definition of LocalRES use cases

As depicted in the diagram above, the methodological process can be divided into five stages:

1. Initial research on REC-driven services & preparation of the preliminary questionnaire for the demo sites
2. Preliminary demo assessment through a questionnaire
3. Detailed analysis on REC-driven services
4. Preliminary definition of use cases through workshop sessions
5. Iterative sessions to refine the LocalRES project use cases

Thus, the first phase started with a **review of existing literature and state-of-the art** of RECs and their associated concepts, such as citizen energy communities, local communities, energy islands or positive energy districts. The review study tried to **identify the most common and accepted services** applied in the context of RECs; therefore, other EU-funded projects directly or indirectly related to LocalRES such as Sysflex, Compile, IElectrix, E-LAND or Renaissance, were revised. From that revision, a preliminary extended list of services was obtained.

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This first long list was later shortened by removing services whose application can be considered out of the scope of RECs and by grouping and merging similar or associated services, reducing this way potential duplicities or ambiguities between services. Next, this shorter list of services was shared with technical partners such as RTOs (Research & Technology Organization) and other relevant stakeholders involved in the project to be refined and validated. As a result, the **initial list of REC-driven services** for the scope of LocalRES project was generated. This list can be found in section 3.3.

The next step was to circulate **a questionnaire among the local stakeholders in the four demo site teams to collect information needed to characterise the demos** in a qualitative way, as well as to find out about the set of services that could be potentially applied in their thermal and electrical energy assets and grids according to the current situation and preferences in the community.

The questionnaire, which can be found in section 7/ Annex A, addressed a wide range of topics to conform a qualitative yet comprehensive basis of the initial situation in every demo site for the of design the use cases and the potential constitution of a REC, including:

- **General information about the demo site**: population, area, range of inhabitants expected to constitute the REC;
- **Availability of information**: weather data, energy strategy and plans, energy demand & production data, etc.;
- **Local natural resources available** in the demo site area;
- **Interest on REC-driven services** in the demo site, according to the initial list of services;
- Current situation about **relevant topics for the constitution of RECs**, including: technical, financial & legal, barriers, citizen and stakeholder engagement, etc.;
- **Status of the local community** prior to the project;
- **Relevance of stakeholders** in the community;
- **Difficulty to engage with stakeholders** in the demo area;
- **Current & future (expected) energy technologies**, both for production, storage and consumption of energy;
- Other relevant **local aspects**;
- Demo's energy **demand profile**;

In order to map a series of particular options, a list of alternatives was provided for some of the previous topics, which had to be scored using a simple numeric scale (0-5). In every case, the associated criterion was simple and clearly stated, as can be seen in section 7/.

In parallel to this assessment, the preconditions of each REC-driven service for its successful deployment were analysed using the methodology from EN/IEC PAS 62559 as a reference, and including aspects such as: scope, objective, involved stakeholders, associated technologies and other local aspects. Also, **specific KPIs were defined for each service**, in line with those defined within Task 4.1. This analysis of each of the services is presented in section 8/, Annex B.

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The information collected through the questionnaire was first analysed to preliminarily evaluate the compatibility of the services with the demo site local conditions. To this end, the suitability of each of the services and different local conditions was assessed, namely: the availability of local resources, the existing interest of the local community on the services, the expected energy technologies in the future in the local area and the demonstration actions that are planned in every demo within the scope of LocalRES project. As a result, the list of services was preliminarily ranked in each of the demo sites.

At this stage, a **first workshop** was held with all demo site teams (demo leader, and technical supporting partners) with the purpose of building a preliminary version of the use cases starting from the ranked list of services and the information provided in the questionnaires. This workshop was held in person in Nice taking the advantage of the second project meeting (M6). During the workshop, it was agreed to define one use case per demo site constituted by a set of linked services, and the demo teams started working on the identification of **relevant assets and actors** involved in these preliminary use cases.

In subsequent online sessions, the demo teams finished an initial definition of the project use case for each of the demo sites with the support of other partners. After several interactions between technical partners, local stakeholders and other members of the demo teams, the LocalRES project use cases were eventually consolidated. These use cases are extensively explained in section 4/.

2.2. Glossary – relevant terms and definitions

A specific glossary has been used for terms used in this report and, since there is not a commonly accepted definition for these terms, they are included in this section to set a comprehensive framework for LocalRES project:

Aggregator: actors within the energy sector responsible for supervising local market operations with the aim of maximizing profits for their Local Energy Community (LEC) members. The cooperation between LECs and aggregators can increase their negotiation power with BRPs and DSOs (see Figure 2). Aggregators can offer flexibility services from LECs to the BRP and the DSO at the same time (Olivella-Rosell, et al., 2018).

Benefit: economic, social or environmental profit generated by services and addressed to REC members, either directly or indirectly, as a community. Benefits can include, for instance, reducing energy costs, implementing new low-carbon technologies, creating new local jobs, or new common-use infrastructures (e.g. green areas) financed with funds generated from the activity of the REC.

Blackout: a complete loss of power in an area, typically affecting large numbers of people over sometimes large areas. Many blackouts are caused by systems or network failures or inadequate energy (resource depletion or climatic conditions of unmanageable resources). (Matthewman, 2014)

BRP: Balance Responsible Party; actors responsible for balancing demand and supply for a certain metering point (Mandatova & Mikhailova, 2014) (see Figure 2).

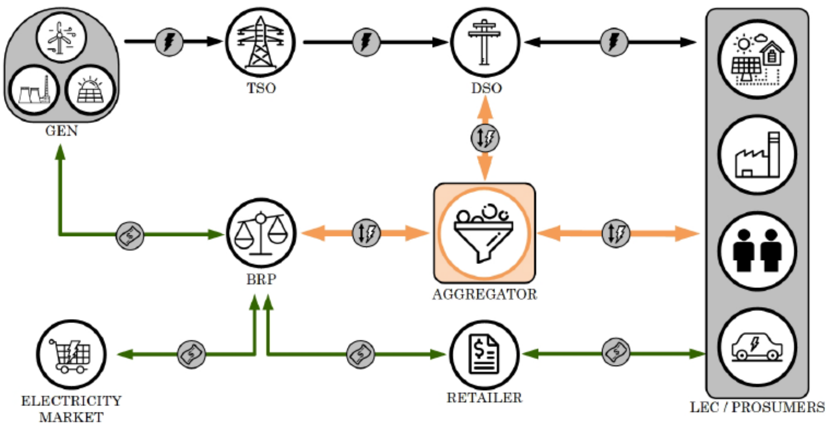

Figure 2. Local flexibility market overview. LEC, Local Energy Community. Source: (Olivella-Rosell, et al., 2018)

DHCN: District Heating and Cooling Network, consists of a centralized urban heating/cooling system that supplies heat/cold to users through pipelines and central (and/or distributed) generation systems. The DHCN can be a local DSO as well, participating in electric local markets,

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and allowing sector coupling strategies (variating thermal demand not only for the DHCN operation, but also for benefiting power grids).

DSO: Distribution System Operator, is a party that operates the distribution grid of one of more energy vectors. These entities are responsible for distributing and managing energy from the generation sources to the end users (Iasonas Kouveliotis-Lysikatos, 2019).

Grid congestion: a lack of transmission line capacity to deliver electricity without exceeding thermal, voltage and stability limits designed to ensure reliability (NRG Editorial Voices, 2018).

Legal issue (or regulation): the necessary legal aspects that are needed to carry out the use case.

LFM: Local Flexibility Market, is an electricity trading platform to sell and buy flexibility within the Local Energy Community (Olivella-Rosell, et al., 2018) (see Figure 2).

Local aspects: the characteristics (orography, land, etc.) of the parcel/s where the community is located.

Peak shaving: is a concept that consists in reducing demand quickly and for a short period of time to avoid a spike in consumption from the grid. This is either possible by temporarily scaling down production, activating an on-site generation system, or relying on a storage system (STORM Project, 2020). Peak loads are to be avoided since they cause an increase in grid usage costs by turning on expensive generation units to cover the peak load (Next-kraftwerke, n.d.).

Renewable energy sources (RES) or resources: energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases[1]. RES must be local (on-site[2]) or from nearby[3] sources.

RES technologies: Systems using RES.

Scenario: each state of a system generated after a change in one or more conditions occurs. Pre-conditions and post-conditions can be defined for every scenario.

Service: every activity offered by the community, either to their internal users (within the boundaries of the community), to external ones (e.g. third parties, market), or both. The services constitute the basic components of the use cases, as defined in the scope of LocalRES project, and have been divided into thermal, electrical and non-technical (see section 3.3 for more information about this classification of REC-driven services). It is to be noted that, in the scope of

[1] ISO52000-1:2017.
[2] ISO52000-1:2017 defines on-site as „premises and the parcel of land on which the building(s) is located and the building itself", as REC consist of more than one building or user, on-site is considered as „on the parcel of land of the community (geographical boundaries of the community)".
[3] ISO52000-1:2017 defines nearby as „the building site on local or district level (e.g., district heating or cooling)" as REC consist of more than one building or user, nearby is considered as „next to the parcel of land of the community (not outside the municipal limits)".

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this task, *services* include both valuable activities for the members of the REC of for external actors, and *capabilities* of the REC, understood as functionalities of the REC that contribute to ensuring a reliable performance of the system (e.g. blackout strategies).

Stakeholder: every actor participating of the system.

System: set of elements that interact with each other. In the context of Energy Communities, namely in the scope of LocalRES project, elements can include participating actors, hardware devices, software, etc.

Use case: a set of one or various services provided by a REC which yields a benefit to the community in a specific context (resources, related regulation, local aspects, etc.) under specific conditions or characteristics (RES technologies, stakeholders, objectives).

> *Definition of Use case according to the norm UNE 62559*:
>
> *specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system. Source: ISO/IEC 19505-2:2012, 16.3.6.*

Waste heat (WH): heat rejected from a process, in which energy (mostly heat and electricity) can be used to produce high-added value products (electricity with ORC, cooling with absorption chillers, or heating with the use of heat pumps (WasteHeat project, 2021)).

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3/ Literature review

In this section a literature review is performed to identify the services that could be deployed and delivered by RECs. First, the concept of Renewable Energy Community and Citizen Energy Community are compared to identify the activities or services that can be performed in each case according to the current EU directive, and highlight the main differences between these two legal figures. Second, the main results of the literature review about potential REC-driven services are summarized, highlighting the main findings from other EU-funded projects. Finally, the list of selected services categorized by scope (layer of analysis) and main objective are presented.

3.1. Renewable Energy Community concept

Energy communities can be understood as *a way to 'organise' collective energy actions around open, democratic participation and governance and the provision of benefits for the members or the local community* (Roberts, Frieden, & d'Herbemont, 2019).

The Clean Energy Package, adopted in 2019, introduced two formal definitions of energy communities: *Citizen Energy Communities* (CECs), which is included in the *revised Internal Electricity Market Directive (EU) 2019/944* (European Parliament & Council of the European Union, 2019) and *Renewable Energy Communities* which is included in the *revised Renewable Energy Directive (EU) 2018/2001* (European Parliament & Council of the European Union, 2018).

Particularly, **Renewable energy communities (RECs) are a legal entity**:

> **(a)** *which, in accordance with the applicable national law, is based on* ***open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members*** *that are located in the* ***proximity of the renewable energy projects that are owned and developed by that legal entity****;*
>
> **(b)** *The shareholders or members of which are natural persons, SMEs or local authorities, including municipalities;*
>
> **(c)** *The primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits.*

RECs cover a broad range of activities if compared with CEC, as the latter is more focused on the electricity sector and can be renewable and fossil-fuel based (i.e. technology neutral) and **RECs can refer to all forms of renewable energy in the electricity and heating sectors** (Caramizaru & Uihlein, 2020). As shown in Table 3, **RECs have more restricting membership conditions** not allowing large companies to join, neither any enterprise whose main economic activity is related to the energy sector (Roberts, Frieden, & d'Herbemont, 2019), but **RECs restricts the control (operation) of the community to only members located in the proximity to RES projects.** Furthermore, according to the Renewable Energy Directive, a renewable energy community: *should be capable of* ***remaining autonomous*** *from individual members and other traditional market actors that participate in the community as members or shareholders*.

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Table 3: Summary of characteristics for 'citizen energy communities' (CEC) and 'renewable energy communities' (REC) *from EU directives, and 'Energy community" from RESCoop*

	REC	CEC	Energy Community (RESCoop)
PRIMARY PURPOSE	Provide community benefits (non-commercial), rather than financial profits	Provide community benefits (non-commercial), rather than financial profits	Provide community benefits. Create social innovation with non-commercial aims
ELEGIBILITY	Natural persons; SMEs or local authorities (including municipalities)	Natural persons; SMEs or local authorities (including municipalities) and large companies	Citizens, but probably the same actors as in REC
PRINCIPLES	Open, voluntary and non-discriminatory participation	Open, voluntary and non-discriminatory participation	Open, voluntary and non-discriminatory participation, + 7 principles of ICA*
DEMOCRATIC GOVERNANCE & OWNERSHIP	Autonomous (possibly democratic), effective control by members located in the proximity to RES projects	Decisions cannot be made by medium/large enterprises related to the energy sector	Democratic. Usually expressed by providing each member with one vote and by limiting the number of shares.
JURISDICTION	Any legal form	Any legal form	Energy cooperative only

Sources: (European Parliament & Council of the European Union, 2019) (European Parliament & Council of the European Union, 2018) (Roberts, Frieden, & d'Herbemont, 2019).

Finally, from a legal perspective, in the corresponding EU directives there are no differences between REC and CEC in terms of legal structures which can support these figures, since no specific forms are defined. According to JRC, there can be numerous alternatives: non-profit customer-owned enterprises, energy cooperatives, limited partnerships, community trusts or foundations, housing associations, public-private partnerships and public utility company (Caramizaru & Uihlein, 2020). Nevertheless, other potential differences in this regard could be made in the national regulations resulting from the transposition of these directives by each of the member states, so they should be studied specifically (see deliverable D1.1 for more details about the regulatory framework of RECs).

In short, despite the project LocalRES is mainly focused on REC, comparing RECs with CEC have offered a broader view of the activities that each legal figure associated to energy communities can deliver. As a summary of the concepts analysis, CECs focus on the power sector only and can deliver, if the national regulation allows it, all types of activities and services (e.g. ancillary services, aggregation). RECs use cases could in principle cover all types of renewable energy technologies, and all sectors (heating and cooling, power generation, industry and mobility), but the membership is restricted, not allowing large or energy-related companies to join, which limits the potential stakeholders participating as members of RECs. Lastly, the REC should be a legal form whose principles comprehend: being autonomous, open and voluntary, but depending on the country some activities (e.g. peer-to-peer; P2P) can be limited, which will also limit the capacity of the REC to deliver a service.

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3.2. Literature review of REC-driven services

As an initial stage of the definition process of the project use cases, **a thorough literature review on REC-driven energy market services** was done. Different H2020 projects were reviewed in order to look for similarities in the same research line. Also, other relevant sources were consulted during the literature review, including scientific publications and reports from institutions of reference (e.g. ENTSO-E). During this review, the different identified services were analysed from three different approaches depending on their scope applicable in each case: (1) member-focused services, (2) REC services to the markets and the grid in the normal operation mode and (3) REC grid services in the grid alert state. Furthermore, in this review different aspects associated to the services were consulted, including stakeholders typically involved in each service, associated technologies and resources, applicable regulatory aspects (in collaboration with Task 1.1[4]) and other local aspects to be considered for the provision of each service. Additionally, the main thematic area associated to each service was identified during this analysis, differentiating between thermal, electrical and non-technical services, and paying special attention to those services which allow a sector-coupling approach.

As previously explained, first a large list of REC-driven services was created based on the literature review. Regarding **electrical services** an initial list was collected based on the analysis of five EU projects.

From the *EU-SysFlex project* (Nolan, et al., 2019), the D3.1 - Annex II was consulted. From the project list of services that were identified in this document, the service related to LocalRES project were selected. For example, manual frequency restoration reserve, voltage and reactive control, congestion management, black start service, load balancing or self-consumption services are found. The aim of *EU-SysFlex project* is to identify issues and solutions associated with integrating large-scale renewable energy sources in the pan-European electricity system, so it did not contribute to the consultation of thermal services. This occurred in most of the projects consulted, they are mostly focused on the electrical system.

The *H2020 EU-projects* consulted in the same line were:

- *COMPILE* (COMPILE, 2019), that shows the opportunities of energy islands for decarbonisation of energy supply, community building and creating environment and socioeconomic benefits. In this project, Congestion Management, peak saving or power reserve provision, among other services, are considered. *IElectrix* (IElectrix, 2021)**,** that increase the integration of renewable energies into the distribution network, combines the Local Energy communities, the smart distribution and renewable energy sources. Voltage and frequency management, demand response or self-consumption services are found in this project.

[4] Regulatory aspects affecting each of the services are not included in this deliverable, but in deliverable D1.1, focused on the regulatory assessment. Therefore, these aspects are not included in the analysis of services, in section 8/.

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- *Renaissance* (Renaissance, 2020), H2020 Project works with the integration and sustainability in energy communities. The services of grid stability, smart contract's performance efficiency, or optimisation a multi-energy vector system, are found.
- *E-LAND* (E-LAND, 2021),that follows the objectives in the same line as the others with the incorporation of more distributed renewable energy resources (RES) and storage assets at the edges of the electricity grid to decrease the level of carbonisation in local energy systems. In this project, the services found were: load management, optimal management of energy assets or storing excess generation in the district heating network.

The state of the art for **thermal services** was relatively limited and was developed to a greater extent from knowledge and expertise of project partners, although also different projects were consulted.

The project *Thermovault* is committed to the global energy transformation using appliances in energy saving solutions for electrical boilers, DHW, storage heaters and heat pumps (integrated use of distributed technology). The project introduces a variety of activities energy communities might exercise such as: optimisation of energy flows, energy-efficiency, renewable energy generation, development of controls that enables communities to lower energy bills and heat demand response applied in energy communities (Peeters, 2020).

Another project to mention, aligned with the heat demand response service, is the European urban transition project *mySMARTLife* (Oy., Helen 2021). *mySMARTLife* aims towards sustainable cities through innovative solutions, in the fields of mobility, energy and digitality. The main challenge is the reduction of the need for heat during peak consumption hours and to enable a greater system-level flexibility, all through the evaluation of heat demand response in district heating. In addition, in the project *SmartEnCity* different thermal services were reviewed for a biomass district heating that will be deployed, leading to better energy prices, lower maintenance and operation costs and improved safety. Furthermore, in *REMOURBAN* project an optimisation and balancing of a district heating network service is performed to adapt generation and demand in *Valladolid*, Spain. Parameters at generation levels are optimised, and also, at building level, the energy exchange in the building's substations is optimised, increasing or decreasing the setpoint temperature within the comfort range provided by the user (Muñoz Rodríguez, Martín Sanz, & Gordaliza Pastor, 2019).

In other relevant projects, other thermal services can be found. For instance, in *Stockholm*, Sweden, waste heat from data centres is upgraded using a heat pump to be injected into the district heating network (FORTUM, 2017). Usually, for selling waste heat from an industry or a data centre to a district heating network, a contractual agreement between the party and the user is needed. The contractual agreement sets the number of hours where waste heat will be supplied, the pricing, the insurance and the quality assurance (temperature, intermittency), among other aspects (REUSEHEAT, 2021). In *Germany*, Power-to-heat services are being studied in district heating networks (Böttger et al. 2014) or to individual heat pumps in a community (Fischer and Madani 2017). In *Smart Energy Management System (SEMS) project*, batteries, demand response and artificial intelligence (AI) are being applied which provide a virtual charge to balance the energy

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demand/response of electricity providers (SEMS project, 2018). In *Community Responsible Innovation in Sustainable Energy (CO - RISE) project*, energy storage at community level is applied for the adaptations of the energy systems towards RES and local communities (Koirala, Oost, & Windt, 2018). In the latter case, the role of prosumers, how to integrate the heat and electricity system for higher flexibility and, grid reinforcement and ancillary services, are discussed.

Since the recognition of the REC and CEC figures in the Clean Energy Package, community energy initiatives are gradually taking on new activities and energy services, from energy generation from renewable sources to investments in electro-mobility services, among others (Caramizaru & Uihlein, 2020). Thus, as previously said, according to the definition in the EU directives energy communities can perform a wide range of activities, including both traditional activities and also new business models. Usually, smaller scale citizen-led initiatives are mostly involved in renewable generation activities, but an increasing number of energy communities have been taking on new roles of energy and energy services providers.

As an example of this wide range of activities, a list of initiatives that energy communities can provide which was prepared by JRC can be found below (Caramizaru & Uihlein, 2020):

- **Generation with RES assets** (mostly solar, wind, hydro) for sale, purchase or auction into electricity markets, avoiding self-consumption.
- **Supply of electricity and gas to customers** (electricity, wood pellets, biogas and others), **by means of aggregation** (e.g. combining costumer loads and flexibility).
- **Individual and collective self-consumption of RES assets, and local sharing of energy amongst members**
- **Ownership and/or management of community-run distribution networks**, such as local electricity grids or small-scale district heating and (bio)gas networks
- Energy services: **energy efficiency or energy savings** (e.g. renovation of buildings, energy auditing, consumption monitoring, heating and air quality assessments); **flexibility, energy storage and smart grid integration; energy monitoring and energy management for network operations; financial services**
- **Electro-mobility:** car sharing, car-pooling and/or charging stations operation and management, or provision of e-cards for members and cooperatives
- **Other activities: consultation services** to develop community ownership initiatives or to establish local cooperatives, **information and awareness raising campaigns, or fuel poverty measures** (e.g. Energie Solidaire Enercoop, France)

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3.3. Selected REC-driven services for the project use cases

The review of REC-driven services summarized in section 3.2, together with the specific inputs collected from LocalRES demo sites through the questionnaire and the subsequent analysis (see the template in section 7.1 and a summary of the results in section 7.2, Annex A), eventually resulted in a list of REC-driven services which has been used as the basis for the definition of the use cases.

All the services included in the list were **analysed in detail from the particular perspective of RECs in case of being provided by these**, and a summary of the most relevant aspects was included in specific tables for each service. These tables were created using the methodology from EN/IEC PAS 62559 as a reference, however the structure and contents have been adapted and simplified with the aim of **constituting accessible material which non-technical actors involved or interested in RECs could potentially use to understand REC-driven services**.

In line with this approach, the services have been categorized according to three different scope levels:

- **Member-focused services**, when member of the REC will be directly affected and benefited from the service (not including economic benefits derived from services to external systems);
- **REC services to the markets and the grid in the normal operation mode**, for services implying the participation in energy markets, and services provided to the grid as an added value, or to improve the operation of the grid.
- **REC grid services in the grid alert state**, for services that are applicable during the abnormal operation of the grid, e.g. blackout strategies.

Additionally, the different services have been classified in technical and non-technical, and subsequently in thermal and electrical, depending on the most relevant energy vector involved in the service in the case of technical services. The final list of REC-driven services can be found below, according to this categorization:

Thermal:

- Operation of a DHN (District Heating Network) with RES (Renewable Energy Sources)
- Sale of waste heat use to a DHN
- Help to balance a DH&CN (thermal demand response)
- Heating/Cooling as a service
- Power to Heat and Heat to Power (P2H and H2P)
- Building energy management & optimization (thermal comfort, systems and/or electricity consumption optimization)

Electrical:

- Collective peak shaving
- REC/Collective self-consumption

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- Optimisation of electric flows within the REC
- Voltage and reactive power control
- Frequency control (FCR, aFRR, mFRR)
- Demand response (implicit and explicit)
- V2G services
- Blackout strategies
- P2P energy trading
- Aggregated (REC-level) energy trading
- Public EV (Electric Vehicles) charging stations
- Smart Energy Storage Management
- Congestion management
- Anomalies detection at REC-level

Non-technical:

- Capitalisation of monitored data
- Legal advice
- Prefeasibility assessment
- End-user engagement
- Support on technical execution
- Support vulnerable citizens reducing risks of energy poverty

It is to be noted that the previous classification is very simple and does not cover all possibilities, such as those services which can be considered both thermal or electrical (e.g. peak shaving, collective self-consumption), or those services which can be consider as thermal-electrical. These services include, for instance, those which can involve heat pumps or CHP systems and other electrically-driven systems for heating purposes (e.g. electric boilers). Examples of these services subject to being considered as thermal electrical are: *Power to Heat and Heat to Power*, *Help to balance a DH&CN*, *Collective peak shaving or Demand response (implicit and explicit)*.

Lastly, Figure 3 presents visually all REC-driven services considered in the scope of this task by category and level of scope, which are described in depth within section 8/ (Annex B). These selected services constitute the basis of the project use cases, and have been used as reference inputs during their definition, together with the different demo site teams.

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Figure 3: Summary of REC-driven services, by category and scope level

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4/ Use cases and demo site characterisation

The present section is subdivided into four subsections, each of them associated to one of the project demo sites. Within each subsection, a summary of the main local aspects characterising the demo sites is first presented, including the results from the local stakeholders through the questionnaire (summarized in section 7.2). Next, the project use case for each demo site is detailed, specifying the services included in the use case, the main targeted objectives, or the most relevant stakeholders associated to the use case, and at the end, a summary of the use case is also presented.

As said in previous sections, the definition of these use cases has been a collaborative and iterative process between members of the demo teams and other partners within LocalRES Consortium to find a suitable set of interconnected services, balancing the technical feasibility and the present and projected needs and interests of local citizens. In next sections, only the consolidated results of this process are presented as part of the final version of the use cases.

4.1. Kökar demo site

4.1.1. Characterisation

GENERAL DESCRIPTION

Kökar is a small archipelago municipality of Åland Islands located in Finland, with a total land area of 64 km^2. Despite the reduced population of Kökar Island, which is 234 persons according to official statistics (2018), from an administrative and political perspective the island is a full-scale municipality (ÅSUB, 2021). The actual population in Kökar experiences significant changes throughout the year, with around 160-170 persons living during wintertime, almost 1,000 in the summertime, and around 18,000 tourists who visit the island every year, resulting in a "technical population" of 467 persons[5]. These variations of population during the year causes a great volatility in the use of local infrastructures, which results in higher flexibility requirements to adapt to these changing scenarios, not only in terms of energy, but also supplies, communication or transportation, with underwater telephone cables and power lines and ferries connecting the island to mainland.

The community is mainly residential, with 123 small houses, 5 row and semi-detached houses, 1 multi-storey building and slightly below 200 holiday cottages. There are only three farms, two small industries (a bakery and an apple orchard) and some small service companies, and tertiary buildings for basic services (school, elderly home, vicarage, bakery, Brudhäll Hotel, Sandvik guest harbour & camping area and Coast Guard station).

[5] [(170 full-time inhabitants × 365 days) + (1,000 summertime inhabitants × 90 days) + (18,000 one-day visitors × 1 day)]

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In line with the regional goals, Kökar has proved a strong commitment with sustainability, with the clean energy transition agenda having been published by summer 2020 (Vainio & Nordlund, 2020), and the island having been selected as one of the 20 islands in Europe that will act as pioneers in the initiative of CE4EUI "Clean Energy for EU Islands" (European Commission, 2017).

LOCAL COMMUNITY & RECS

In Kökar, a board of representatives is responsible for making the decisions affecting the community, and citizens and members meet periodically to be informed and actively involved in the local community aspects.

According to the local stakeholders involved in LocalRES project, the most challenging aspects to potentially constitute a REC are the associated business models as well as legal and regulatory barriers, while the rest of relevant topics (e.g. technical, data treatment, financial) are not seen as critical.

In terms of stakeholders, the local government, building owners (citizens), the DSO and the consultancy companies in the island as seen as the most relevant actors in relation to a potential constitution of a REC in Kökar, being also especially relevant the regional government, ESCOs and SMEs. Regarding the engagement of stakeholders, the local government and DSO are considered as involved or very easy to engage, while the rest of relevant stakeholders are seen as easy or not especially difficult to engage.

Nevertheless, it is to be noted that, despite the majority of locals are keen on promoting sustainable living conditions in the island community, there are a few islanders that do not trust EU nor believe that climate change is real, and thus oppose all actions oriented towards sustainability, including the LocalRES project.

ENERGY SYSTEM CONFIGURATION

The existing energy system in Kökar is characterised by a strong dependence on the electricity supply from the main grid, which is connected to the island with a 1.5 MW capacity underwater electric cable (Kökar-Sottunga-Gustavs). Due to the weakness of the grid connection, there are occasional power outages (3-4 per year) which cause problems to the 401 electricity subscribers in the local community, requiring reserve (backup) generators during these interruptions. The minimum power demand is 400 kW and the peak load is 800 kW, resulting in a yearly electricity consumption of 2.9 GWh.

Current energy technologies in the island include for heating purposes include: wood-based systems (around 70 houses, some combined with oil), air-to-water heat pumps (30-40 houses, and a 26-kW unit in the hotel), oil-based systems (12 houses), ground-source heat pumps (in 2-3 houses, the elderly home and the vicarage), and direct electric systems (170 residential and 32 non-residential subscribers). Additionally, all buildings have smart meters which can handle bidirectional 15 minutes' intervals, include a breaker to cut the grid connection, and also have power quality measurement as well as the zero-error detection.

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In terms of energy resources, wind constitutes the most abundant natural resource in the island, while solar energy is moderate. Biomass is also relatively abundant, but the sustainability concerns and strong interest to preserve the natural environment in the area limit the exploitation of this resource.

In line with the availability of resources, there is a wind power plant in the island ("Mika", 500 kW) that covers around 37% of the electricity consumption in the island, and also 35 kW of micro-wind power and 39.1 kW of PV.

It is also to be noted that, regarding transportation, ferry transport to and from the island accounts for one third of the total energy consumption, and .there is currently only one electric vehicle in the island.

Finally, according to local stakeholders, an extensive deployment of PV and heat pumps could be expected in the future in terms of energy technologies, while traditional fireplaces are also expected to remain one of the most frequent heating systems.

4.1.2. Kökar use case

OBJECTIVES OF KÖKAR USE CASE

A strategic objective for Kökar is the contribution to the development and sustainability agenda for Åland, which is aligned with the objectives of the LocalRES project. Åland Islands have set vision and strategic development goals for 2030 to create a sustainable society. Among other goals, Kökar will contribute in LocalRES to reduce CO_2 emissions by at least 60 % compared to 2005 and to increase the share of renewable energy to at least 60% (currently 32% in the whole Åland).

The creation of a REC in the area is meant to be achieved thanks to the community engagement in Kökar, by making use of the distributed energy resources (PV, micro-wind turbines, heat pumps). This will favour grid flexibility and self-reliance on the island, which will also potentially reduce the effects of blackouts. As ultimate targets, there will be a better adaptation of RES and a proper exploitation of the demand response (DR) mechanisms.

SELECTED SERVICES FOR KÖKAR USE CASE

The services identified within Kökar demo site to be integrated as part of the use case are listed below:

Thermal:

- P2H
- Building energy management & optimization

Electrical:

- Demand response (implicit and explicit)
- Blackout strategies

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- Public EV charging stations
- Smart Energy Storage Management

Non-technical:

- Capitalisation of monitored data
- Prefeasibility assessment
- End-user engagement
- Support on technical execution

MAIN STAKEHOLDERS INVOLVED IN KÖKAR USE CASE

Next, the main stakeholders expected to be involved in Kökar use case are presented:

FLEXENS: Demo site coordinator and responsible for the energy management system for the households. FLEXENS will be continuously the connection with the information part of the REC or the municipality. They will keep the information always updated on the island (during these years and in the future) and they will be responsible for the user interface.

Kökar service: It's a local company for the installation works. They provide the service for the power and data network. They are certified for cooling machines and are in charge of the maintenance works and heat installation. They ensure the technical equipment is up-to-date and have the responsibility to make the correct operation of the REC. They own the only e-car that is currently in the island.

Local energy group: There are four people, one for each small group in the island. They are the gateway to the local community, so the contact to the citizens. They are technical engineers in FLEXENS. The local energy group is the contact to the citizens and to the Kökar municipality

Kökar Municipality: They are in charge of the installation of the new assets and energy management systems. The person in charge in Kökar municipality has the energy system information and this tool could be handed over to other stakeholders such as Kökar service and could be useful also for the school.

VTT is a Finnish RTO in charge of the research actions of the project.

DSO: Ålands Elandelslag, ÅEA, responsible for the installation of smart meters in all buildings in Åland,

Consilia Solutions AB: entity responsible for operating the datahub where all the consumption data measured in the smart meters are sent via both cell radio and fibre cables.

Single Wing Energy Oy is developing Small Scale Single-blade wind turbine (TRL6) and is expected to provide one for the Kökar School.

Polar Night Energy: is the technology provider for the novel TESS for Kökar's school.

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Local citizens: will participate in the participatory processes and engagement activities associated to the REC, and will benefit directly or indirectly from the different actions and services provided by the REC. In particular, the users of the school, the elderly home and the households included in the REC will be directly benefited.

Additionally, there is a **technician** in charge of the works in the local school and elderly home, and there is no organisation acting as **aggregator**.

DESCRIPTION OF KÖKAR USE CASE

The **prefeasibility assessment** and **capitalisation of monitored** data will be performed by **FLEXENS** to evaluate new scenarios in the demo and add value to the monitored data.

Kökar service will be in charge of the **support on technical execution** of the different actions requiring technical activities.

The **local energy group**, and in turn, the **Kökar municipality**, will be responsible for the **end-user engagement**. It must be noted that already before the start of the project there was a strong community engagement in the Kökar area involved in LocalRES project, which will be used to promote the involvement of prosumers in the demonstration actions.

The selected technical services will be applied on one, two or the three main buildings from this demo site: the elderly home, twenty households and the school.

The **demand response (implicit and explicit)** is linked to the school, elderly home and households by the Smart Energy Management System, which will provide their energy systems to potentially participate in demand response mechanisms. The technologies that make this service possible are mainly the storage systems (Battery Energy Storage System -BESS and Thermal Energy Storage System-TESS). These energy storage technologies favour the flexibility, and thus can provide demand response.

Power to heat (P2H): the school has an old oil heating system that is going to be renovated with a hybrid heating system. The school is one of the biggest consumers in the area and has an energy cost of approx. 2000 € per month (250 MWh/a). It also has inefficient control with high saving potential (estimated up to 30%). Two 25-kW_{th} Air Water Heat Pumps (AWHP) will transfer heat from the outside air to a water-based system. This heat can be used for space heating or as a hot water supply for the house. There will be also 5 + 10 kW Vertical Axis Wind Turbines (VAWT) which will generate wind energy to provide electricity to the school. An innovative 100 kW_{heat}/9MW_{heat} Power-to-Heat thermal energy storage system (TESS) will rely on solar and wind energy generation. Electricity generation will be primarily used for the heating system, but also to cover electrical needs, thus accommodating to the fluctuating nature of the local grid. The thermal storage is capable of mitigating blackouts, while excess energy can be stored as heat for later use, hence providing more flexibility.

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As regards **public EV (Electric Vehicles) charging stations**, a public charging station will be placed in the school and near Brudhäll hotel. Since this location is in a very touristic area, it will provide good visibility.

The **Blackout strategies** are connected to the **Smart Energy Management System,** and will potentially increase the resilience of the community before power outages scenarios.

The **Building heating optimization** (systems and electricity consumption optimization) is expected to be applied to the school and households, and the target is to optimise the heating system in synergy with the RES energy systems. This will allow to enhance the current hosting capacity for RES (micro-wind turbine and PV). PV from the school (50 kW) is achieved by means of solar panels installed on the roof. The micro-turbines are Small Scale Single-blade wind turbines with rated power generation of 5kW. Linked to the **Smart Energy Management System.**

Smart Energy Storage Management System[6]: The RES energy systems (micro-wind turbine and PV) will be combined with a smart EMS to optimise the heating system. This will be applied to the school and 20 interested households. There is an open system which has all the information from the smart EMS. Information on the energy system can be shared through an app, so energy generation can be followed.

The school is expected to be connected to installations that are placed in the same location: EV charger, Vertical-Axis Wind Turbine (VAWT), Air-to-Water Heat Pump (AWHP) and the Thermal Energy Storage System (TESS). A Finnish company **Single Wing Energy Oy** is developing Small-Scale Single-blade wind turbine (TRL6) and has suggested to install one at the Kökar School. The rated power generation of the wind turbine is 5 kW.

Solar PV technologies will be installed in the school and the elderly home. A 50-kW system of solar panels will be mounted on the roof of the school and integrated in the local energy system. A new 70 kW PV system will be mounted on the roof of the elderly home and combined with battery storage system and an energy management system to shave peaks and provide security during power shortages.

The EV charger is located in the school because it has to be placed in the municipality own land and it is near to the hotel as well.

A diagram illustrating the description of the use case in Kökar is shown in Figure 4.

[6] By the time of writing this report the technology supplier declared bankruptcy. As of now they have not announced a new owner for the technology,

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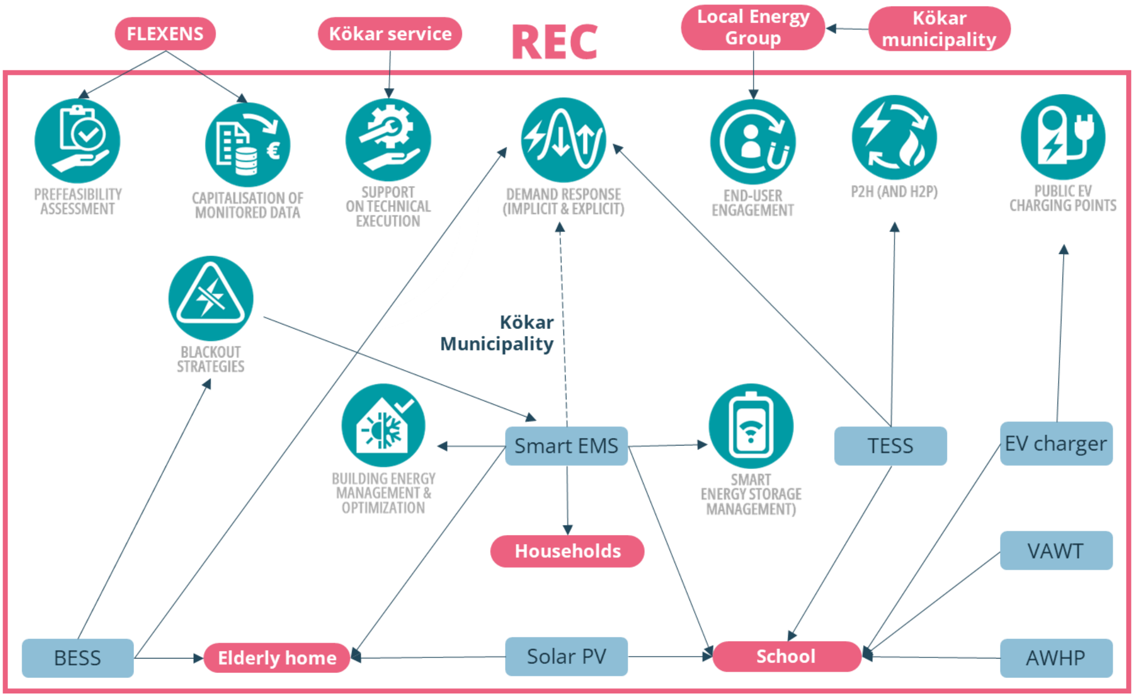
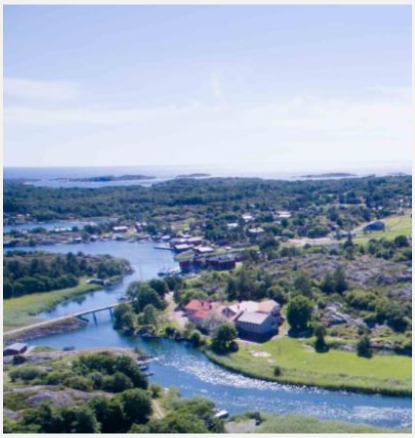
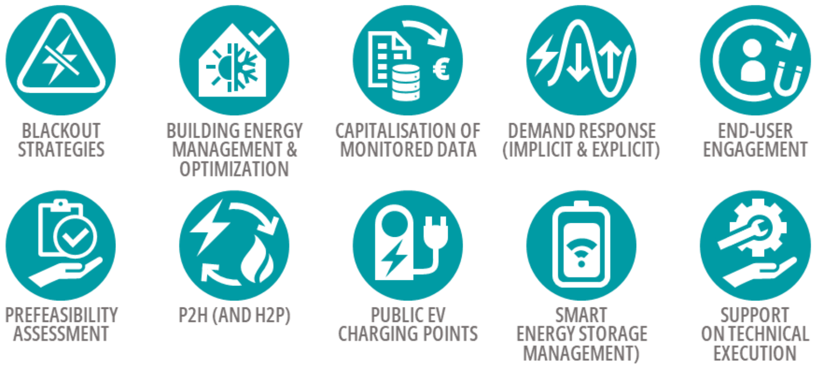


Figure 4: Diagram of Kökar use case

SUMMARY OF KÖKAR USE CASE

To conclude with Kökar demo site, Table 4 summarizes the most relevant aspects of the use case, including basic information, services, technologies, stakeholders, and the use case diagram.

Table 4: Summary of Kökar use case

Name of the demo site: Kökar	
Characteristics	 **Location:** Kökar archipelago (Åland islands, Finland) **Type:** geographical island **Land area:** 64 km^2 **Population:** 234 persons (2018) **Grid:** underwater power lines; weak grid connection with occasional outages (3-4/year) **Stakeholders:** Local energy group (citizens), FLEXENS (Energy utility), Kökar service (craftsmen/workers), Kökar Municipality (public staff), VTT (RTO), Ålands Elandelslag (DSO), Consilia Solutions AB (datahub entity), Single Wing Energy Oy (Tech. provider), Polar Night Energy (Tech. provider), technicians.
Services	
Technologies	**In the island:** Reserve generators, smart meters, ground-source heat pumps, air-water heat pumps, wood heating/oil heating, direct electric heating systems, e-cars, wind power plants **In the demo case (to be installed)**: smart EMS, TESS, EV chargers, air-water heat pumps, solar PV, VAWT, Battery energy storage system (BESS)

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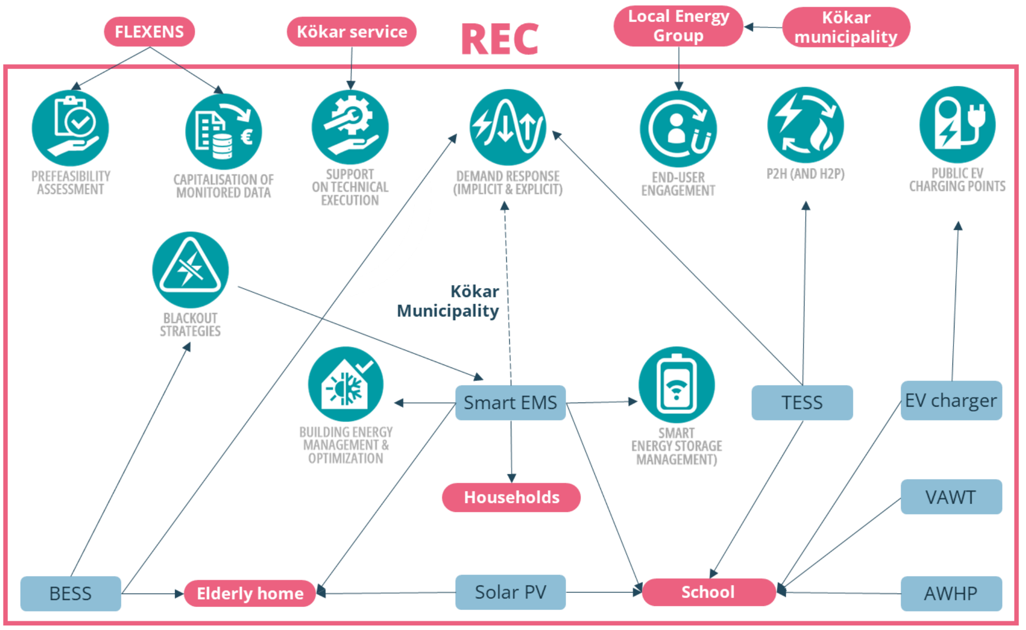
Use case diagram	

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4.2. Berchidda demo site

4.2.1. Characterisation

GENERAL DESCRIPTION

Berchidda is a village located on the Southern slopes of Mount Limbara in the North of Sardinia Island, Italy, with a population of around 3000 inhabitants. The land covers approximately 201 km^2 and is located at an average altitude of 300 m, with a wide hilly area in a radius of almost 20 km. The strong interest of Berchidda to achieve energy independence, reduce energy dissipation and regain and strengthen the local community has led it to adhere to the Covenant of Mayors.

Figure 5: Hill view of the Berchidda Municipality

LOCAL COMMUNITY & RECS

In Berchidda, there is not a formal community established, but the municipality is making great efforts in the promotion of energy-related activities and initiatives. A good example, is that the Municipality of Berchidda owns the local grid and DSO through AEC - Azienda Elettrica Comunale (Pubblic Energy Office).

According to the local stakeholders involved in LocalRES project, there are not critically challenging aspects to potentially constitute a REC, and stakeholder and citizen engagement or activities related to technology providers as seen as easy.

Regarding stakeholders, the local government, the energy system operator and household tenants (citizens) are seen as the most relevant actors in relation to a potential constitution of a REC in Kökar, being also especially relevant the national government, the DSO, ESCOs, RTOs, and consultancy companies, neighbourhood associations or local cooperatives. Regarding the engagement of stakeholders, the local government, the DSO, consultancy companies, RTOs and universities, the energy system operator and ESCOs are considered as involved or very easy to engage, while the rest of relevant stakeholders are seen as easy or neutral in terms of difficulty to be engaged.

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ENERGY SYSTEM CONFIGURATION

In Berchidda, there is a high availability of solar radiation, and in consequence PV systems are relatively frequent in the village. Thus, Berchidda counts 87 PV plants (1,000 kWp total), of which 82 are owned by individual citizens, while others 5 belong to local Municipality. The PV installations provide around 20% of the electricity energy demand on an annual basis (comparison between annual energy needs of Berchidda and annual PV generation). The rest of the energy is purchased from the grid. Most of the PV installations existing in Berchidda belong to private homes, which use them for instantaneous self-consumption; the surplus of electricity produced is sold back to the grid. The first installation of PV for self-consumption dates to 2011, followed by other installations until today. The development of local PV production has been prompted by individual emulation rather than a collective, coordinated move. The access to PV load curve data will be made possible within LocalRES with the installation of the smart meters and the associated local radio transmitter and gateway.

Gas and oil boilers and traditional fireplaces are very common in Berchidda, but heat pumps are being introduced, with at least 20 air-air domestic heat pumps foreseen to be installed by the end of December 2022. The recruitment of the households for the installations of the heat pumps has started in April 2022. A form for the expression of interest for the free installation of 20 air-to-air heat pumps for heating, cooling and DHW production based on existing or new photovoltaic systems have been circulated. Some mandatory and some rewarding selection criteria have been settled for the household's selection procedure including:

a) To be resident in the municipality of Berchidda
b) To have wi-fi connection available
c) To have an indoor living space available of a surface not less than 1 m x 1 m
d) To have certification of regularity of the energy systems (Declaration of Conformity)
e) To have the floor plans of the house available
f) To have the technical data sheet of the systems currently present
g) To have the following requirements to take advantage of the rewarding criteria (tick the relevant item/s):
    a. Presence or photovoltaic system with less than 3 kWp installed
    b. Presence of air-to-air heat pump (even old generation)
    c. Presence of storage battery

Also, around 10 public EV charging stations are envisioned to be installed in the course of 2023. The exact location of these will be evaluated in tandem with the municipality over the next months.

Berchidda Energy 4.0:

As previously said, the electric network is owned by the Municipality of Berchidda and operated by AEC - Azienda Elettrica Comunale (Public Energy Office), making Berchidda one of the few municipalities in Italy which owns the electricity grid. It is a smart grid, ready for remote management and control, smart billing, and balancing. They own the last mile, and together with Azienda Elettrica Comunale (AEC) they have the role of a DSO. Recently the Administration

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acquired the electricity network of the rural area and decided to upgrade its facilities to an urban microgrid. They aim at merging the rural and the urban grids into the Berchidda Energy 4.0 smart grid. More specifically:

- Berchidda has carried out a major renovation of the agricultural grid with the construction of the new electrical cabins.
- It has planned to extend the use of smart meters to the historic centre as well.
- It is building a free communication network that interconnects all users.

It will be possible to integrate the energy production that takes place in the municipal area, photovoltaic and wind power. There is also a plan for extension with offshore wind power.

The main characteristics of the Berchidda residential power grid are presented as follows:

- 17 MV/LV substations, which are equipped with transformers of varying power between 100kVA and 500kVA, for a total power installed of about 5,000kVA
- 4km of MV underground cables, 3.2km for the meshed network and 0.8km for the radial network; 15.4km of LV aerial cables; 21.6km of LV underground cables

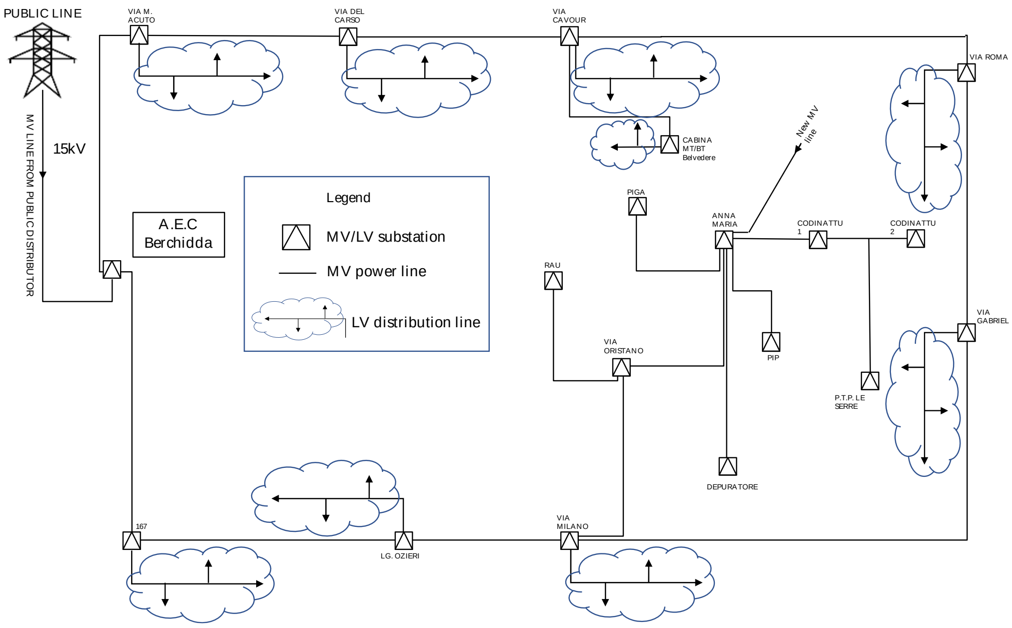

Figure 6: Berchidda residential power grid 4.0

Table 5: Berchidda energy consumption (data from 2017)

Type of demand	Electricity [MWh/yr]
Residential	2,561
Public lighting	414
Industrial	369
Non-residential	201
Commercial /Tertiary	2,216
TOTAL	**5,762**

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4.2.2. Berchida use case

OBJECTIVES OF BERCHIDDA USE CASE

The strategic objectives for this demo are to demonstrate solutions for the decarbonisation of the local energy system solution. Berchidda will constitute one of the first Italian local energy communities fully active, in which RES and flexible assets from different sources will be deployed.

That will include:

- Full distribution of PV panels (there is a wide deployment already)
- Power-to-heat
- Power- to- vehicle
- ICT infrastructure
- Management and monitoring of high-resolution data

The smartening of the grid and establishment of a local energy community has the potential to greatly increase the uptake of RES in Berchidda. The ability for residents to participate in the local energy community and to become prosumers instead of consumers will act to boost the installation rate of private investment into RES. The project will directly install heat pump systems that in many cases will be coupled to private investment into PV.

SELECTED SERVICES FOR BERCHIDDA USE CASE

The services identified within Berchidda demo site to be integrated as part of the use case are listed below:

Thermal:

- Building energy management & optimization
- P2H: Installation of around 20 air-to-air heat pumps for heating, cooling and DHW production based on existing or new photovoltaic systems.

Electrical:

- Collective Peak shaving
- Optimisation of electric flows within the REC
- Demand response (implicit and explicit)
- V2G services
- P2P energy trading (planned activities within the scope of NEON project)
- Aggregated energy trading
- Public EV charging stations
- Smart Energy Storage Management
- REC-level/Collective self-consumption
- P2H: Installation of around 20 air-to-air heat pumps for heating, cooling and DHW production based on existing or new photovoltaic systems.

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Electrical:

- Capitalisation of monitored data
- Prefeasibility assessment
- End-user engagement
- Legal advice

MAIN STAKEHOLDERS INVOLVED IN BERCHIDDA USE CASE

Next, the main stakeholders expected to be involved in Berchidda use case are presented:

R2M: In charge of the installation of the heat pumps and the community EV charging points.

GridAbility: In charge of providing information for the services to be integrated in the MEVPP and for the responsible for the overall physical implementation in the demo site. In charge of the installation of smart meters in the households where the heat pumps will be installed. Responsible for the installation of 20 residential batteries having 5.1 kWh storage each in the scope of Hestia project. Responsible for the installation of the smart management platform that will connect all the community users. Stakeholder in charge of the citizen engagement. Responsible for the provision of the prosumer platform in the scope of "Berchidda Energy 4.0" local plan (developed by Prosume Energy, who is one of their associated partners).

AEC: Grid manager (DSO-TSO) that will offer local know-how including support to the energy system sizing and legal documentation that may be required.

Energy4com: private non-profit company connected to Gridability, that is supporting the community of Berchidda to set up the legal entity.

Axpo: energy supplier in the area (not involved in LocalRES). They are helping to create the smart contracting, also to manage the storage capacity and the surplus of energy that would be monetised somehow. AXPO has the role of energy aggregator within Berchidda.

Berchidda municipality is the local distributor.

Local citizens: will participate in the participatory processes and engagement activities associated to the REC, and will benefit directly or indirectly from the different actions and services provided by the REC.

DESCRIPTION OF BERCHIDDA USE CASE

Energy4com provides **legal advice** and a **prefeasibility assessment** on how the community would be, which energy flows would be needed, etc. They are supporting the formation of the community itself. This would lead to the **end-user engagement** service that consists in organising events involving users. They are taking advantage of the already existing strong engagement and the distributed energy resources (PV, battery storage, heat pumps, smart meters) with the aim to increase the grid flexibility and self-reliance enabling a better exploitation

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of the demand response (DR) mechanisms. They already created a channel of trust led by GridAbility.

The **end-user engagement** can be considered as the first service for Berchidda. **Berchidda municipality** is involved too. The purpose is to provide the community with **demand response (implicit and explicit).** The first step would be the installation of the smart meters (20) and the smart devices to get the planned loads to enable demand response through the HESTIA platform.

The connection with the **smart energy storage management** is enabled to ensure the maximisation of the sub consumption through the energy storage, providing the capability of **collective peak shaving**. GridAbility is in the installation phase of 20 residential batteries of 5.1 kWh of storage per household. The complete delivery is expected by the end of May 2022.The 20 batteries will be one of the controllable assets and will be connected directly to the GridAbility database and community platform for data gathering and storage. that might connect to the MEVPP. **GridAbility** is developing a consumer app (called Prosumer app), through which the final user will be able to, among other functions, to visualise the energy load balancing at community and individual levels.

The second step is to increase the capacity of storage, also using the **public EV charging points**. Currently there are no charging points available but the development would encourage tourism in the Municipality and enhance the connections between the two ends of the island. Installation of charging infrastructure, partnering, development of business model, and the development of services surrounding EV is a project activity. **R2M** will install 10 to 15 new community EV charging stations. **V2G services** are expected, thus making E-Mobility a marketing aspect for tourism. Due to the location of the Municipality, in between two different tourist areas (Costa Smeralda, Olbia on the east coast and the area around Alghero on the west coast), Berchidda can become the mid-point recharging station of North Sardinia.

Another controllable asset is the **building heating optimisation** through the installation of the heat pumps, in connection with the GridAbility IoT energy hub and the 2nd generation smart meters that are already enabled with the blockchain of Prosume. This will allow to **optimise the electric flows** connected to the heat and cooling flows, and to move to the next level, which would be to find out how to use these aggregated data and to provide **data-driven optimisation** for heating and cooling flows.

Currently there is no gas grid connection in Berchidda, but there is a program in the region to bring a gas network. On the other hand, there is a clear trend towards electrification (to make the grid smarter). People are used to get heated with domestic stoves fed with biomass, diesel, or gas hobs.

Activities related to **P2P energy trading** are planned to be carried out in Berchidda in the scope of NEON project, and enables transactions in terms of contracting. This is to be done by Power Purchase Agreements enabled by blockchain (transparent and digitalised contracts). Either the community as a whole or the individuals within the community can subscribe with other producers of renewable energy around the area. This will be an expansion of the production capacity, since they will be allowed to purchase RES outside the community.

Capitalisation of monitored data: this service would feed the optimisation algorithms and is connected to the aggregated energy trading because they can leverage on forecasts and predictions about people's behaviour.

Aggregated energy trading: theoretically it is possible to trade with the outside world. However, the main target is to maximise the self-consumption. Whenever there is a surplus energy to enable the purchase agreements, they are able to buy from external communities and also to sell, so energy saving potential might be monetised outside. But for the time being they mostly focus on buying energy from the outside since they do not have enough.

There is a **self-consumption** service (not included in the diagram).

A diagram illustrating the description of Berchidda use case is shown in Figure 7.

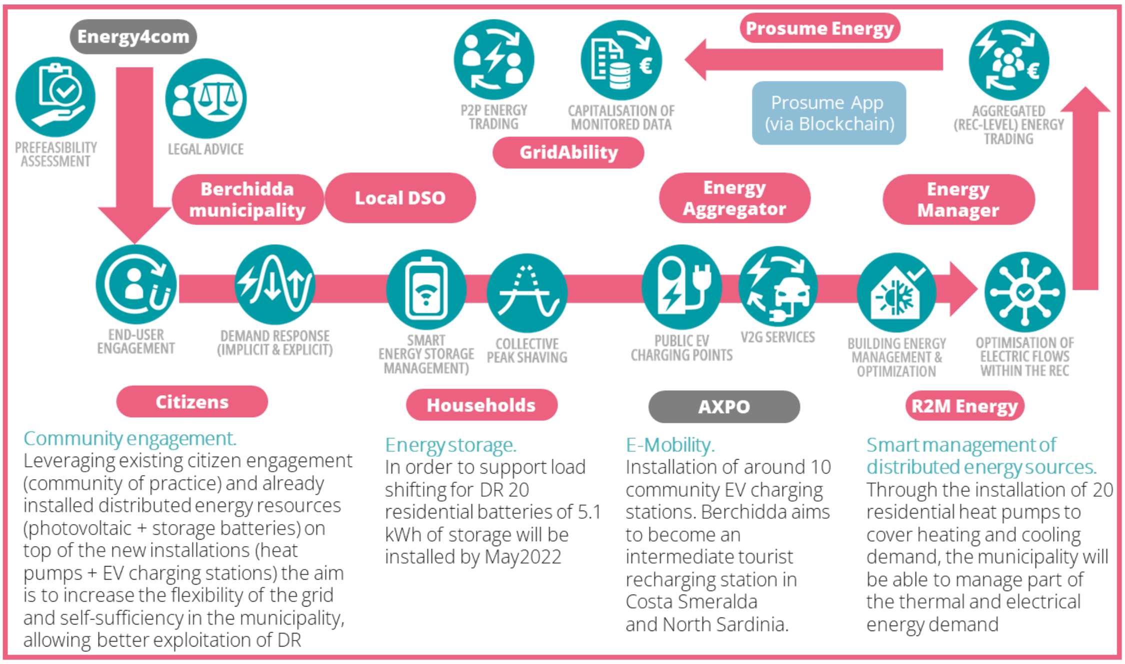

Figure 7: Diagram of Berchidda use case

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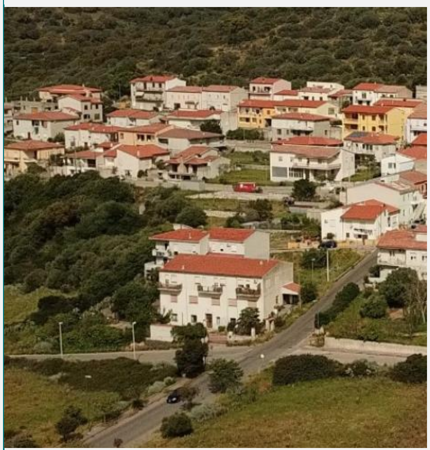
SUMMARY OF BERCHIDDA USE CASE

To conclude with Berchidda demo site, Table 6 summarizes the most relevant aspects constituting the use case, including basic characteristics, services, technologies or stakeholders, as well as the diagram of the use case.

Table 6: Summary of Berchidda use case

Name of the demo site: Berchidda		
Characteristics		**Location:** Berchidda (Italy) **Type:** Rural community / village **Land area:** 201 km² **Population:** 2648 inhabitants (2021) **Grid:** municipal-owned grid **Stakeholders:** Citizens, Berchidda municipality (owns electric grid and it is a local distributor), AEC - Azienda Elettrica Comunale (Public Energy Office and DSO-TSO). R2M (installer), GRIDABILITY (Energy utility / installer), Energy4com (private non-profit company, legal issues), Axpo energy supplier in the area (not involved in LocalReS).
Services		
Technologies	**In the village:** PV plants (1,000kWp total), batteries, gas and oil boilers, traditional fireplaces **In the demo case**: digital applications (for aggregation, demand response, smart meters), electric storage, EV charging points, air-air heat pumps, existing PV and batteries	

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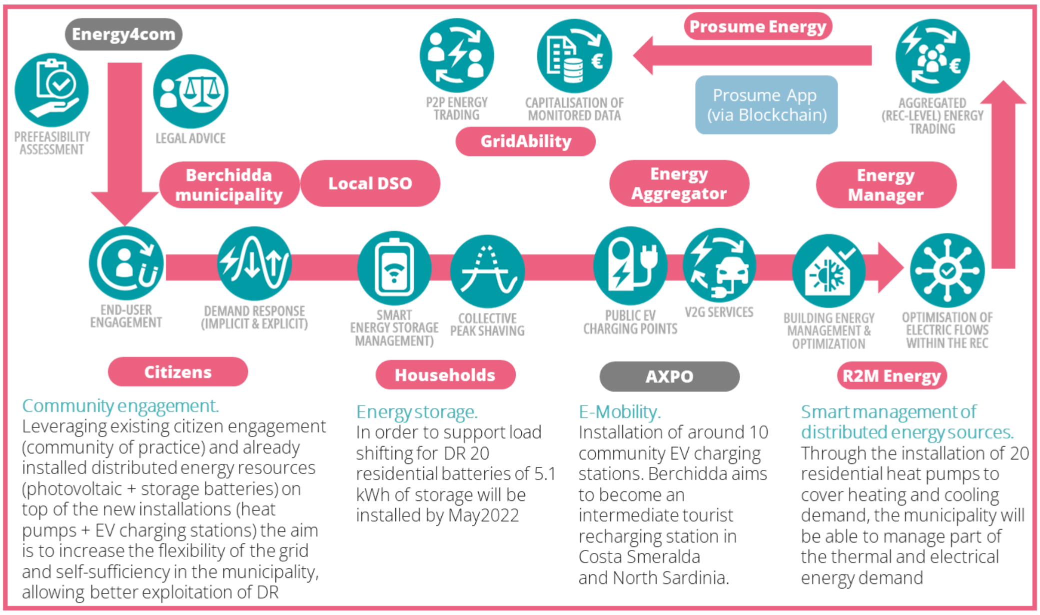
Use case diagram



4.3. Ispaster demo site

4.3.1. Characterisation

GENERAL DESCRIPTION

Ispaster is a small village located in the coast of Bizkaia, in the north of Spain, with 740 inhabitants spread over a municipal area of 22 km^2. The demo site is located in the Eleixalde district, a neighbourhood with 350 inhabitants, which constitutes the main urban area in the village, where the Town Hall, the public school, a cultural centre and most of the public services can be found. There is no relevant industry area near the demo site, but there are some small services and industries.

LOCAL COMMUNITY & RECS

In Ispaster, there is not a formal community established, but the municipality is making great efforts in the promotion of energy-related activities and initiatives, and has started by addressing the municipal building and facilities, being selected since 2015 as a pilot village in Biscay by the Basque Government. The existing systems are mainly managed by a local ESCO, which is also part of LocalRES project.

According to the local stakeholders involved in LocalRES project, there are several aspects seen as potentially challenging for the constitution of a REC, including technical, financial and regulatory barriers, citizen and stakeholder engagement or the definition of a business model.

In terms of stakeholders, a wide range are considered as relevant in relation to a potential constitution of a REC in Kökar, being especially relevant the local SMEs, ESCOs and cooperatives, citizens (building owners, household tenants and neighbourhood associations), and regional and national government. Regarding the engagement of stakeholders, local cooperatives and ESCOs, and local and regional governments are considered as already involved, while SMEs, large companies, DSOs or energy trading and financial companies are seen as challenging to involve.

ENERGY SYSTEM CONFIGURATION

In Ispaster there is abundant biomass and sea potential, and moderate availability of solar radiation. The village of Ispaster is characterised by a strong dependence on the main grid, but there are two isolated micrognids mainly supplying public buildings:

- A hybrid one (90 kW biomass + 42 kW solar thermal vacuum tubes) District Heating (DH) network with 12 consumption points,
- A (28.3 kWp, 20,8 MWh/yr PV = 49,5 kW system's power) micro-grid supported by batteries (178 kWh Pb-Ac) with 10 consumption points for public buildings.

The rest of the area is powered by the external grid, and the rest of the thermal demand is covered via a network with liquefied petroleum gas tanks and diesel and gas boilers. There is a ventilation system (sport centre) and the rest of the system is completed with a waste-heat recovery system powered by the PV micro-grid. Such system feeds a multipurpose mezzanine and public restaurant and includes an exhaust air heat recovery (1.02 kW, 1,656 m^3/h, 77.9% performance), in conjunction with an air-water chiller (5.77 kW), an accumulator (500 l) and a cooling coil for refreshment. Smart electric and thermal meters allow electricity and thermal energy consumption monitoring in a local open SCADA system for micro grid and DH.

There also exist batteries that are sized to cover 3-days electricity demand, and the grid connection is weak and not enough to supply new demands and with occasional outages, voltage swings and blackouts (by fallen trees or strong winds) in the distribution grid that cause local energy problems on Ispaster.

Figure 8 shows the location of energy producing assets in Ispaster before the start of LocalRES:

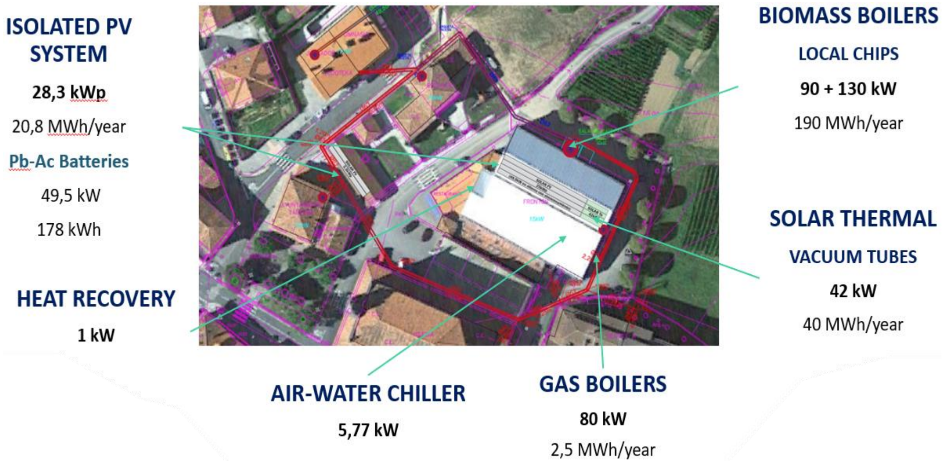


Figure 8: Generation assets in Ispaster

The red ring in Figure 8 is surrounding the sports centre, town hall, one tavern, culture house, school, public services (elderly home, childcare school restaurant). Some dwellings are already connected to this generation ring. On top of the roofs there are PV panels with 28.3 kWp.

There are two boilers for chips that are used during the whole year, but in summer the consumption is very small. Solar thermal vacuum tubes (42 kW) allow to have hot water between April and October with no need of using the biomass boilers.

Two taverns and 10 buildings are being supplied with hot water for DHW and heating.

In summer the consumption is lower, so a refreshment system is in place and is used for the sports centre and for the 2 taverns. They are also supplied with hot water.

These gas boilers are a back-up plan to supply energy when there are maintenance works in the DHN.

4.3.2. Ispaster use case

OBJECTIVES FOR ISPASTER USE CASE

The mid-to-long term goal for Ispaster is to be an autonomous and isolated energy island based on 100% RES. To this end, Ispaster signed the Programme for the Further Implementation of Agenda 21 in 2008 and the Covenant of Mayors (Adapt. 2030) in 2016.

Ispaster wants to increase the capacity of the microgrid to operate outside the community. More specifically, they are planning to install 100 kWp PV on roofs in Elexalde (main district). Some regulatory issues are needed for this. It would allow to upgrade the DHN and connect new consumers. Three public buildings are left to connect to the microgrid and district heating. Two private buildings are interested. They are considering Combined Heat and Power (CHP) biomass unit (60 kWt + 5 kWe) pellets.

Increase the renewable share of the electricity network from 13% to 62% (additional 80 MWh of renewable electricity will be locally produced and used).

Ispaster aims at defining new business models for ESCOs and different RES system operation. In this sense, a legalisation procedure will be needed for the microgrid to allow selling the surplus energy in the market.

A medium to long term objective in Ispaster is to establish a solid REC in the area. First steps were taken with the involvement of the school and the public services. Knowledge gained in this project can be used to improve future policies relating to RECs and efficiency.

Identified foreseen challenges include:

- Involvement of citizens in the management of their energy and related processes such as generation, distribution and consumption. They need to get technical information from the citizens.
- Real possibilities of replicating the project in nearby villages.
- Achieve a favourable public-private relationship for decision making investments.
- Fix population and create quality jobs in rural areas.

SELECTED SERVICES FOR ISPASTER USE CASE

The services identified within Ispaster demo site to be integrated as part of the use case are listed below:

Thermal:

- Operation of a DHN with RES
- Help to balance a DHCN
- Heating/Cooling as a service
- P2H
- Building energy management & optimization

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Electrical:

- Collective Peak shaving
- REC-level/Collective self-consumption
- Blackout strategies
- Public EV charging stations
- Smart Energy Storage Management
- Congestion management
- Anomalies detection at REC-level

Non-technical:

- Capitalisation of monitored data
- Prefeasibility assessment
- End-user engagement
- Support on technical execution

MAIN STAKEHOLDERS INVOLVED IN ISPASTER USE CASE

Next, the main stakeholders expected to be involved in Ispaster use case are presented:

Ispaster town council: It's a public body which has the ownership of the installation

Barrizar is a small cooperative, more specifically, an ESCO with 5 people. They are in charge of the operation and management at technical and financial level of the REC and its services. They have the leadership over the REC and provide thermal and electrical energy to Ispaster town council.

Public sector (Regional): Support of the REC. Funding of different intervention in the REC.

Aiguasol provides support on technical execution and the Prefeasibility assessment service.

Local citizens: will participate in the participatory processes and engagement activities associated to the REC, and will benefit directly or indirectly from the different actions and services provided by the REC.

DESCRIPTION OF ISPASTER USE CASE

The microgrids in Ispaster were public only since their creation, but, in 2019, 10 households were included in the district heating network (only thermal service).

A ring-shaped DHN is electrically fed by means of a microgrid. This means that all the assets within the DHN work with electricity from the microgrid. The thermal energy is then supplied to both the public administration and the private households. The electricity is only supplied to the public administration. The town council owns all installations outside the private households. The 10 private members have purchased a deposit and a thermal station to be able to connect themselves to the microgrid and all the provided services.

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The town council owns the microgrid that supplies electricity only for public services. By the time of writing the current report, the microgrid could only provide electricity for self-consumption inside Ispaster. They want to increase its capacity and allow it to operate with the public network (not only in isolated mode), but so far it has not been possible due to administrative/regulatory issues. Inside LocalRES project, a solar PV with storage system has been foreseen: 100kW of PV and 200 kWh from batteries. These should be considered together with a new one if the total capacity is to be increased.

The district heating network provides thermal energy for heating and domestic hot water. The thermal energy generated for the district heating network comes from:

- 2 biomass boilers providing heat to the school and to public buildings (local chips, 90 + 130 kW, 190 MWh/year).
- Gas boilers: 80 kW, 2.5 MWh/year. These are used to provide thermal energy during maintenance works in the district heating network.
- Solar thermal vacuum tubes (42 kW) allow for hot water (2 taverns and 10 buildings) in summer without need of biomass boilers.
- CHP biomass unit (60 kWt + 5 kWe) pellets, which will be installed in the scope of LocalRES project.
- **Power to heat** in residential buildings will be used to generate heat from renewable resources. Related assets are: heat pumps fed by PV that will be installed in 6 houses within LocalRES project, PV and storage (13,000 litres of water for thermal storage). Stirling engine with electric 5kW and a pellets boiler. P2H is related to **building heating optimisation** since it is a way to optimise heating in buildings.

All the above generation sources are renewable (except for the gas boilers), and constitute the **Operation of DHN with RES** service. The gas boilers are going to be replaced with heat pumps and PV.

There are 12 points of thermal consumption. These are spread among: sports center, town hall, two taverns, culture house, childcare school, public services (elderly home, school restaurant), dwellings.

The microgrid generation consists of:

- Solar PV: 28,3 kWp (panels), 20,8 MWh/year
- Solar PV: 100 kWp, expected to be installed in the scope of LocalRES project

There are 10 points of electrical associated consumption.

The microgrid is supported by batteries (178 kWh Pb-Ac, 4,100 Ah)

A waste heat recovery system powered by the PV micro-grid feeds a multipurpose mezzanine and public restaurant and includes an exhaust air heat recovery (1.02 kW, 1,656 m3/h, perform. 77.9%), in conjunction with an air-water chiller (5.77 kW) an accumulator (500 l) and a cooling coil for refreshment.

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There are batteries sized to cover 3-days electricity demand (20,956 kWh/year, 178 kWh) since the grid connection is weak and not enough to supply new demands and with occasional outages, voltage swings and blackouts (by fallen trees or strong winds) in the distribution grid that cause local energy problems on Ispaster. These batteries can be used within the **blackout strategies** service, together with new electrical batteries (200 kWh) that are planned to be integrated to enhance the flexibility of the microgrid. Blackout strategies service refers to strategies to avoid blackouts. When combined with **smart energy storage management**, the strategy is refined and optimised.

Demand response (implicit & explicit) service might be implemented in Ispaster demo site. Discussions are going on to identify in which way this could be implemented in the MEVPP.

Aggregated (REC level) energy trading service might not be possible due to regulatory issues.

A visualisation (possibly interactive) platform will be used as an interface for the users. They will be able to use it for **end-user engagement** purposes. It will be connected to the Centralised SCADA and will show users data related to their consumption, as well as information about the thermal network and microgrid. End users will be able to have access to **technical support** (e.g. how to optimise heating in the buildings and households). Thermal meters allow thermal energy consumption monitoring and **capitalisation of monitored data** by means of a local open SCADA system

The **building heating optimisation** service is managed by means of a waste heat recovery system powered by the PV micro-grid. This includes an exhaust air heat recovery (1,02 kW, 1.656 m3/h, perform 77.9%), in conjunction with the air-water chiller (5.77 kW) and accumulator (500 l) and cooling system and battery for refreshment.

The **prefeasibility assessment** can provide support on technical execution. **Aiguasol** is providing a tool that will be used as a user interface and will offer this preliminary assessment service. Additionally, a visualisation platform for the user will be developed within the project.

The **Help to balance a DCHN (thermal demand response)** service is connected to the local district heating network. This service would manage thermal assets within the district heating network to provide a thermal demand response. Cooling is also considered a service and is provided only to the town council. **Heating and cooling as a service** is offered by **Barrizar**.

Anomalies detection at REC-level service detects assets malfunctioning by means of thermal and electrical alarms that can be depicted in the centralised SCADA or in another system. Some assets have already their own systems. All signals should be integrated in a unique system

EV charging points will be fed by the local microgrid. One of them will be close to the town council; it will be public and still not known if charging will be free. The other one will be located inside the municipal pavilion and used by the municipal brigade.

A diagram illustrating the description of Ispaster use case is shown in Figure 9.

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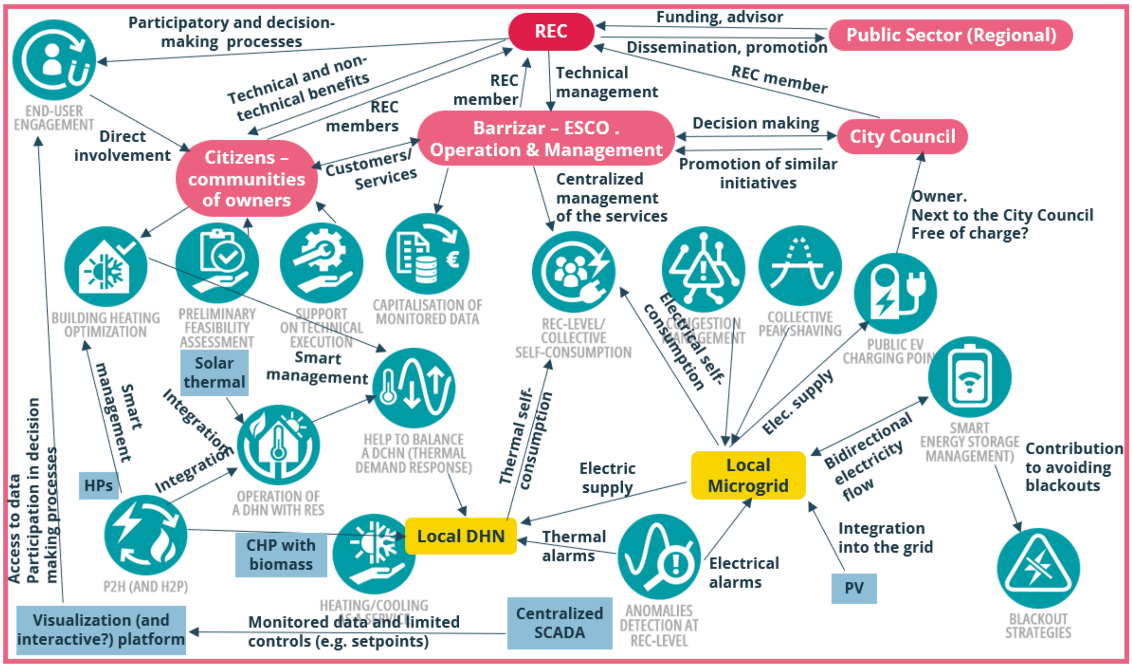

Figure 9: Diagram of Ispaster of use case

SUMMARY OF ISPASTER USE CASE

To conclude with Ispaster demo site, Table 7 summarizes the most relevant aspects constituting the use case, including basic characteristics, services, technologies or stakeholders, as well as the diagram of the use case.

Table 7: Summary of Ispaster use case

Name of the demo site: Kökar	
Characteristics	 **Location:** Ispaster (Bizkaia, Spain) **Type:** Rural community / village **Land area:** 22 km^2 **Population:** 740 inhabitants **Grid:** municipal-owned microgrid and DHN **Stakeholders:** Citizens, Ispaster municipality, Barrizar (ESCO cooperative, operator and maintenance of the district), Public sector (regional/provides funds), Aiguasol (cooperative, technical assistance)
Services	
Technologies	**In the village:** besides the demo case, the rest of the village is supplied with the national grid and gas and oil boilers, air-water chiller for the restaurant **In the demo case**: Existing microgrid supplied by 28.3 kWp PV and batteries (178 kWh Pb-Ac), existing solar thermal and biomass driving a district heating network (DHN), Besides that, a solar PV with storage system has been foreseen, as well as the extension of the DHN, the installation of heat pump-based solutions, a CHP system and a public EV charger.

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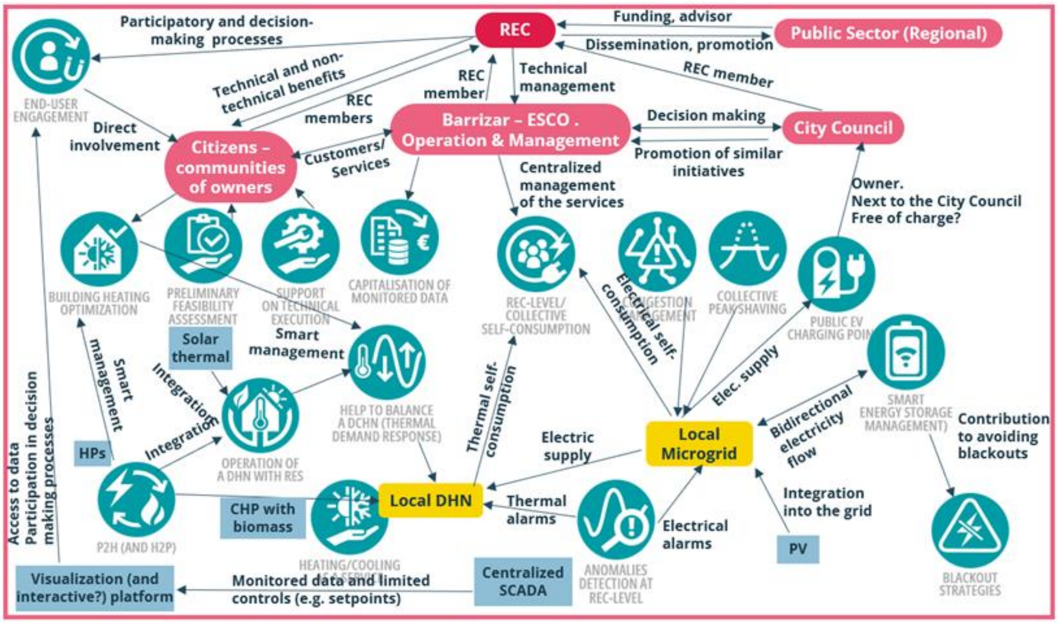
Use case diagram	

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4.4. Ollersdorf demo site

4.4.1. Characterisation

GENERAL DESCRIPTION

Ollersdorf is in the South-East of Austria and has about 1,000 inhabitants, whereas 200 inhabitants are already part of several activities in order to further increase the integration of renewable energy sources. The area is mostly agricultural with no industries settled there. The municipality of Ollersdorf is part of the Klimate and Energy Model Region (KEM) "KEM Golf und Thermenregion Stegersbach". KEM's are a program of the Austrian Klimate and Energy Fund. Ollersdorf is also part of the Innovation Lab act4.energy which is an initiative of the Austrian Ministry of Transportation, Innovation and Technology in the program "City of Tomorrow". As such Ollersdorf has a clear strategy to focus on renewable energy and smart municipality.

LOCAL COMMUNITY & RECS

Despite there was not a formal community established by the beginning of LocalRES project, Ollersdorf demo site has recently become a local energy community after the approval of the legal and regulatory framework in year 2021. This is the result of great efforts from the municipality and the local community to promote RES-related activities, which has also allowed the village to participate in different initiatives, as previously said. In the village, an ESCO is responsible for managing the existing, which is also part of LocalRES project.

According to the local stakeholders involved in LocalRES project, data treatment and stakeholder engagement constitutes challenging aspects in the constitution of a REC, while citizen engagement is considered as easy.

In terms of stakeholders, neighbourhood associations and household tenants are seen as essential, while local cooperatives and SMEs, building owners and the local government are also considered as relevant. Regarding the engagement of stakeholders, the local government, consultancy companies and household tenants are considered as involved or very easy to engage,

Finally, it is to be noted that Ollersdorf has done 5 campaigns of community-funded PV installations since 2011, which means that the community is already very well versed with RES and there is a high commitment in the community and municipality to follow through with the energy transition. Citizen engagement is high and measures to save energy or use low carbon technologies are very likely to be adopted.

ENERGY SYSTEM CONFIGURATION

In Ollersdorf, there is abundant source of solar radiation, and a moderate availability of resources like biomass and biogas. In terms of energy technologies, some buildings have biomass-based heating systems (wood pellet burners), many buildings are equipped with PV plants, and most new and recently refurbished buildings are equipped with heat pumps (instead of oil boilers). PV,

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heat pumps and solar thermal, together with batteries, SEMS and EV chargers for transportation are foreseen as the most frequent technologies in the future.

The energy system is a multiple connection grid with public electric and gas networks. All households have smart meters installed (smart meters are rolled out in the whole province). The public EV charging stations are all connected to the E-Car operation centre of act4.energy and charging data is monitored and can be accessed with OCPP protocol. There are no monitored transformers. A battery storage was already implemented in the town hall and is also directly connected to the fire-police. A car-port with integrated PV and five charging stations is available. There is a number of heat pumps and electric boilers. Regarding EV infrastructure, there are 7 standard EV charges for e-Vehicles and one fast charger.

4.4.2. Ollersdorf use case

OBJECTIVES FOR OLLERSDORF USE CASE

After the set-up of an energy community, this demo site sets its targets at sharing the locally produced energy, increasing the share of RES and coupling different energy sectors (electricity, mobility, heating, waste-water, etc.). Furthermore, (control) strategies in blackout-cases for different time-scales (from seconds to days) and strategies for re-starting the power-system and ICT-system will be developed, validated, and deployed.

Ollersdorf aims at the development of scenarios for future investments and optimal generation mix to reduce the dependence from the main transmission line. This includes benchmarking, comparison of different assumptions, data sources, scenario building, estimating probability of blackouts and modelling suites to explore the pathways to long-term climate – energy policies. Additionally, the measures and strategies to update the local electric grid to allow these changes must be identified. An existing automation framework will be further extended and used for simulation and validation of the power system, the ICT system, as well as control strategies and software components within the community.

SELECTED SERVICES FOR OLLERSDORF USE CASES

The services identified within Ollersdorf demo site to be integrated as part of the use case are listed below:

Thermal:

- Power to Heat (P2H)

Electrical:

- REC-level/Collective self-consumption
- Optimisation of electric flows within the REC
- Blackout strategies
- P2P energy trading

- Public EV (Electric Vehicles) charging stations

MAIN STAKEHOLDERS INVOLVED IN OLLERSDORF USE CASE

Next, the main stakeholders expected to be involved in Ollersdorf use case are presented:

AIT: Demo site coordinator. AIT is also in charge of the smart converter installation and deployment for local control and integration with the MEVPP.

Ollersdorf Municipality is in charge of the management and interaction with local stakeholders.

University of Passau will be in charge of the design and development of the black-out strategies' integration in the MEVPP.

Local citizens: will participate in the participatory processes and engagement activities associated to the REC, and will benefit directly or indirectly from the different actions and services provided by the REC.

DESCRIPTION OF OLLERSDORF USE CASE

Local actors and stakeholders are actively engaged in this recently created renewable local community, including the private owners of RES, energy storages and e-vehicles as prosumers. Several services have been identified and constitute the use case for Ollersdorf demo site:

Power-to-Heat and Heat-to-Power (P2H and H2P) service is guaranteed by means of heat pumps and biomass-CHP. The buildings of the municipality are equipped with HPs and they are using them with the RES generated power.

REC/Collective self-consumption: RES (PV panels), sector coupling (heat pumps and electric boilers). The battery storage at the townhall will be used to increase the self-consumption optimization within the community.

Optimisation of energy flows within the REC: Development and deployment of control algorithms to optimize the energy flows within the REC and to maximize the integration of local resources (RES, E-Vehicles and energy storages) to support energy communities.

P2P energy trading: In addition to the optimization of energy flows in normal operation and emergency cases, Ollersdorf demo is interested in implementing a P2P open marketplace for accounting within the REC based on the settings by customers and infrastructure system states (e.g. electric vehicles with bi-directional charging infrastructure), the energy demand of customers (e.g. household-baseload, power-2-heat-applications), the generations via RES, and storage capabilities.

Control algorithms will be developed and deployed to optimise the energy flows within the REC and to maximise the integration of local resources (RES, E-Vehicles and energy storages) to support energy communities. In a first step, the integration of RES will be done with simulations to achieve 100 % equality in production and consumption within one year. Next, the integration

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will be further carried out by covering the demand in each timestep, based on optimization of all involved stakeholders and available resources. This strategy is further used as baseline for the blackout strategies. The battery storage at the townhall will be used to increase the self-consumption optimization within the community.

Blackout strategies: Development of the strategies to minimize the impact of the blackouts in Ollersdorf including blackstart strategies. These strategies will be considered in different time scales: short-timing (seconds and minutes), medium-timing (hours), long-timing (days). These strategies must allow to maintain in operation the basic services of Ollersdorf municipality and be supported by the resources accounted by the energy community (e.g. PV plants, micro-CHP…) in case of necessity. RES, battery storage, electric vehicles (charging and discharging), heat pumps, etc. will be considered in the blackout and blackstart strategies. Furthermore, the ICT infrastructure will be analysed (and adapted if necessary) to provide stable emergency operation in emergency cases and in the start-up procedure. The AIT Smart Grid Converter will be used to enhance the MEVPP capacities.

Public EV (Electric Vehicles) charging stations: The E-Car Operation Centre is connected to all charging stations within the area. New algorithms will be developed and integrated into this Operation Centre to control the charging power depending on the available energy from RES and grid restrictions.

Many households have PV panels installed, while the PV on some of the public buildings is citizen funded. Moreover, there are HPs, E-mobility, but they are not integrated in a network. All assets from the households should be connected to the REC platform. This way, aggregated flexibility can be connected to the MEVPP. The REC platform would work as an aggregator, optimising the electricity system operation in synergy with local RES (PV panels), sector coupling (Heat pumps and electric boilers), mobility (EVs) and energy storages (batteries).

It is planned to design and deploy a visualization (information) system that will be installed in the current public facilities of the smart street showcase in Ollersdorf to inform the citizens about the important events and to present community-rated information: blackout events, generated energy within the community, number of electric vehicles charged in a dedicated period and used energy, amount of traded energy within the community, announcement of project-related events.

A diagram illustrating the description of Ollersdorf use case is shown in Figure 10.

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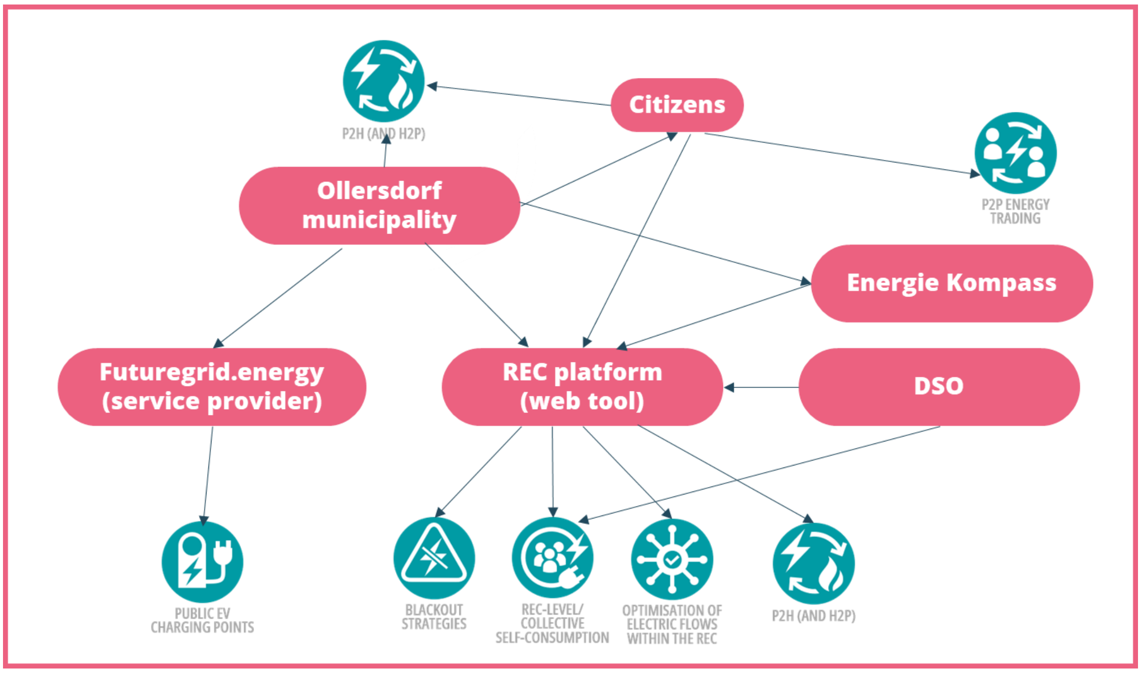

Figure 10: Diagram of Ollersdorf use case

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SUMMARY OF OLLERSDORF USE CASE

To conclude with Ollersdorf demo site, Table 8 summarizes the most relevant aspects of the use case, including basic information, services, technologies, stakeholders, and the use case diagram.

Table 8: Summary of Ollersdorf use case

Name of the demo site: Ollersdorf	
Characteristics	 **Location:** Ollersdorf (Austria) **Type:** Rural community / village **Land area:** 8.9 km^2 **Population:** 1000 inhabitants **Grid:** special concerns of the local community before potential blackout scenarios **Stakeholders:** Citizens, AIT (demo site coordinator, installation of equipment), Ollersdorf Municipality (management and interaction with local stakeholders), University of Passsau (blackout strategies)
Services	BLACKOUT STRATEGIES; OPTIMISATION OF ELECTRIC FLOWS WITHIN THE REC; P2H (AND H2P); P2P ENERGY TRADING; PUBLIC EV CHARGING POINTS; REC-LEVEL/ COLLECTIVE SELF-CONSUMPTION
Technologies	**In the village:** PV, biomass-based heating system (wood pellets burners), heat pumps, smart meters, e-cars, EV chargers, a battery storage, one fast charger. In the future batteries, SEMS, and EV chargers are foreseen **Use case:** biomass-CHP. Heat pumps, PV panels, electric boilers, battery storage, smart EMS (optimisation of energy flows, P2P), ICT platform

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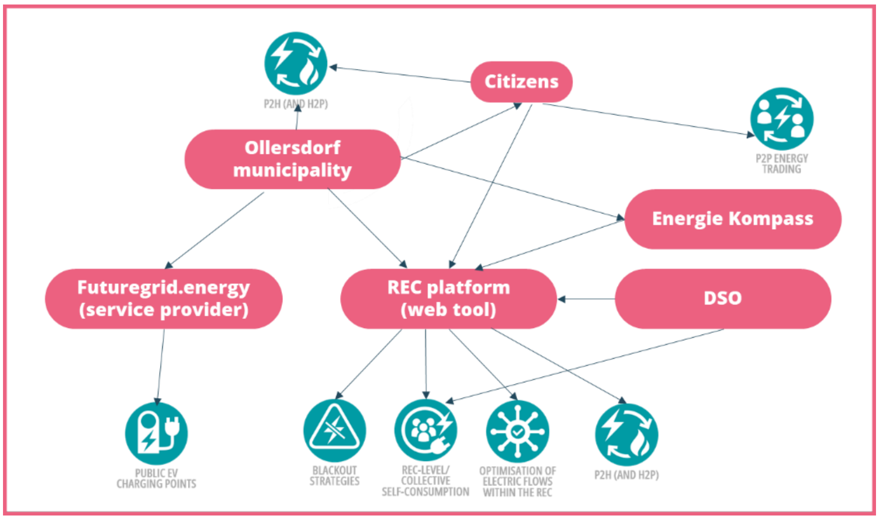
Use case diagram	

5/ Conclusions

A number of Renewable Energy Communities-driven services have been selected for the four demo sites from LocalRES project in close collaboration with local stakeholders, following the methodology described within section 2/. This selection has been done according to **local regulation, local aspects and needs, physical resources, technology and strategic objectives** of each region.

This set of services has been analysed in detail from the perspective of a REC, has been categorised as thermal, electrical and non-technical, and have been classified under three layers of analysis: i) member-focused services; ii) REC services to the markets and the grid in the normal operation mode; iii) REC grid services in the grid alert state. Also, specific KPIs to evaluate each service from the perspective of a REC have been defined, and aligned with the categories of the KPIs defined under *T4.1 Demonstration actions KPIs definition and baseline studies*. This analysis of services aims at constituting **accessible material which non-technical actors involved or interested in RECs could potentially use to understand REC-driven services**.

The services inside each demo site are linked according with a structure that is dependent on the available assets, stakeholders and technologies. This linked structure constitutes a use case per demo, which provides **a starting point for the integration of the identified services within the MEVPP** (to be achieved within *WP3 - Digitalisation and management of local energy systems)* **and the physical implementation inside each physical pilot** (to be achieved within *WP4 - Demonstration of LocalRES solutions*).

The functional and non-functional requirements of the use cases are determined by those of the services selected inside each demo site. **Relevant stakeholders have been identified** and their role has been defined for each use case. **The four use cases will be considered to be implemented in LocalRES project through their constituting services**, via the MEVPP as far as possible, depending on technical limitations or the scope of the project. Thus, not all services are bound to be physically implemented within the project timeframe, but they have been identified as of high interest for the demo site stakeholders and the local communities, for future scenarios.

Finally, the use cases defined within *Task 1.2.- Definition of REC-driven services and Use Cases* will be subject to a **Cost Benefit Analysis** (T1.4) which will facilitate the design of **business models** (T1.5) for different stakeholders that will help unlock investments in the REC.

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7/ Annex A: Initial questionnaire for the preliminary definition of use cases and the characterisation of the baseline

In this first annex, a template of the questionnaire is included first (subsection), followed by a summary of the results from the closed-answer items collected from the demo sites through this questionnaire. The rest of answers are integrated within the characterisation of each demo site.

7.1. Template of the questionnaire

Dear demo responsible partner,

As part of the initial steps of the LocalRES project, the baseline of every demo needs to be characterised, and the REC-driven services are to be defined, too. To do so, knowing the specificities of each demo is essential. For that reason, we have created this first questionnaire, which we kindly ask you to fill in. Please, contact us in case you have any question.

Thank you very much in advance.

1. Please, fill in next information about your demo.

City/demo name		
Main contact	Name	
	e-mail	
Population		
Community range (Inhabitant)		
Area		

2. What is the expected range of inhabitants that would potentially become part of the REC? *Please, try to provide either values or share of total population (e.g. 50-120 or 30%-45%). In case it is unknown, estimate a first tentative figure.*

3. **Available documentation/** Please, indicate if next information is **available** for your demo **site,** and, if yes, indicate the source, type of information, data resolution or any other relevant comment (e.g. link to an online report or database).

YES | NO | NK/NA. Not known/No Answer

DATA	Available?	Comments
Weather data		
Energy strategy or plan (local or regional)		
Local maps[7]		
Energy diagrams and schemes (conceptual, technical…)		
Energy demand data		
Energy production data		

4. **Local natural resources/** How would you evaluate the availability of following **natural resources** in your demo's **local environment** for their use in the energy sector? *Mark with an "X" the level of availability.*

1. Unavailable/Protected | 2. Scarce/Not abundant | 3. Neutral/Moderate availability | 4. Abundant/High availability | 5. Very abundant/Functionally "unlimited" | NK/NA. Not known/No Answer

NATURAL RESOURCES	1	2	3	4	5	NK/NA
Sun (Solar radiation)						
Wind						
Geothermal (Moderate to High)						
Biomass						
Biogas						
Biofuels						
Natural gas						
Water (hydropower potential)						
Sea (Tidal/wave potential)						
Other						

[7] Versions containing more information than that included in Google Maps.

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5. **REC-driven services/** what would be the interest of the potential REC in your demo in providing next **services?** *Mark with an "X" the level of interest, for every REC-driven service.*

1. Not allowed/Not possible | 2. Not interesting/Not desirable | 3. Neutral/Indifferent | 4. Interesting/Recommended | 5. Very interesting/Essential | NK/NA. Not known/No Answer

SERVICES	1	2	3	4	5	NK/NA
Operation of a DHN (District Heating Network) with RES (Renewable Energy Sources)						
Sale of waste heat to a DHN						
Help to balance a DHN (Thermal demand response)						
Heating/Cooling as a service[8]						
P2H (Power to heat) and H2P (Heat to Power)						
Building heating optimization (systems and electricity consumption optimization)						
Collective Peak shaving[9]						
REC-level/Collective self-consumption[10]						
Optimisation of electric flows within the REC[11]						
Voltage and reactive power control[12]						
Frequency control (FCR, aFRR, mFRR)[13]						
Demand response (Implicit and explicit)[14]						
V2G[15] services						
Blackout strategies[16]						
P2P energy trading[17]						
Aggregated (REC-level) energy trading[18]						
Public EV (Electric Vehicles) charging stations						
Smart Energy Storage Management[19]						

[8] The user does not own the system, but the community and the user pay for the amount of energy or temperature difference (in degrees, ºC, difference between supply and return flows) that is consumed.

[9] Collective Peak shaving: As a group of users, to reduce power consumption to avoid spike in consumption; e.g. by using storage or by shifting loads.

[10] REC/Collective self-consumption: as a group of users or a community, to consume the energy produced by your own energy system.

[11] Optimisation of electric flows within the REC: to ensure an optimal operation of the grid by minimizing the losses in the lines, considering their restrictions, including voltage drops and overloading in lines.

[12] Voltage and reactive power control: to collaborate in maintaining the voltage stability, reliability of the power system and reduce the total loss in the system.

[13] Frequency control: to ensure short-term supply and demand balancing by keeping the system frequency within the normal operating band.

[14] Load shifting (demand response): to move loads, typically, from peak hours to off-peak hours of the day.

[15] V2G: Vehicle-To-Grid. To provide your electric vehicles' batteries as electrical storage.

[16] Blackout strategies: To solve service restoration problems in the event of a blackout.

[17] P2P energy trading: Peer-to-peer energy trading. Buying or selling energy between multiple parties or the grid.

[18] Aggregated (REC- level) energy trading: to combine individual consumptions or productions and enter as one only party in energy trading systems.

[19] Smart Energy Storage Management: dynamic use of storage system considering factors such as price signals or the maximization of renewable energy resources.

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Congestion management						
Anomalies detection at REC-level						
Capitalisation of monitored data[20]						
Sale of waste heat for the purpose of drying products						
Legal advice[21]						
Prefeasibility assessment[22]						
End-user engagement[23]						
Support on technical execution						

6. **Relevant topics for the constitution of RECs/** How **challenging** are these topics for your demo, with regards to the potential constitution of a REC. *Mark with an "X" the level of importance, for every topic.*

1. Very easy/Not challenging at all | 2. Easy/Not challenging| 3. Neutral | 4. Challenging/Hard | 5. Critical/Strongly challenging | NK/NA. Not known/No Answer

	1	2	3	4	5	NK/NA
Technical barriers						
Financial barriers						
Legal/regulation barriers						
Citizen engagement/commitment						
Stakeholder engagement						
Business model definition						
Data treatment						
Technology providers						
Other						

[20] Capitalisation of monitored data: use of data as an exploitable asset to be offered to external parties (e.g. DSO).
[21] Legal advice: consultancy services for regulatory and legal aspects related to RECs.
[22] Prefeasibility assessment: pre-evaluation of potential RECs during the first stages of the design process.
[23] End-user engagement: participatory and collaborative actions oriented to an effective engagement of end-users for their participation in the activities of RECs.

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7. **Local community/** How **accurate** are next statements referred to the status of the local **community in your demo, prior to the LocalRES project?** Please, include any additional description or clarification that may help describing the local community before the project. *Mark with an "X", for every statement.*

1. Not accurate at all | 2. Vague/Imprecise | 3. Somehow accurate | 4. Accurate | 5. Totally accurate | NK/NA. Not known/No Answer

	1	2	3	4	5	NK/NA
There is a legal entity around the local community (e.g. cooperative, association)						
Members meet periodically to make decisions, vote or discuss						
The decisions affecting the community are made by a board of representatives						
The members of the community actively take part in the decision-making process						
There is not a formal community established						
A third party (e.g. Energy Services Company, ESCO) centralize the decisions and management of the communities. "Members" = Clients						
Engaging citizens is typically very difficult						
Other:						

Include any additional explanation here:

8. **Relevant stakeholders for the RECs/** How **relevant** do you consider these stakeholders, with regards to the potential constitution of a REC. *Mark with an "X" the level of relevance, for every stakeholder.*

1. *Not relevant at all | 2. Little relevance| 3. Neutral | 4. Relevant | 5. Essential/Very relevant | NK/NA. Not known/No Answer*

Stakeholder	1	2	3	4	5	NK/NA
Local government/politicians						
Regional government						
National government						
Local SMEs[24]						
Large companies						
DSO[25]						
Consultancy companies						
Financial entities						

[24] SME: Small and Medium-sized enterprises
[25] DSO: Distribution System Operator

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RTOs[26] & universities						
NGOs[27]						
Energy trading companies						
Energy system operator						
Local cooperatives						
ESCOs[28]						
Building owners						
Neighbourhood associations						
Household tenants						
Other						

9. **Engagement of stakeholders for the RECs/** How **challenging** do you consider the **engagement of these stakeholders**, with regards to the potential constitution of a REC. *Mark with an "X", for every stakeholder.*

1. Very easy/Already involved | 2. Easy/Not challenging | 3. Neutral | 4. Hard/Challenging | 5. Very hardly/Strongly challenging | NK/NA. Not known/No Answer

Stakeholder	1	2	3	4	5	NK/NA
Local government/politicians						
Regional government						
National government						
Local SMEs[29]						
Large companies						
DSO[30]						
Consultancy companies						
Financial entities						
RTOs[31] & universities						
NGOs[32]						
Energy trading companies						
Energy system operator						
Local cooperatives						
ESCOs[33]						
Building owners						
Neighbourhood associations						
Household tenants						

[26] RTO: Research and Technology Organizations
[27] NGO: Non-Governmental Organization
[28] ESCO: Energy Service Company
[29] SME: Small and Medium-sized enterprises
[30] DSO: Distribution System Operator
[31] RTO: Research and Technology Organizations
[32] NGO: Non-Governmental Organization
[33] ESCO: Energy Service Company

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Other						

10. **Current energy technologies/** Include the latest information on installed energy technologies and current production for your demo. *Any additional information, technical or not technical, is very welcome.*

11. **Future energy technologies/** How **frequent or common** are next energy technologies expected/projected in the future local energy system of your demo (2030-2050)? Please, base f available, provide specific information (e.g. total installed power, number of systems). *Mark with an "X", for every technology.*

1. Very rare/Inexistent/Not expected | 2. Rare/Uncommon| 3. Common/Frequent | 4. Moderately common/Moderately frequent | 5. Very common/Highly frequent | NK/NA. Not known/No Answer

Energy technology	1	2	3	4	5	NK/NA
Gas/Oil boilers						
Biomass boilers						
Solar thermal						
Wind turbines						
Photovoltaics						
Heat Pump						
CHP[34]						
Electrical batteries						
Thermal storage (e.g. PCM)						
SEMS[35]						
P2H						
H2P						
Electric Vehicle charger (EV)						
Radiators						
Radiant floor						
Traditional fireplace						
Fuel cells (H2-powered)						

[34] CHP: Combined Heat and Power
[35] SEMS: Smart Energy Management System

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Electrolyser/Hydrogen production						
Other						

12. **Relevant local aspects/** Could you provide information about **local aspects** of your demo that could potentially affect the project (either drivers or barriers)? *Find examples below, and include as much relevant information as possible.*

Examples*: location of a zone that requires consideration nearby the demo, e.g.: a natural park, the sea, estuaries or aquifers, endangered animals' zone, historical ruins. Any additional information You could complement the information with documentation.*

13. **Demo's energy profile/** How would you define the energy profile of your demo in terms of energy consumption? In case more detailed data has been provided in question #9, you can omit this one. *Mark with an "X" in the one that fits the best your demo's profile. Try to*
.

1. Not significant (<10%) | 2. Significant (>10% & <50%)| 3. Nearly half (≈50%) | 4. Very significant (>50% & <90%)| 5. Major consumer (>90%) | NK/NA. Not known/No Answer

Example*: if the demo is mainly residential, with a part of commercial use, but almost no industry (see* . e.g. X *in the table)*

Building profiles	1	2	3	4	5	NK/NA
Industrial						
Residential						
Commercial (Tertiary)						
Public buildings						

Include more information, if available:

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7.2. Summary of the questionnaire results

4	Local Natural resources	Kökar	Berchidda	Ispaster	Ollersdorf
	Sun (Solar radiation)	3	4	3	4
	Wind	5	1	2	2
	Geothermal (Moderate to High)	-	1	2	2
	Biomass	3	1	4	3
	Biogas	2	1	2	3
	Biofuels	1	1	2	1
	Natural gas	1	1	1	1
	Water (hydropower potential)	1	1	1	1
	Sea (Tidal/wave potential)	-	1	4	1
	Other:	-	-	-	-

1	Unavailable/Protected
2	Scarce/Not abundant
3	Neutral/Moderate availability
4	Abundant/High availability
5	Very abundant/Functionally "unlimited"
-	Not known/No Answer

5	REC-driven services	Kökar	Berchidda	Ispaster	Ollersdorf
	Building heating optimization	4	4	4	4
	Sale of waste heat to a DHN	1	2	1	2
	Sale of waste heat for the purpose of drying products	2	2	3	2
	Heating/Cooling as a service	2	-	4	2
	Help to balance a DCHN (thermal demand response)	1	4	4	2
	Operation of a DHN with RES	1	3	4	3
	P2H (and H2P)	4	-	4	4
	Collective Peak shaving	4	5	4	4
	REC-level/Collective self-consumption	5	5	4	5
	Demand response (implicit and explicit)	4	5	4	4
	Aggregated (REC-level) energy trading	2	5	3	3
	P2P energy trading	3	5	3	4
	Optimisation of electric flows within the REC	4	5	4	5
	Voltage and reactive power control	4	4	4	3
	Frequency control (FCR, aFRR, mFRR)	2	4	4	3
	V2G services	1	1	4	4
	Blackout strategies	4	2	4	5
	Public EV charging points	5	2	4	4
	Smart Energy Storage Management	5	5	4	3
	Congestion management	3	4	3	4
	Anomalies detection at REC-level	4	4	4	4
	Capitalisation of monitored data	5	4	4	4
	Legal advice	5	5	4	3
	Prefeasibility assessment	2	5	4	4
	End-user engagement	4	5	4	4
	Support on technical execution	5	5	4	4

1	Not allowed/Not possible
2	Not interesting/Not desirable
3	Neutral/Indifferent
4	Interesting/Recommended
5	Very interesting/Essential
-	Not known/No Answer

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6	Relevant topics for the constitution of RECs	Kökar	Berchidda	Ispaster	Ollersdorf
	Technical barriers	4	3	2	3
	Financial barriers	4	3	2	3
	Legal/regulation barriers	2	3	2	3
	Citizen engagement/commitment	4	5	2	1
	Stakeholder engagement	4	5	2	4
	Business model definition	2	3	2	3
	Data treatment	5	3	3	4
	Technology providers	5	5	3	3
	Other: *Logistics*		4		

1	Critical/Strongly challenging
2	Challenging/Hard
3	Neutral
4	Easy/Not challenging
5	Very easy/Not challenging at all
-	Not known/No Answer

7	Local Community	Kökar	Berchidd	Ispaster	Ollersdor
	There is a legal entity around the local community (e.g. cooperative, association)	4	1	1	5
	Members meet periodically to make decisions, vote or discuss	4	1	1	4
	The decisions affecting the community are made by a board of representatives	5	1	1	2
	The members of the community actively take part in the decision-making process	4	1	1	4
	There is not a formal community established	1	5	5	1
	A third party (e.g. Energy Services Company, ESCO) centralize the decisions and management of the communities. "Members" = Clients	3	1	5	1
	Engaging citizens is typically very difficult	2	2	4	1
	Other:				

1	Not accurate at all
2	Vague/Imprecise
3	Somehow accurate
4	Accurate
5	Totally accurate
-	Not known/No Answer

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8	Relevance of stakeholders for the RECs	Kökar	Berchidda	Ispaster	Ollersdorf
	Local government/politicians	5	5	4	4
	Regional government	4	1	5	3
	National government	2	4	5	3
	Local SMEs	4	1	5	4
	Large companies	1	1	4	1
	DSO	5	4	4	2
	Consultancy companies	5	4	4	2
	Financial entities	-	3	4	2
	RTOs & universities	3	4	4	2
	NGOs	2	4	3	2
	Energy trading companies	2	3	3	2
	Energy system operator	3	5	4	2
	Local cooperatives	3	4	5	4
	ESCOs	4	4	5	3
	Building owners	5	3	5	4
	Neighbourhood associations	-	4	5	5
	Household tenants	1	5	5	5
	Other:				

1	Not relevant at all
2	Little relevance
3	Neutral
4	Relevant
5	Essential/Very relevant
-	Not known/No Answer

9	Engagement of stakeholders for the RECs	Kökar	Berchidd	Ispaster	Ollersdor
	Local government/politicians	1	1	1	1
	Regional government	2	-	1	3
	National government	3	-	2	3
	Local SMEs	2	-	4	2
	Large companies	3	-	4	-
	DSO	1	1	4	4
	Consultancy companies	2	1	3	1
	Financial entities	2	3	4	3
	RTOs & universities	2	1	3	3
	NGOs	3	3	4	3
	Energy trading companies	3	3	4	3
	Energy system operator	3	1	4	3
	Local cooperatives	2	-	1	2
	ESCOs	2	1	1	2
	Building owners	2	-	3	3
	Neighbourhood associations	2	3	3	2
	Household tenants	2	3	3	1
	Other:				

1	Very easy/Already involved
2	Easy/Not challenging
3	Neutral
4	Hard/Challenging
5	Very hard/Strongly challenging
-	Not known/No Answer

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11	Future energy technologies	Kökar	Berchidd	Ispaster	Ollersdor
	Gas/Oil boilers	2	5	3	3
	Biomass boilers	3	1	4	3
	Solar thermal	2	1	4	4
	Wind turbines	4	1	2	1
	Photovoltaics	5	4	5	5
	Heat Pump	5	3	5	4
	CHP	2	2	4	2
	Electrical batteries	2	2	4	4
	Thermal storage (e.g. PCM)	2	1	4	3
	SEMS	3	2	4	4
	P2H	2	2	4	2
	H2P		2	3	2
	Electric Vehicle charger (EV)	3	1	4	5
	Radiators	3	4	3	-
	Radiant floor	2	2	3	-
	Traditional fireplace	5	5	3	2
	Fuel cells (H_2-powered)	1	1	4	1
	Electrolyser/Hydrogen production	1	1	4	1
	Other:				

1	Very rare/Inexistent/Not expected
2	Rare/Uncommon
3	Common/Frequent
4	Moderately common/frequent
5	Very common/Highly frequent
-	Not known/No Answer

13	Demo's energy profile	Kökar	Berchidda	Ispaster	Ollersdorf
	Industrial	1	3	1	1
	Residential	4	4	4	4
	Commercial (Tertiary)	1	3	2	2
	Public buildings	5	1	2	2

1	Not significant (<10%)
2	Significant (>10% & <50%)
3	Nearly half (≈50%)
4	Very significant (>50% & <90%)
5	Major consumer (>90%)
-	Not known/No Answer

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8/ Annex B: REC-driven services

Annex B contains the description of all the REC-driven services that have been included in the final list of services, in the scope of this task. As previously explained, this thorough assessment was included as part of the definition of the LocalRES project Use Cases, and aimed at providing detailed analyses of all the services to allow the different actors involved in the process making informed decisions in relation to specific services to be integrated as part of the use cases.

First, a summary table of all REC-driven services is presented, where the category, scope and KPI(s) are specified for each of the services, as well as the demo sites whose use case include the services. Additionally, the category or categories of the services according to the classification of KPIs applied in Task 4.1 is also indicated for each of the proposed KPIs.

Next, individual tables detailing the main aspects relevant to every service are presented, including a short description, objective, technologies, stakeholders, local aspects or associated KPIs. These tables have been elaborated using as a reference the methodology from EN/IEC PAS 62559, which has been simplified and adapted to the context of RECs and the particular context of LocalRES project. It is to be noted that no regulatory aspects have been addressed in these analyses because they are out of the scope of this task and they have been included in the regulatory assessment performed in Task 1.1, so D1.1 can be consulted for specific information about regulatory aspects.

Regarding the specific KPIs proposed for the REC-driven services, it is to be noted that they have been proposed for the evaluation of services from the perspective of the REC, so they may not correspond to those that would have been proposed in a different context. Furthermore, a high level has been kept in their definition to facilitate the understanding by non-technical actors. Thus, only the concept and unit of every KPI has been included, but not specific formula, methodology or assessment framework has been specifically defined in this document. Nevertheless, the calculation and assessment methodology defined in Task 4.1 would be of application in all cases. Furthermore, all KPIs have been defined to be calculated on a yearly basis in comparison with a baseline scenario, i.e. a previous scenario under similar conditions when the service was not provided. This information has been omitted when presenting the different KPIs for simplicity reasons.

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8.1. Summary of REC-driven services

Table 9: Summary of REC-driven services

Category[36]	Service	Scope[37]			Key Performance Indicators (Task 1.2)		Category[38](T4.1)				Kökar	Berchidda	Ispaster	Ollersdorf
		MEMBER	NORMAL	ALERT	Proposed KPI	Unit	TECH	ENV	ECON	SOC				
TH	**Building energy management & optimization**	✓			Total primary energy savings	MWh or %	✓							
					Total final energy savings	MWh or %	✓				✓	✓	✓	
					Energy bills reduction	€ or %			✓					
TH	**Heating/Cooling as a service (H/CaaS)**				PPD (Predicted Percentage of Dissatisfied)	%				✓				
		✓			Thermal energy consumption	kWh	✓						✓	
					Energy systems efficiency	%	✓							
TH	**Help to balance a DHCN (thermal demand response)**	✓	✓	✓	Deviation in thermal demand during demand response events	MWh or %	✓						✓	
					Economic earnings associated to participating in thermal DR events	€			✓					
TH	**Operation of a DHCN with RES**	✓	✓		Renewable energy ratio: (RES MWh)/ (Total MWh)	-	✓	✓					✓	
TH	**P2H (and H2P)**	✓	✓	✓	Deviation in thermal energy demand during the peak hours (demand response event)	MWh or %	✓				✓	✓	✓	✓
					Economic earnings associated to the interactions with the grid (P2H and H2P)	€ or %			✓					
TH	**Sale of waste heat use to a DHN**				Non-renewable primary energy savings thanks to the use of WH	MWh or %	✓							
			✓		Reduction of wasted energy in form of WH	MWh or %	✓							
					Remuneration for WH	€ or €/kW			✓					

[36] Main service category: TH = thermal, EL = electrical, NT = non-technical
[37] Scope: MEMBER = member-focused services; NORMAL = REC services to markets and the grid in the normal operation mode; ALERT = REC grid services in the grid alert state
[38] KPI categories according to Task 4.1: TECH = Technological, ENV = Environmental, ECON = Economic, SOC = Social.

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Category	Service	Scope: MEMBER	Scope: NORMAL	Scope: ALERT	Key Performance Indicators (Task 1.2): Proposed KPI	Unit	Category (T4.1): TECH	ENV	ECON	SOC	Kökar	Berchidda	Ispaster	Ollersdorf
EL	**Aggregated (REC-level) energy trading**		✓		Energy cost savings due to the aggregated participation in energy markets	MWh or %			✓			✓		✓
					Traded volumes in energy markets (sold or bought)	€ or €	✓							
EL	**Anomalies detection at REC-level**	✓		✓	No. of anomalies detected within the REC	-	✓						✓	
EL	**Blackout strategies**	✓		✓	Loss of load time to withstand a potential blackout using available flexibility	% of loss, hours lost	✓				✓		✓	✓
					Backup power supplied during blackouts	kW	✓							
EL	**Collective peak shaving**	✓	✓		Change in energy consumption during peak hours (demand response event)	MWh or %	✓					✓	✓	
EL	**Congestion management**		✓	✓	Number of congestion management events (in the REC, or in the main grid), in which the REC has been involved	-	✓							
EL	**Demand response (implicit and explicit)**		✓		Power flexibility or power deviation	kW	✓				✓	✓		
EL	**Frequency control (FCR, aFRR, mFRR)**		✓	✓	Time during which the network frequency is out of the nominal operating values.	minutes	✓							
					Frequency deviation ratio (FDR)	%	✓							
					Number of events in which the REC has been involved (within the REC, or in the main grid)	-	✓							
EL	**Optimisation of electric flows within the REC**		✓		Difference of energy use from a conventional system (without optimal energy flows).	MWh or %	✓					✓		✓
EL	**P2P energy trading**	✓			Amount of energy exchanged by means of P2P energy trading	MWh	✓					✓		✓
					Number of users involved	-				✓				

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Category	Service	Scope: MEMBER	Scope: NORMAL	Scope: ALERT	Key Performance Indicators (Task 1.2): Proposed KPI	Unit	Category (T4.1): TECH	ENV	ECON	SOC	Kökar	Berchidda	Ispaster	Ollersdorf
EL	Public EV charging stations	✓			Hours of use of the public EV chargers	-	✓			✓	✓	✓	✓	✓
					Number of unique users of the public EV chargers	-				✓				
					Energy consumption of the public EV chargers	MWh	✓							
EL	REC/Collective self-consumption	✓			Self-consumed energy	%	✓						✓	✓
					Ratio between self-consumed and total energy consumption	%	✓							
EL	Smart Energy Storage Management	✓	✓	✓	Self-consumption increase	MWh or %	✓				✓	✓	✓	
					Cost saving	€ or %			✓					
					Energy used from the ESS during blackouts	MWh or %	✓							
EL	Voltage and reactive power control		✓	✓	Number of events in which the REC has been involved (within the REC, or in the main grid)	-	✓							
					Voltage deviation ratio (VDR)	%	✓							
EL	V2G services		✓		Storage capacity of the PEV batteries offered through V2G service	Wh	✓					✓		
NT	Capitalisation of monitored data	✓	✓		Economic value (or monetary equivalence of non-economic rewards) generated by the capitalization of data	€			✓		✓	✓	✓	
NT	End-user engagement	✓			Number of members constituting the REC	-				✓	✓	✓	✓	✓
					Number of participants in activities associated to the REC (members or not)	-				✓				
NT	Legal advice	✓			Number of legal or regulatory issues addressed within the scope of the REC	-				✓				
NT	Prefeasibility assessment	✓			Number of prefeasibility studies performed	-				✓	✓	✓	✓	
NT	Support on technical execution	✓			Number of new projects developed	-				✓				
NT	Support vulnerable citizens	✓			Citizens suffering from energy poverty supported by the REC	- or %				✓	✓		✓	

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8.2. Thermal services

Table 10: Building energy management & optimization

<table>
<tr><th>Service</th><th colspan="3">Building energy management & optimization</th></tr>
<tr><td>Description</td><td colspan="3">The building energy management and optimization service consists of monitoring and controlling in the most efficient way the energy systems within a building including heating, cooling or electricity consumption (e.g. lighting, appliances, electrical devices).
BUILDING ENERGY MANAGEMENT & OPTIMIZATION
The management and optimization in the building can be done according to different aims or objective functions, such as decreasing or minimizing the primary energy consumption, reducing energy bills or maximizing the on-site self-consumption.
Providing this service usually implies using an Energy Management System (EMS) or Building Energy Management System (BEMS), which will include the optimisation algorithms and will act as the “brain”. These EMS can use metering data from the systems and appliances and/or validated dynamic models of the building, considering size, architecture, occupancy, location, utility rates and all systems. Additionally, weather prediction, occupancy monitoring, and user surveys (through apps) to consider effective occupants’ requirements can be also integrated in the EMS (Pisello, Bobker, & Cotana, 2012; Energy.gov, 2021), which will use the data to optimize the entire system according to the objective function and therefore decide at every moment the best way to use the energy assets in the building.</td></tr>
<tr><td>Objective(s)</td><td colspan="3">• Optimise the use of energy systems and appliances in a building while maintaining the comfort and covering the energy needs</td></tr>
<tr><td rowspan="3">KPI(s)</td><td>Total primary energy savings</td><td rowspan="3">Unit</td><td>MWh or %</td></tr>
<tr><td>Total final energy savings</td><td>MWh or %</td></tr>
<tr><td>Energy bills reduction</td><td>€</td></tr>
<tr><td>Scope</td><td>☑ Member-focused service</td><td>○ REC service to markets and the grid in normal operation mode</td><td>○ REC service to grids in grid alert state</td></tr>
<tr><td>Stakeholders</td><td colspan="3">• Building users, as main beneficiaries of this service and active actors in the definition of use schedules, operating restrictions and comfort conditions according to their preferences.
• Operator or provider of the EMS/BEMS to configure and manage the energy system and optimize the building energy flows.</td></tr>
</table>

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	• Indirectly, technology providers, responsible for supplying energy systems, sensors, controllers or communication devices.
Technologies	• Monitoring, control and communication devices (e.g. sensors, actuators, cloud-based systems), usually including a high-level controller (i.e. software linked to models and predictions) • Controllable energy systems of the building (e.g. heating or cooling systems), smart equipment and appliances. • Additionally, on-site RES technologies to be integrated in the energy management
Local aspects	No relevant local aspects needed. Only, buildings where the corresponding technologies can be installed are required.

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Table 11: Heating/Cooling as a service (H/CaaS)

Service	Heating/Cooling as a service (H/CaaS)		
Description	H/CaaS is a pay-per-use model for providing cooling or heating to buildings, in which the upfront investment of the energy system is done by the H/CaaS provider. The customer receives the heating or cooling service, paying a monthly fee per unit of cooling used. The fees include the system as well as all costs related to operation (including electricity and water), maintenance, and repair of equipment. The provider takes care of everything (electricity/water costs, etc.) and owns the installation, which incentivizes the provider to install energy-efficient equipment and conduct proper maintenance and operation to achieve the lowest life cycle cost, making the service more cost-effective (Abramskiehn & Richmond, 2019). Similarly, there is another pay-per-use model called *Comfort as a service*, which guarantees a certain level of "comfort hours" in the user's buildings. The user receives a heating or cooling service as a fix set-point temperature (or a range) set by the user to maintain the thermal comfort (Gómez-Romero, Molina-Solana, Ros, Ruiz, & Martin-Bautista, 2018). Besides the benefits above-mentioned, in the *comfort as a service* scheme, there is also an incentive to make users understand energy efficient behaviour and use heating/cooling responsibly.		
Objective(s)	• Provide heating or cooling to costumers at the highest efficiency • Ensure thermal comfort		
KPI(s)	PPD (predicted percentage of dissatisfied)	Unit	%
	Thermal energy consumption		kWh
	Energy systems efficiency		%
Scope	☑ Member-focused service	◯ REC service to markets and the grid in normal operation mode	◯ REC service to grids in grid alert state
Stakeholders	• H/CaaS or comfort provider, which can be an external actor, the REC community itself, or also a REC member. • The users (consumers), who pay for heating or cooling services, and receive in exchange comfort hours in a specific space, either inside or outside the REC.		
Technologies	• Equipment that supplies heating or cooling (E.g. Heat pumps, RES driven boilers, solar thermal collectors, chillers, etc.)		
Local aspects	Buildings where the required technologies can be installed. Members who cannot assume the upfront investment.		

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Table 12: Help to balance a DHCN (thermal demand response)

<table>
<tr><th>Service</th><th colspan="4">Help to balance a DHCN (thermal demand response)</th></tr>
<tr><td>Description</td><td colspan="4">

In District Heating and Cooling Networks (DHCN) with RES integrated, control strategies to adapt generation and consumption to stabilize network loads might be needed. The proposed service includes operations actions at network level (e.g. adjust the supply temperature of the DHCN) to adjust generation and also, at building level, to be able to optimize the energy exchange in the building's substations (increasing or decreasing the setpoint temperature within the comfort range provided by the user) (Muñoz Rodríguez, Martín Sanz, & Gordaliza Pastor, 2019).

This service usually includes a contract between the DHCN operator and the user that states the range of variation of demand or comfort the user allows to change. The user communicates its demand and the DHCN operator informs the need of reducing or increasing demand (e.g. switching on controllable assets such as heat pumps, or taking advantage of thermal storage for non-manageable renewable resources in order to use the maximum of these RES) within the comfort range of the user. User allows the change in the demand and will modify its consumption at the times required to improve the efficiency of the community system.

The REC or a member of the community would sign the contract with the DHCN operator of DHCN inside the rec or nearby to provide this thermal demand response when needed. This service is classified as thermal but it could imply thermal-electric systems if heat pumps or CHP are used.</td></tr>
<tr><td>Objective(s)</td><td colspan="4">• Adapt the production or consumption profile of users (individual or aggregated) from the DHCN as a response from the network operator to ensure the operation under nominal conditions</td></tr>
<tr><td rowspan="2">KPI(s)</td><td colspan="2">Deviation in thermal energy demand during demand response events</td><td rowspan="2">Unit</td><td>MWh or %</td></tr>
<tr><td colspan="2">Economic earnings associated to performing thermal demand response events</td><td>€</td></tr>
<tr><td>Scope</td><td>✓ Member-focused service</td><td>✓ REC service to markets and the grid in normal operation mode</td><td colspan="2">✓ REC service to grids in grid alert state</td></tr>
<tr><td>Stakeholders</td><td colspan="4">• User (REC community or member of the community)
• DHCN operator that can be also the power grid operator or at least has communication with it</td></tr>
<tr><td>Technologies</td><td colspan="4">• Controllable thermal assets, e.g. heat pumps, CHP, or thermal storage, e.g. stratified thermal tanks.
• Control system:</td></tr>
</table>

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	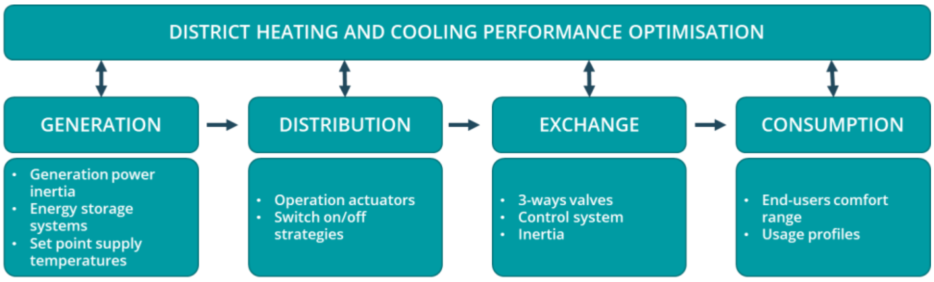 Based on (Muñoz Rodríguez, Martín Sanz, & Gordaliza Pastor, 2019)
Local aspects	Connection to a DHCN

Table 13: Operation of a DHCN with RES

Service	Operation of a DHCN with RES
Description	The REC or some of its members cover the heating and/or cooling needs with a DHCN that is supplied by RES, such as biomass, waste, RES-driven heat pumps, solar technologies and/or geothermal energy (Caramizaru & Uihlein, 2020). A proper operation of the DHCN requires optimizing the availability of RES to maximize their use, while ensuring that energy needs of the user are met. OPERATION OF A DHN WITH RES Depending on the RES source of the network the technologies needed might be different. The networks using low-temperature hydrothermal or geothermal sources usually need a heat pump to distribute energy at the needed temperature. There are also networks that distribute the energy at low temperature (<25ºC), and require distributed water-to-water heat pumps for each building/user to meet the desired temperature at the consumer point.
Objective(s)	• Maximize the RES thermal share in the DHN system
KPI(s)	Renewable energy ratio: (RES MWh)/ (Total MWh) — **Unit**: -
Scope	☑ Member-focused service ☑ REC service to markets and the grid in normal operation mode ○ REC service to grids in grid alert state
Stakeholders	• DH&CN operator is a member of the REC, whereas users do not necessarily need to be a member of the REC, but it is aligned with the objectives of the grid (by means of the contract of heat supply)
Technologies	• Technologies that use renewable resources and generate or exchange heat/cold; fuels such as wood or biomass, and technologies such as CHP, solar thermal collectors or heat pumps
Local aspects	DHCN are usually more economically feasible in high-density areas. Availability of local RES to be integrated into the DHCN In case of new DHCN, important civil works are typically required, which might need permission from local authorities and local/social acceptance

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Table 14: Power to heat & Heat to power (P2H and H2P)

Service	**Power to heat & Heat to power (P2H and H2P)**		
Description	P2H consists of the process of transforming power into heat to either use it or store it use it later for other purposes (e.g. heating, cooling or transform it to power again). P2H technologies can offer flexibility in the power system, especially if applied in district heating networks (Böttger et al. 2014) similar to the service *Help to balance a DHCN*, or to individual heat pumps in a community (Fischer and Madani 2017). As an example, the service P2H could follow the next steps: the grid operator communicates with the facility manager to provide the P2H service, the facility manager gets paid to use the electricity and transform it into heat and, store it or sell it. The service can be used to absorb potential surplus from intermittent RES to produce heat, so the electricity surplus will not strain the grid. Other options, referred to as power-to-x, for instance electrolytic hydrogen generation from the electricity surplus, could also be considered as a similar service, but it is not applied in LocalRES project. Despite it is not common, also a H2P approach can be considered, typically using Organic Rankine Cycle. In this case, the use of heat (which could be use excess heat or waste heat) would be used to produce power.		
Objective(s)	• Optimization of the technical performance of a system or the REC		
KPI(s)	Deviation in thermal energy demand during demand response events	**Unit**	MWh or %
	Economic earnings associated to the interactions with the grid (P2H and H2P)		€
Scope	✓ Member-focused service	✓ REC service to markets and the grid in normal operation mode	✓ REC service to grids in grid alert state
Stakeholders	• Facility or System manager • Grid operator • Users (REC community or member of the community)		
Technologies	• RES Technologies for thermal, electrical and thermo-electric applications (E.g. Heat pumps, Controllable thermal assets). The following diagrams (from (Bloess, Schill, and Zerrahn 2018)) show the different possibilities and where the technologies can be applied:		

	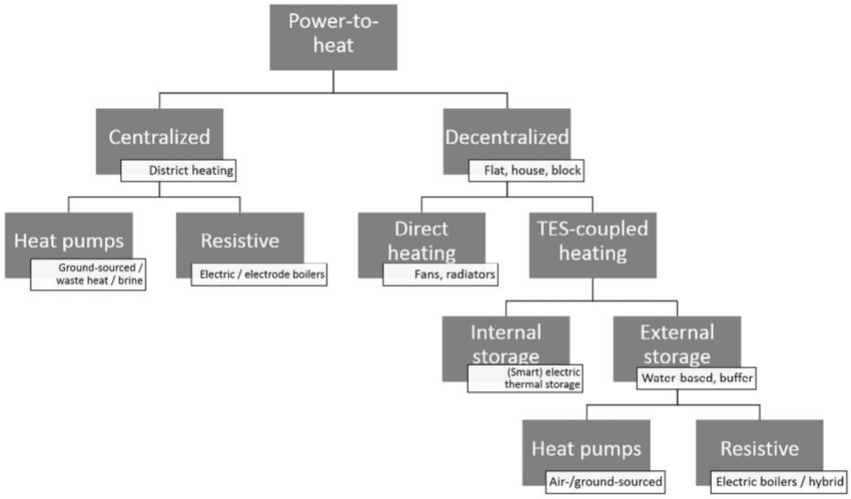 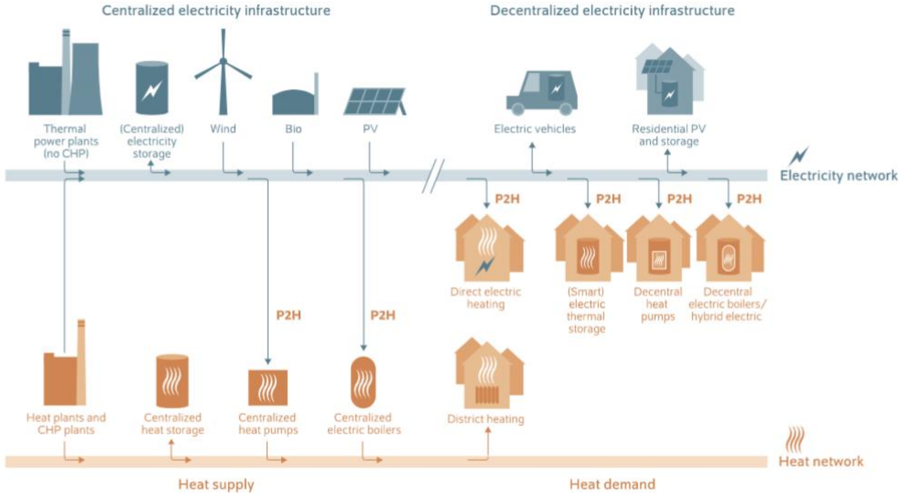 • For control: monitoring (sensors and usually a cloud), actuators and a high-level controller (software linked to models and predictions) are needed.
Local aspects	No relevant local aspects needed. Only, buildings where the corresponding technologies can be installed are required.

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Table 15: Sale of waste heat use to a DHN

<table>
<tr><th>Service</th><th colspan="4">Sale of waste heat use to a DHN</th></tr>
<tr><td>Description</td><td colspan="4">Sale of Waste heat (WH) is a service that can be supplied by industries, supermarkets, and data centers, to a DHCN. This service typically implies contractual agreement between the party responsible for the WH and the user to set the number of hours where WH will be supplied, the pricing, the insurance and the quality assurance (temperature, intermittency), among other aspects (REUSEHEAT, 2021).

The service could be applied to sell waste heat for different purposes: for heating, to be integrated into a DHN, for drying products, or for its use in industrial processes, among others.

RECs operating DHN would mainly have a role of receiver of WH, to use it for heating buildings connected to the network. Additionally, in case the REC includes members from the industrial or service sector, it could also be the case that these members would sell their WH to a DHN, either owned by the REC or not.</td></tr>
<tr><td>Objective(s)</td><td colspan="4">• Exploitation and revalorisation of WH</td></tr>
<tr><td rowspan="3">KPI(s)</td><td colspan="2">Non-renewable primary energy savings thanks to the use of waste heat</td><td rowspan="3">Unit</td><td>MWh or %</td></tr>
<tr><td colspan="2">Reduction of wasted energy in form of waste heat</td><td>MWh or %</td></tr>
<tr><td colspan="2">Remuneration for waste heat</td><td>€/kWh</td></tr>
<tr><td>Scope</td><td>○ Member-focused service</td><td>✓ REC service to markets and the grid in normal operation mode</td><td colspan="2">○ REC service to grids in grid alert state</td></tr>
<tr><td>Stakeholders</td><td colspan="4">• Waste heat provider (industries, supermarkets, data centers, etc.)
• User: district heating network, industries, REC members</td></tr>
<tr><td>Technologies</td><td colspan="4">• Depending on the revalorisation of waste heat the technology needed might be different: for example, if WH is used to produce electricity it needs a ORC system, if WH is used to produce cooling it needs adsorption or absorption chillers, if WH is used to produce heating It needs heat pumps and the type of heat pump will depend on the temperature to be supplied (WasteHeat project, 2021)). In case WH Is used for DHN, it will need a substation to connect the revalorisation of heat (with heat pumps) with the network (and probably pipelines to get to the substation). If WH potential is low and intermittent, storage and solar thermal technologies can be used to provide a more a constant supply.
• Figure shows how the waste heat from a data centre that is upgraded using a heat pump can be injected into the district heating network (FORTUM, 2017):</td></tr>
</table>

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	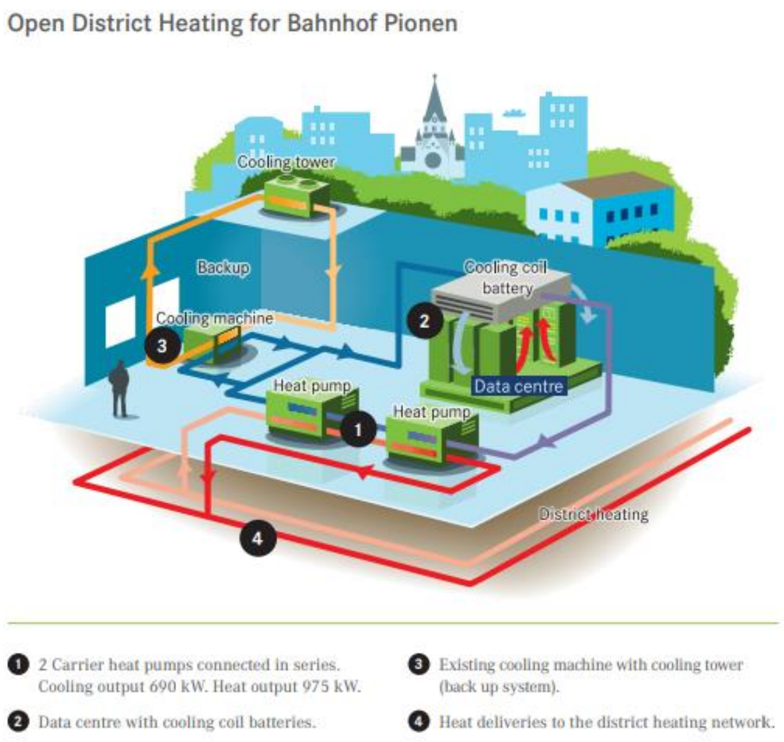
Local aspects	WH potential. For instance, in case WH is used for DHN, a nearby DHN is required (no further than 30 km[39] from the WH source). In case the WH is used for users nearby it will need proper conditions to perform the connection.

[39] "a temperature of 120–250 °C can be transported over approximately 3–5 km while water with a temperature of 90–175 °C can be transported over 30 km" Source: https://www.sciencedirect.com/science/article/pii/S0306261918302058

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8.3. Electrical services

Table 16: Aggregated (REC-level) energy trading

<table>
<tr><th>Service</th><th colspan="3">Aggregated (REC-level) energy trading</th></tr>
<tr><td>Description</td><td colspan="3">REC members can participate in energy markets to sell their electricity production or buy energy through an aggregator. The aggregator can set a trading platform to enable better management of local electricity demand and supply within the community at all times.


This platform would encourage consumption of electricity at the right time of the day to enable peak load reduction, while also minimising the reverse flows of electricity. Thus, it can help to reduce investments related to the generation capacity and grid infrastructure needed to meet peak demand.
The platform can also allow the provision of ancillary services to the main grid. The DSO can potentially discount on the network charges for the consumers or prosumers that help reduce grid congestion (Olivella-Rosell, et al., 2018).</td></tr>
<tr><td>Objective(s)</td><td colspan="3">• Participating in energy markets as an aggregated agent.
• Benefiting of the aggregated structure in the participation in energy markets</td></tr>
<tr><td rowspan="2">KPI(s)</td><td>Energy cost savings due to the aggregated participation in energy markets</td><td rowspan="2">Unit</td><td>€ or %</td></tr>
<tr><td>Traded volumes in energy markets (sold or bought)</td><td>MWh</td></tr>
<tr><td>Scope</td><td>○ Member-focused service</td><td>✓ REC service to markets and the grid in normal operation mode</td><td>○ REC service to grids in grid alert state</td></tr>
<tr><td>Stakeholders</td><td colspan="3">• Aggregator or an equivalent actor to manage the energy trading process of the REC
• REC members, in case they participate in the trading process</td></tr>
<tr><td>Technologies</td><td colspan="3">• Trading platform.
• RES technologies, in case the participation in markets includes selling energy</td></tr>
<tr><td>Local aspects</td><td colspan="3">No relevant local aspects needed.</td></tr>
</table>

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Table 17: Anomalies detection at REC-level

Service	Anomalies detection at REC-level
Description	Efficiently detecting anomalies in the energy systems within a REC is of critical importance for the reliable and efficient operation of the grid. Thus, an efficient detection system can help minimizing the adverse effects of faults and other anomalous events, both in duration and severity, or even preventing them. For that, detection systems usually register and assess the anomalies, which identifying recurring faults and establishing preventive and/or corrective procedures. Typically, anomalies detection systems incorporate alerts to notify system operators and/or users about abnormal events, and are usually integrated into SCADA or EMS/BEMS where all energy systems are monitored and controlled, and where maintenance strategies can be also implemented (corrective, preventive or proactive). The anomalies within a REC may be originated in any of the energy systems integrated in the community, both electrical and thermal (Zhang, Boulet, & Wu, 2021). In the case of electrical anomalies, they can be induced by faulty grid infrastructures, outages, external cyberattacks or unusual consumption patterns of the users (e.g. energy fraud). In thermal systems, such as DHCN, anomalies can be caused by malfunctioning in energy-producing equipment or faults in hydraulic elements, among others. This service may be provided by a technical actor within the REC (e.g. ESCO), or by a third party in charge of the management of the energy systems.
Objective(s)	• Detect anomalies within the energy systems of a REC (thermal or electric) • Minimize the duration and severity of anomalies, or prevent them, maximizing the quality of the services
KPI(s)	Number of anomalies detected within the REC — **Unit**: -
Scope	✓ Member-focused service ○ REC service to markets and the grid in normal operation mode ✓ REC service to grids in grid alert state
Stakeholders	• REC members, affected by potential anomalies • System operator or manager, who can be an external actor or a member of the REC • Technology providers, who can provide the most frequent anomalies of their systems in their manuals or maintenance reports.
Technologies	• Monitoring, control and communication devices (e.g. SCADA, sensors, actuators, cloud-based systems)
Local aspects	No relevant local aspects needed; suitable anywhere

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Table 18: Blackout strategies

<table>
<tr><th>Service</th><th colspan="4">Blackout strategies</th></tr>
<tr><td>Description</td><td colspan="4">Weak connected grids providing electricity supply to small communities are particularly vulnerable to blackouts due to the lack of spare power lines.

Three main scenarios for blackout strategies can be considered:

• Within one REC: Whenever possible, the REC grid can operate in islanding mode. Available flexibilities should be used to continue operation while in an islanding mode and support the grid-forming generators/converters.
• Between multiple RECs: Flexibilities available within one REC might be shared between neighbouring RECs;
• From one REC as service to the DSO: Flexibilities available within one REC might be fed into the higher grid layer recovery strategy of the main grid operator.

Flexible distributed energy resources (DER) can provide backup power during blackouts and support grid-forming generators/converters. DER are located onsite, so they may be less at risk of being disrupted when storms prevent electricity transmission and down distribution wires. They include microgrids, CHP systems, rooftop solar installations, backup power generators, and BESS.

Backup power can be provided by batteries, especially when solar panels are installed nearby. In addition, flexible loads, such us battery electric vehicles and heat pumps can be considered as potential devices to promote resilience to power outages. New technology is just beginning to be tested to allow vehicle-to-building (V2B) and V2G interactions that can use vehicle batteries to power buildings or the grid at large (Center for Climate and Energy Solution, 2018).</td></tr>
<tr><td>Objective(s)</td><td colspan="4">• Ensure power supply for the community in case of a blackout scenario</td></tr>
<tr><td rowspan="2">KPI(s)</td><td colspan="2">Loss of load time to withstand a potential blackout using available flexibility</td><td rowspan="2">Unit</td><td>% of loss, hours lost</td></tr>
<tr><td colspan="2">Backup power supplied during blackouts</td><td>kW</td></tr>
<tr><td>Scope</td><td>✔ Member-focused service</td><td>○ REC service to markets and the grid in normal operation mode</td><td colspan="2">✔ REC service to grids in grid alert state</td></tr>
<tr><td>Stakeholders</td><td colspan="4">• Grid operator of RECs, responsible for managing flexibilities in RECs.
• DSO, in case the service is provided to the higher grid layer recovery strategy.</td></tr>
<tr><td>Technologies</td><td colspan="4">• Combination or installation of technologies to produce or store electricity, such as BESS, V2B, V2G, CHP, PV and/or, Heat pumps.</td></tr>
<tr><td>Local aspects</td><td colspan="4">No relevant local aspects required to provide this service have been identified</td></tr>
</table>

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Table 19: Collective peak shaving

Service	**Collective peak shaving**		
Description	Collective peak shaving is a service which can be oriented both to the grid (and the DSO) to obtain an ideal and uniform power generation and consumption scenario without peak loads on the grid, or to the users (individual or collective) to avoid exceeding the contracted power or paying extra costs due to high peak loads. Thus, from an operator perspective, peak loads cause an increase in grid usage costs, as peak loads need to be satisfied by turning on expensive generation units to cover it, so need to be avoided (Next-kraftwerke, n.d.). These peak loads can be avoided by temporarily scaling down production, activating an on-site power generation system, relying on a community battery (H. Ortmeyer & Vu, 2021) or performing demand response service (See Table 21). While this service is usually associated to power system and grids, it is also applicable to thermal systems and DHCN.		
Objective(s)	• Avoid peak loads, either at system or grid levels (or both), while the energy needs are covered		
KPI(s)	Change in energy consumption during peak hours (demand response event)	**Unit**	MWh or %
Scope	✓ Member-focused service	✓ REC service to markets and the grid in normal operation mode	○ REC service to grids in grid alert state
Stakeholders	• REC members • System operator/manager or local DSO, who can be an external actor or a member of the REC		
Technologies	• Technologies that produce electricity from RES (E.g. PV technology, wind generation) or help to balance the energy system (E.g. Storage solutions) • Monitoring, control and communication devices (e.g. sensors, actuators, cloud-based systems), usually including a high-level controller (i.e. software linked to models and predictions, for applying collective peak saving actions) • If also demand response is applied, see Table 21.		
Local aspects	No relevant local aspects required to provide this service have been identified		

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Table 20: Congestion management

<table>
<tr><th>Service</th><th colspan="4">Congestion management</th></tr>
<tr><td>Description</td><td colspan="4">A grid congestion is defined as a lack of transmission line capacity to deliver electricity without exceeding thermal, voltage and stability limits designed to ensure reliability (NRG Editorial Voices, 2018). Therefore, managing these events is essential to maximize a stable and secure supply.


Within the REC, it is possible to aggregate small generation resources (e.g. heat pumps) and users' loads to generate some flexibility and alleviate congestion inside the REC. For example, heat pumps can be operated to avoid transformer overloading thereby helping to reduce or postpone investments for grid reinforcement. Operation of heat pumps (by means of aggregating several ones) can be planned to avoid load peaks on household and grid level, as well as to avoid transformer loadings and lower voltage levels in the grid. In most studies, a real-time control to decide when to operate the heat pump, and sometimes combined with day-ahead planning to avoid operation during critical periods(Fischer and Madani 2017). In certain studies, heat pumps are operated when the terminal voltage of grid is above a certain threshold to avoid hunting effect, but, to ensure the grid does not get stressed due to connection and disconnection of HPs some delays need to be considered(Sinha, Bak-Jensen, and Pillai n.d.).
The REC can provide an adequate level of flexibility, coordinating in the best possible way the energy systems within the REC in order to provide ancillary services to the grid (Olivella-Rosell, et al., 2018)</td></tr>
<tr><td>Objective(s)</td><td colspan="4">• Alleviate congestion inside the REC
• Sell flexibility to the grid operator once self-consumption is ensured to help alleviating congestion in main grid</td></tr>
<tr><td>KPI(s)</td><td colspan="2">Number of congestion management events (in the REC, or in the main grid, in which the REC has participated</td><td>Unit</td><td>-</td></tr>
<tr><td>Scope</td><td>○ Member-focused service</td><td>✓ REC service to markets and the grid in normal operation mode</td><td colspan="2">✓ REC service to grids in grid alert state</td></tr>
<tr><td>Stakeholders</td><td colspan="4">• REC members.
• System operator or manager or local DSO, who can be an external actor or a member of the REC.</td></tr>
<tr><td>Technologies</td><td colspan="4">• Grid infrastructure
• Monitoring, control and communication devices (e.g. sensors, actuators, cloud-based systems), and controllable assets</td></tr>
<tr><td>Local aspects</td><td colspan="4">No relevant local aspects required to provide this service have been identified</td></tr>
</table>

Table 21: Demand response (implicit and explicit)

Service	**Demand response (implicit and explicit)**		
Description	Demand response is a tariff or service that incentivises the end-users to change their consumption patterns, based on changes in the grid reliability or in the electricity market price. There are two types of demand response: • Explicit: when the user sells the flexibility of their loads and storage capacities participating in the market, with an aggregator. This is comparable to a generation asset and receives direct payment for its service. • Implicit: when the user does not participate in the market but has contracted a supply contract with the DSO a dynamic tariff in which electricity prices are time-varying. So, the user chooses the cheapest moments to consume electricity in their flexible assets in which moment consume, in order to reduce billing costs. (Zancanella, Bertoldi, & Kiss, 2018)		
Objective(s)	• Balance energy consumption • Increase of grid flexibility and stability • End-user economic savings		
KPI(s)	Power flexibility or Power deviation	**Unit**	kW
Scope	○ Member-focused service	✓ REC service to markets and the grid in normal operation mode	○ REC service to grids in grid alert state
Stakeholders	• REC members. • System operator or manager or local DSO, who can be an external actor or a member of the REC		
Technologies	• Monitoring, control and communication devices (e.g. sensors, actuators, cloud-based systems), usually including a high-level controller (i.e. software linked to models and predictions, to actuate in the flexible assets or send recommendations to users) • Controllable and flexible assets in the building (e.g. heating or cooling systems), smart equipment and appliances.		
Local aspects	No relevant local aspects needed.		

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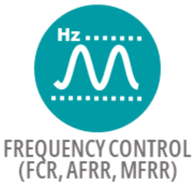
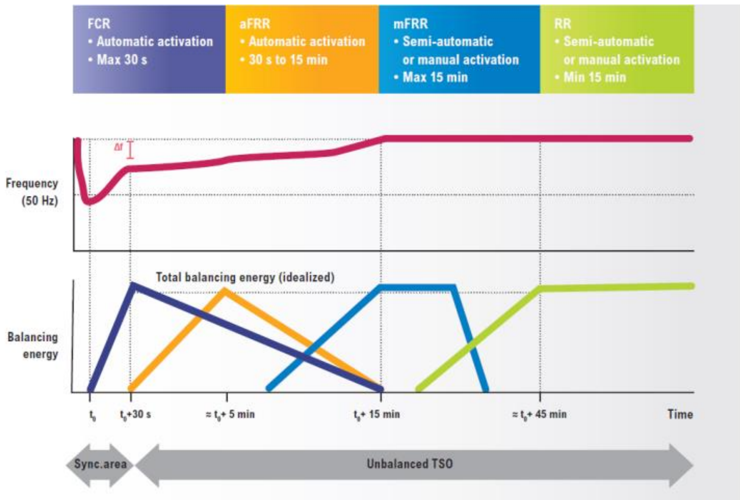
Table 22: Frequency control (FCR, aFRR, mFRR)

Service	**Frequency control (FCR, aFRR, mFRR)**
Description	 The power grid frequency is 50 Hz or 60 Hz. If too much power is produced (or not enough consumed), the frequency rises. In case not enough power is produced (or too many consumers need too much power), the frequency drops. Beyond a certain threshold (+/- 0.2 Hz), a blackout is eminent. To avoid such scenario, system operators (in Europe transmission grid operators (TSO)) deploy balancing energy. This balancing energy is a power consuming or producing capacity that is added to or taken off the grid in case the frequency steers too far away from the stable level. Balancing energy is divided into three to four different main products, called Frequency Containment Reserve (FCR) recently R1, or primary control reserve, Automatic Frequency Restoration Reserve (aFRR, R2, or secondary control reserve), Manual Frequency Restoration Reserve (mFRR, R3, or tertiary control reserve) and Replacement Reserve (RR) .  *Source: (INTERRFACE, 2019)* RECs owning a microgrid fed by RESs, typically solar and wind, are subject to severe frequency fluctuations. Battery energy storage systems (BESS) and plug-in hybrid electric vehicles (PHEV) or EVs can be used locally for frequency control purposes. Frequency control may be also offered as an ancillary service to the external grid. However, due to their relatively small size regarding peak power, microgrids generally do not participate in energy markets and channel their participation through aggregators or an Energy Service Company (ESCO).
Objective(s)	• Keep the frequency of the network in the nominal operating level • Balancing and providing flexibility to the local grid (empowering the customer and the growth of RES)

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KPI(s)	Time during which the network frequency is out of the nominal operating values.	**Unit**	minutes
	Frequency deviation ratio (FDR), calculated as a ratio of time step counts where the frequency is outside the required band		%
	Number of events in which the REC has been involved (within the REC, or in the main grid)		-
Scope	◯ Member-focused service	✔ REC service to markets and the grid in normal operation mode	✔ REC service to grids in grid alert state
Stakeholders	• TSOs are responsible for transmission system security and for frequency control, congestion management and voltage support in transmission networks. DSO take care of distribution system security through congestion management, voltage control, etc. DSO facilitate the market by connecting parties to the distribution grid and TSO by connecting parties to the transmission grid • Both DSO and TSO are responsible for the secure operation of their respective networks, involving management of congestions and voltage levels of their grids. • Prosumers, consumers or producers (member Of REC) can deliver flexibility through demand response and more flexible use of their distributed energy • Balance Responsible Partiers (BRP), aggregators and suppliers are parties involved in the markets (ENTSO-E, 2021).		
Technologies	• Potential technologies capable of proving fast response. • Generating technologies like synchronous generators and inverter-based units • RES, Electrical storage systems and PHEVs		
Local aspects	No relevant local aspects needed.		

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Table 23: Optimisation of electric flows within the REC

Service	Optimisation of electric flows within the REC		
Description	 The optimisation of electricity flows main goal is to balance generation and demand. In a conventional system, this was easier to reach, but due to the implementation of distributed RES, which are variable and intermittent source of energy; and has created the need for additional balancing and other ancillary services to maintain the balance between generation and consumption. This service can offer different optimization approaches: from maximising the RES production in the REC; to minimizing energy costs and energy losses; or even optimising the operation of the grid. To achieve this, the REC members can offer their flexibility to the local electricity network, through controlling their flexible assets (Smart home management system) or offering their storage capacity (Smart Energy storage management system). To do this, the system needs an ICT (Information and Communication Technology) platform, local controllers and even weather forecasting (Olivella-Rosell, et al., 2018).		
Objective(s)	• Minimize energy-systems costs • Maximize self-consumption to make sure that REC electricity generation is used locally • Maximize RES integration and production • Avoid grid congestion		
KPI(s)	Difference of energy use from a conventional system (without optimal energy flows)	Unit	MWh or %
Scope	○ Member-focused service	✔ REC service to markets and the grid in normal operation mode	○ REC service to grids in grid alert state
Stakeholders	• System or grid operator or local DSO • REC members or community users (citizens).		
Technologies	• Local network with connections needed to import/export electricity and, storage technologies for providing flexibility • Flexible assets (e.g. heat pumps), and controllers and actuators		
Local aspects	No relevant local aspects needed.		

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Table 24: P2P energy trading

Service	**P2P energy trading**		
Description	Peer-to-peer energy trading (in REC) refers to buying and selling of energy between multiple parties that allows consumers the choice to decide who they purchase electricity from and who they sell to (CEE, n.d.). Energy trading between participants of an energy community enables the usage of surplus energy in regional context. The trading platform provides a mean to rate the commitment of flexibility into community objectives, like self-consumption optimization. Participants offer surplus generation (e.g., from PV systems), which are then matched to flexibilities behind the meter, such as heat pumps, battery storage or electric vehicles. This matching could depend on willingness to pay or, in case of emergency situations, on the importance of energy usage for the community. Economic incentives can be provided in form of real money flows (E.g. rebated prices for local consumption or subsidised prices for local production) or tokens for participation, depending on the local regulation (Olivella-Rosell, et al., 2018).		
Objective(s)	• Ease access to renewable energy within the energy community • Promote the use of renewable energy for local consumption		
KPI(s)	Amount of energy exchanged by means of P2P mechanisms	**Unit**	MWh
	Number of users involved		-
Scope	☑ Member-focused service	○ REC service to markets and the grid in normal operation mode	○ REC service to grids in grid alert state
Stakeholders	• System or grid operator or local DSOs, TSOs and BRPs. Individual market actors like prosumers would not have access to wholesale markets depending on their size and national regulations. • End users (REC members)		
Technologies	• Aggregator uses an Information and Communication Technology (ICT) Trading platform • Monitoring, control and communication devices (e.g. sensors, actuators, cloud-based systems) • RES technologies		
Local aspects	Regulation allows P2P Energy trading		

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Table 25: Public EV charging stations

<table>
<tr><th>Service</th><th colspan="4">Public EV charging stations</th></tr>
<tr><td>Description</td><td colspan="4">

A charging station, also called an EV charger or electric vehicle supply equipment (EVSE), is a piece of equipment that supplies electrical power for charging plug-in electric vehicles (including hybrids, electric vehicles, trucks, buses, and others).

Public charging stations are located in parking areas, like street-sides, retail shopping centres, office buildings, government facilities, etc. They can be promoted by government entities or by the REC for the community members or for all the citizens.

The host of the Public EV charging station can offer different business models like act as a profit centre, or promote the use of EVs with incentives such as a free tariff (just for REC members or for everyone), or a nominal fee focus to cover minimum costs.

The infrastructure for urban electro-mobility is needed to obtain a smart city with electrified public transport and taxis, along with car-sharing services, that can have a reduced fee (mySMARTLife, 2016) (REMOURBAN, 2017) (Ehsani, Falahi, & Lotfifard, 2012)</td></tr>
<tr><td>Objective(s)</td><td colspan="4">• Promote the use of EVs as a clean alternative for traditional internal-combustion engine (ICE) vehicles
• Facilitate the access to charging infrastructure where home charging is often unfeasible due to the scarcity of single-family housing units or there is a lack of individual parking space</td></tr>
<tr><td rowspan="3">KPI(s)</td><td colspan="2">Hours of use of the public EV chargers</td><td rowspan="3">Unit</td><td>-</td></tr>
<tr><td colspan="2">Number of unique users of the public EV chargers</td><td>-</td></tr>
<tr><td colspan="2">Energy consumption of the public EV chargers</td><td>MWh</td></tr>
<tr><td>Scope</td><td>☑ Member-focused service</td><td>○ REC service to markets and the grid in normal operation mode</td><td colspan="2">○ REC service to grids in grid alert state</td></tr>
<tr><td>Stakeholders</td><td colspan="4">• EVSE suppliers
• REC members and/or citizens
• local administration staff</td></tr>
<tr><td>Technologies</td><td colspan="4">• E-cars and charging points: EVSE, PEV.</td></tr>
<tr><td>Local aspects</td><td colspan="4">No relevant local aspects needed.</td></tr>
</table>

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Table 26: REC-level/Collective self-consumption

Service	**REC-level/Collective self-consumption**
Description	Collective self-consumption consists on directly using the energy that is produced within the same system (onsite), therefore reducing the amount of energy imported from external systems. This typically refers to RES electrical technologies but it can also refer to thermal technologies (e.g. solar thermal, local biomass) and to non-renewable sources, although is very uncommon. In a REC, together with RES technologies, a storage system can be also installed to increase the share of self-consumption within the community or to optimize operational costs, by storing energy when there is a surplus or a cheap electricity supply, so it can be consumed at a later time. This concept allows citizens to collectively organise their participation in the energy system (Dorian Frieden, 2020). As an example, a REC can install a collectively-owned PV system, so that the different members can produce RES electricity and consume directly from it as much as possible.
Objective(s)	• Ensure the REC energy needs are covered by self-consuming electricity production of local energy production
KPI(s)	Self-consumed energy (Unit: MWh) Ratio between self-consumed and total energy consumption (Unit: - or %)
Scope	☑ Member-focused service ☐ REC service to markets and the grid in normal operation mode ☐ REC service to grids in grid alert state
Stakeholders	• REC members or Community users • System or grid operator (or local DSO)
Technologies	• Onsite RES technologies, both electrical (PV, wind) and thermal (e.g. solar thermal, local biomass), as well ass energy storage systems
Local aspects	No relevant local aspects needed.

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Table 27: Smart Energy Storage Management

Service	Smart Energy Storage Management
Description	A Smart Energy Storage Management system allows to achieve a more flexible system, with better management and control, by applying advanced algorithms which are usually combined with innovative ICTs (Information and Communication Technologies), IoT (Internet of things) or AI (Artificial Intelligence). Thus, these systems facilitate a better integration of intermittent RES (Renewable energy resources), a better balancing between generation and demand, and more stability, reliability, quality, and control of local grids in different energy vectors such as heat, electricity and transport. The main benefits of this system are related with maximizing the local production and self-consumption within RECs, and to offer ancillary services to the DSO helping to avoid local congestion and contributing to the grid reinforcement and stability. Other benefits are the security of supply, the greater efficiency and the reduction of the related energy costs and CO_2 emissions. Different examples of smart management are: • Reduce mismatch between local supply and demand as well as increase local renewables self-consumption. • Promote peak shaving • Benefit from arbitrage in the energy market, avoiding peak prices. • Provide energy for essential services during disaster or emergency. • Improve the power quality and reliability providing short-term power supply to compensate renewable resources' variability. • Offer their available capacity as an ancillary service to the grid operator (Koirala, Oost, & Windt, 2018) (SEMS project, 2018)
Objective(s)	• Maximize the self-consumption and integration of variable distributed energy resources • Participation in emergency service events or peak shaving • Economic incentives and profits
KPI(s)	Self-consumption increase — Unit: MWh or % Economic savings or profits — Unit: € or % Energy used from the ESS during blackout scenarios — Unit: MWh
Scope	✓ Member-focused service ✓ REC service to markets and the grid in normal operation mode ✓ REC service to grids in grid alert state
Stakeholders	• REC members or Community users

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	• System or grid operator (or local DSO)
Technologies	• Energy Storage Systems (ESS), both thermal (TESS) and electrical (e.g. BESS).
Local aspects	No relevant local aspects needed.

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Table 28: Voltage and reactive power control

Service	Voltage and reactive power control		
Description	 System voltage is determined by the balance of reactive power production and absorption. However, it becomes more challenging when RES integration is increased and decreased in generation from conventional plants (INTERRFACE, 2019). Voltage and reactive power control in an electrical power system is important for proper operation of the electrical power equipment and to prevent damage such as overheating of generators and motors; also, to reduce transmission losses and to maintain the ability of the system to withstand and prevent voltage collapse. In general terms, decreasing reactive power causes voltage to fall, while increasing it causes voltage to rise. A voltage collapse occurs when the system tries to serve much more load than the voltage can support. RECs can offer voltage and reactive power control as an ancillary service for external grids. Additionally, those RECs owning a microgrid will need voltage control to ensure reliability and safe operation of their own microgrid		
Objective(s)	• Contribute to maintain the setpoints of the reactive power or voltage in the network • Ensure energy losses and peak power are reduced while voltage is kept within allowable limits		
KPI(s)	Number of events in which the REC has been involved (within the REC, or in the main grid),	Unit	-
	Voltage deviation ratio (VDR): counting registered time steps where the deviation is larger than the permitted value	Unit	%
Scope	○ Member-focused service	✓ REC service to markets and the grid in normal operation mode	✓ REC service to grids in grid alert state
Stakeholders	• TSO are responsible for transmission system security and voltage support in transmission networks. DSO take care of distribution system security through congestion management, voltage control, etc. DSO facilitate the market by connecting parties to the distribution grid and TSO by connecting parties to the transmission grid • Both DSO and TSO are responsible for the secure operation of their respective networks, involving management of congestions and voltage levels of their grids. • Prosumers, consumers or producers (member of REC) can deliver flexibility through demand response and more flexible use of their distributed energy • Balance Responsible Partiers (BRP), aggregators or ESCO and suppliers are parties involved in the markets. (ENTSO-E, CEDEC, EDSO, 2021)		

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Technologies	• Voltage is mainly maintained by generators, which have an obligation to provide voltage control service for grid companies according to the EU network SOGL (ENTSO-E).
Local aspects	No relevant local aspects needed.

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Table 29: V2G services

Service	V2G services
Description	Vehicle-to-grid (V2G) services consist of a system in which plug-in electric vehicles (PEV), such as battery electric vehicles (BEV), plug-in hybrids (PHEV) or hydrogen fuel cell electric vehicles (FCEV), communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate. V2G storage capabilities can enable EVs to store and discharge electricity generated from RES such as solar and wind, with output that fluctuates depending on weather and time of day. (Ehsani, Falahi, & Lotfifard, 2012). Thus, EVs have the potential to serve the grid as distributed energy storage. Most vehicles are parked an average of 95% of the time and remain connected to the grid in charging or idle mode (low level of energy consumption with enhanced performance) (Ehsani, Falahi, & Lotfifard, 2012). This service motivates different type of business models that can be classified (the stakeholders will be define with this same classification) in these three applications (Sovacool, Kester, Noel, & Rubens, 2020): • Home charging: charged at home as other domestic appliance. One unique supply contract for electricity • Public or street charging: public property with public access for parking with multiple EV charging points. Multiple suppliers have access to manage different customers at the same charge point • Public-private charging: public access to charging station on private property with options to have local generation, storage devices and fast charge services.
Objective(s)	• Offer flexibility to the grid (within a REC or not) • In isolated systems or systems aiming at being autonomous, maximize the energy independence
KPI(s)	Storage capacity of the PEV batteries offered through V2G service — **Unit**: Wh
Scope	☐ Member-focused service ☑ REC service to markets and the grid in normal operation mode ☐ REC service to grids in grid alert state
Stakeholders	• Home charging: the primary actor is the EV owner that will get involved with the supplier. The supplier is the one who will have the contract with the DSO. • Public or street charging: the main actor is DSO. The EV owner gets involved with the electric vehicle supplier aggregator (EVSA) and this actor with the DSO and market supplier. • Public-private charging: the main actor is the charge point manager (CPM). EV owner will have the contract with this main stakeholder. CPM will make the

	deals directly with the DSO and market (Sovacool, Kester, Noel, & Rubens, 2020). • And other stakeholders involved: TSOs, equipment manufacturers, public transit operators, etc.
Technologies	• PEV, BEV, PHEV or FCEV (or any other type of electric vehicle) • RES generation and renewable energy storage technologies
Local aspects	Infrastructure support at local level

8.4. Non-technical services

Table 30: Capitalisation of monitored data

Service	Capitalisation of monitored data
Description	 Energy systems, and in particular those integrated within a REC usually include monitoring data related to the performance and operation of assets, systems and processes, the boundary conditions (e.g. weather data), or the energy production and consumption, but these data are frequently not processed. By properly preparing, processing and analysing these monitored data in a smart way, an added value can be obtained, which typically result in a direct or indirect monetary value. This service can be offered to REC members so that they can manage their available assets and save money in their bills, or even earn money consumption behaviour and save some money in their bills. The processing and capitalization of data can be directly done by actors which are part of the REC, or by external actors. As another option, monitored data from the REC can be valuable for third parties, which can offer in exchange rewards or retributions.
Objective(s)	• Obtain added value (monetary or not) from monitoring data
KPI(s)	Economic value (or monetary equivalence of non-economic rewards) generated by the capitalization of data — **Unit**: €
Scope	✓ Member-focused service; ✓ REC service to markets and the grid in normal operation mode; ○ REC service to grids in grid alert state
Stakeholders	• REC members, who generate and own the data, decide about how can be capitalized and are benefited from it. • Parties external to the REC capable of capitalizing data. • Third parties interested in offering rewards or retributions in exchange to data.
Technologies	Monitoring devices: sensors, communication elements (if necessary), databases.
Local aspects	No relevant local aspects needed; suitable anywhere

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Table 31: End-user engagement

<table>
<tr><th>Service</th><th colspan="4">End-user engagement</th></tr>
<tr><td>Description</td><td colspan="4">Activities associated to REC implicitly need the engagement of actors according to the definition of REC. An effective engagement of end users can be very positive for the REC. First, engaging members already involved in the REC can result in a more active participation in the decision-making processes of the REC and other associated activities, which can lead to an extension of the REC or new services provided.

END-USER ENGAGEMENT

Second, citizen engagement activities are also important to maintain the interest of involved member or share information of the REC. Also, engagement activities are essential to involve new actors in the REC or create news RECs, both directly, by addressing engagement actions to non-members, and indirectly, by spreading the benefits of the REC by means of other engaged members.

Finally, engagement activities can promote a higher awareness of end users on energy technologies or efficient energy usage, which can indirectly result in a more efficient use of energy, costs reductions and environmental benefits.

The engagement of end users can be done using very different approaches, ranging from group identity, information provision, gamification or incentives (Shortall, Mengolini, & Gangale, 2022), and very different resources, such as digital tools, participatory sessions, working groups or co-creation workshops, among others (d'Oca, et al., 2021). Therefore, adapting the engagement activities to the particular conditions in the community is essential to maximize the impacts on end users. For that reason, engagement activities are usually led by experts on social dynamics and participatory processes, who prepare training and informative material, organize activities or disseminate data and results.</td></tr>
<tr><td>Objective(s)</td><td colspan="4">• Engage end users to actively participate in the activities associated to the REC</td></tr>
<tr><td rowspan="2">KPI(s)</td><td colspan="2">Number of members constituting the REC</td><td rowspan="2">Unit</td><td>-</td></tr>
<tr><td colspan="2">Number of participants in activities associated to the REC (members or not)</td><td>-</td></tr>
<tr><td>Scope</td><td>☑ Member-focused service</td><td>○ REC service to markets and the grid in normal operation mode</td><td colspan="2">○ REC service to grids in grid alert state</td></tr>
<tr><td>Stakeholders</td><td colspan="4">• End users, both members of RECs or not, as main beneficiaries of the service
• Municipalities and/or other active members within the REC, as relevant actors in the engagement of end users.
• Experts on social dynamics, (if the engagement process is professionalized).</td></tr>
<tr><td>Technologies</td><td colspan="4">N/A</td></tr>
<tr><td>Local aspects</td><td colspan="4">No relevant local aspects needed; suitable anywhere</td></tr>
</table>

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Table 32: Legal advice

Service	Legal advice
Description	Different activities and procedures which can take place in the scope of RECs imply the application of legislation, regulatory principles or complex administrative procedures. A lack of extensive knowledge on these areas can constitute a critical barrier and a relevant disincentive for members of existing members and potential members of new RECs to perform these activities. Therefore, having the possibility to receive advice in these matters is of high importance for a successful deployment of RECs. Experienced members of RECs or external professionals either in public or private institutions can offer their knowledge to overcome legal, administrative and regulatory issues related to RECs. This service is currently of special interest due to the uncertainties around regulation of RECs in many EU countries, which is incomplete, lacking or very recent in the best case (see deliverable D1.1 for a detailed analysis of the current status of the regulatory framework affecting LocalRES demo sites). This service can also include the preparation of guidelines or explanatory documents about simplified interpretation of the applicable regulation and laws, the most frequent problems and ways to solve them, or lessons learnt from previous experiences.
Objective(s)	• Overcome legal, regulatory and/or administrative barriers associated to activities and procedures which involve RECs
KPI(s)	Number of legal or regulatory issues addressed within the scope of the REC — **Unit:** -
Scope	☑ Member-focused service ○ REC service to markets and the grid in normal operation mode ○ REC service to grids in grid alert state
Stakeholders	• REC members, who can address their questions or issues. • Experienced actors involved in a REC who can offer their knowledge within the community or to other RECs. • External professionals, who can provide the service in the REC.
Technologies	N/A
Local aspects	No relevant local aspects needed; suitable anywhere

Table 33: Prefeasibility assessment

Service	Prefeasibility assessment
Description	 Prefeasibility studies constitute a relevant phase of the concept development of an action or project. In the case of RECs, considering the complexity of the systems and the large number of actors involved in the decision-making processes, prefeasibility studies are crucial not only to evaluate in advance the viability of new potential scenarios within the REC, but to provide valuable information to REC members so that they can make informed decisions. These prefeasibility assessments can be made by expert members of the REC or external professionals, and can be performed using specialized resources and tools for this type of studies (e.g. LocalRES planning tool). Community members could propose their ideas of possible projects and scenarios for the REC, and by means of the prefeasibility assessment, the best options could be sorted considering relevant factors, such as economic, technical, legal or environmental. Due to the main aim of screening attractive options, prefeasibility studies typically imply significant assumptions and a low level of detail, which can result in high uncertainties ranging from -35% to +65% in the case of capital cost (Danish Energy Agency, Viegand Maagøe, Ea Energy Analyses, 2021). Once the results of the prefeasibility assessment of a specific action or project are positive, that option can be considered for further stages of the design and execution processes.
Objective(s)	• Discard unattractive ideas and choose the best among different alternatives • Provide valuable information to REC members to allow them make informed decisions related to the REC
KPI(s)	Number of prefeasibility studies performed — **Unit**: -
Scope	☑ Member-focused service ☐ REC service to markets and the grid in normal operation mode ☐ REC service to grids in grid alert state
Stakeholders	• REC members, who can be interested in prefeasibility assessments, both at individual or collective levels. • Experienced or professional members of the REC, who can perform prefeasibility assessment, both within the REC and to other RECs. • External consultants or advisers, who can perform prefeasibility assessments.
Technologies	N/A
Local aspects	No relevant local aspects needed; suitable anywhere

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Table 34: Support on technical execution

Service	Support on technical execution		
Description	The technical execution of new projects in the REC will normally require support from professional personnel to ensure a high quality in the results. This can be provided either by a member of the REC or by someone from outside contracted to offer this service to the members of the community. In both cases the final beneficiary will be the REC or a group of REC members 		
Objective(s)	• Execute high-quality technical actions and projects in the REC		
KPI(s)	Number of technical projects developed	Unit	-
Scope	☑ Member-focused service	○ REC service to markets and the grid in normal operation mode	○ REC service to grids in grid alert state
Stakeholders	• Actors executing the new projects REC, either external companies or within the REC		
Technologies	N/A		
Local aspects	No relevant local aspects needed; suitable anywhere		

Table 35: Support of vulnerable citizens reducing risks of energy poverty

Service	Support vulnerable citizens		
Description	As a legal figure, RECs can take different actions to reduce risk or alleviate energy poverty within its members, starting by cooperating with public administration on the identification and support of people suffering from energy poverty. Examples of actions to support vulnerable citizens include donations of economic earnings from the REC or solidarity funds (drawn from REC budget), which can be used to cover energy costs of those in most need. Also, RECs can offer at no cost or a lower cost the energy supply to vulnerable citizens.		
Objective(s)	• Reduce energy poverty within the REC, or nearby the REC		
KPI(s)	Citizens suffering from energy poverty supported by the REC	Unit	- or %
Scope	☑ Member-focused service	○ REC service to markets and the grid in normal operation mode	○ REC service to grids in grid alert state
Stakeholders	REC members, REC management, public administration		
Technologies	N/A		
Local aspects	No relevant local aspects needed; suitable anywhere		

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