reschool
Creation, growing and management
of energy communities

Requirements of technical development based on Use-Cases

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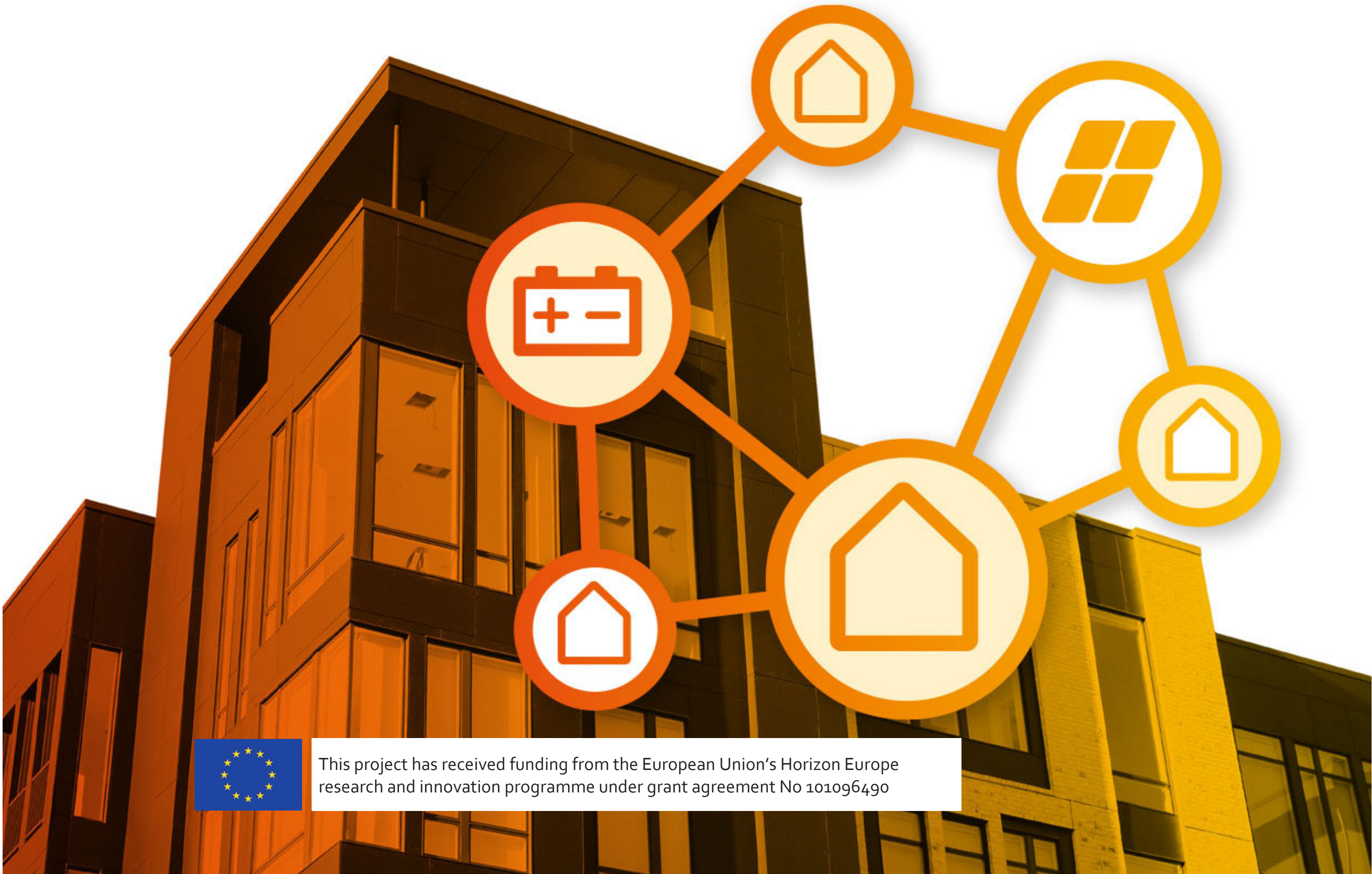

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Executive Summary

This document elaborates the RECHOOL objective as a set of Business Use Cases (BUCs), from which a set of High Level Use Cases (HLUCs) have been derived. BUCs link energy community goals with main business actors and stakeholders in the sector, whereas HLUCs allow identifying technical actors and requirements needed for the development of technical solutions and methodologies proposed to increase participation and awareness within the community.

Main RESCHOOL goals include energy management within the community aiming to improve self-sufficiency, but also to offer and manage aggregated flexibility services to interact with markets and third parties. This also implies organisational challenges (management, sizing, etc.) to assure their economic sustainability, from which the necessity of developing engagement strategies is envisioned.

Thus, the following Business Use Cases have been developed, aiming to identify interactions with stakeholders in the energy sector at business level. These are developed in the Chapter 3 of this document.

- **BUC1 –** Energy management (intra community)
- **BUC2 –** Community as flexibility provider
- **BUC3 –** Sizing and organisation of energy communities
- **BUC4 –** Social awareness and participation in the value proposition of communities

And the implementation of these BUCs is proposed in twelve HLUCs, that have been groped in two categories:

Technical HLUCs, mainly covering BUC1 and BUC2 and widely described in Chapter 4, focus on energy management challenges of communities. These include self-sufficiency and collective generation, participation in flexibility programmes including DSO interaction (e.g.: congestion avoidance) or aggregated access to markets or energy communities composed by housing associations with multiple energy vectors:

- **HLUC0 –** Energy monitoring.
- **HLUC1 –** Energy balance and self-sufficiency.
- **HLUC2 –** Optimal management of energy assets in energy communities with PV generation and implicit flexibility management.
- **HLUC3 –** Automated participation of energy communities in energy markets.
- **HLUC4 –** DSO interaction: Avoidance of congestions at secondary substations.
- **HLUC5 –** Operation on energy hubs consisting of interacting housing associations.

Socioeconomic and engagement: HLUCs to develop BUC3 and BUC4, described in Chapter 5. These tackle issues related to public-private collaboration, the use of serious games and gamification as engagement and participative strategies, intergenerational training and learning or adaptation of communities to changing contexts:

- **HLUC6 –** Public-Private collaboration: Local energy communities (LEC).
- **HLUC7 –** Intergenerational engagement for community building at local scale.
- **HLUC8 –** Citizen engagement for community building at broad scale through gamification and rewarding.
- **HLUC9 –** Interactive communication and collaborative participation oriented to foster joint initiatives and investments.
- **HLUC10 –** Benchmarking and gamification with the inclusion of rewards/incentives.
- **HLUC11 –** Adaptive communities: reacting to evolution of markets, regulations and contexts.

A short description for all of them is provided in the introductory chapter whereas a specific entry in the document includes the complete description and requirements for the implementation, including the relevant actors at technical level, interactions and a first identification of information that should be exchanged. The activities describing the High-Level Use Cases (HLUCs) have been standardized across all Use Cases to create a

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common list of functionalities. These functionalities have been compiled into a set of technical Primary Use Cases and a set of Socioeconomic Use Cases at the end of their respective chapters. Description of Use Cases follows a template (Annex1) based on the IEC 62559-2:2015 methodology and adapted to the project necessities (Chapter 2). The document ends with a proposed list of KPIs to evaluate the performance or degree of achievement or objectives in the HLUCs.

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1 Introduction

1.1 Objectives

This document provides a complete description of Use Cases that served to define the technical requirements and methodologies needed for the development of technologies and engagement activities proposed in RESCHOOL. These Use Cases and requirements have been elaborated to cope with the following project goals:

- Improve the energy management within the community and address the goal of self-sufficiency, that is the maximisation of local consumption of self- generated energy at community level.
- Exploitation of flexibility of demand, at community level, and demonstrating energy communities as relevant stakeholders in the energy value chain with capabilities to interact with local and global energy markets and stakeholders.
- Address organisation challenges, including dimensioning of energy communities to convert them into organisations economically feasible and sustainable.
- Value and promote social awareness of energy communities and their participants as a fundamental value proposition of communities.

These project goals have been elaborated in 4 Business Use Cases (BUCs), from which a set of High Level Use Cases (HLUCs) have been derived. The definition of BUCs links energy community goals with main business actors and stakeholders in the sector, whereas HLUCs allow identifying technical actors and requirements needed for the development and further deployment of solutions that implement the BUCs.

Identified BUCs include: BUC1-Energy management (intra community), Buc2-Community as flexibility provider, BUC3-Sizing and organisation of energy communities, and BUC4-Social awareness and participation in the value proposition of communities.

HLUCs have been divided in two categories: technical and socioeconomic and engagement Use Cases. Despite the inclusion of a use case in one or another category, it is not always simple and clear. Thus, the main purpose of the division is to associate Use Cases with specific building blocks in the RESCHOOL architecture (Figure 1), and the associated work packages and activities. Thus, HLUCs falling in the category of technical Use Cases (HLUC0 to HLUC5) mainly support developments in work package WP3 whereas socioeconomic and engagement Use Cases push developments in work package WP2.

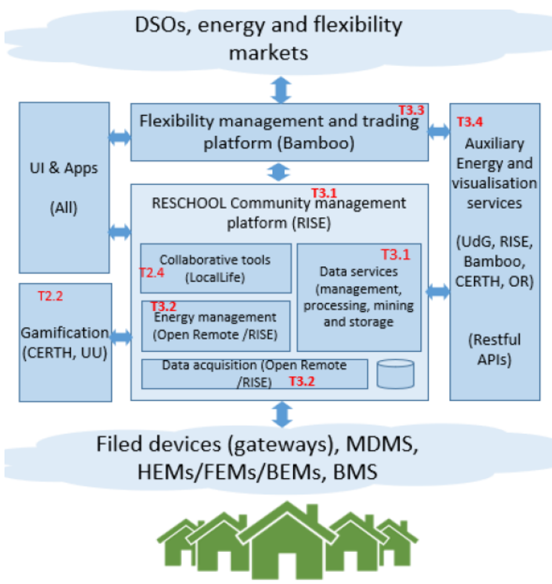

Figure 1 RESCHOOL architecture and vision: main components

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A short description of proposed Use Cases follows in the next paragraphs:

- **HLUC0 – Energy monitoring**, is a common use case. Basic process of energy data acquisition and management from the field devices in the energy community and how these are made available to the energy community manager and members, and to other applications/systems.
- **HLUC1 – Energy balance and self-sufficiency**, focuses on the promotion of sharing energy generated within the community, in order to maximise the rate of self-consumption. This includes influencing user behaviour for a better use of energy assets (adaptation of consumptions to generation) and the tools to monitor performance at both member and whole community level and to adapt the operation according to external and internal factors.
- **HLUC2 – Optimal management of energy assets in energy communities with PV generation and implicit flexibility management**. Optimal use of local storage and demand (flexible loads) to maximise the benefit considering both consumption of locally (inside the energy community) produced energy and external energy price signals (implicit flexibility management).
- **HLUC3 – Automated participation of energy communities in energy markets**. Assessment of the flexibility capacity that the energy community (EC) can offer. Aggregated flexibility of the energy community is traded to third parties enabled by market mechanisms (explicit energy management).
- **HLUC4 – DSO interaction: Avoidance of congestions at secondary substations**. Collaboration of energy communities with Distribution System Operators (DSO) to improve the operational safety of distribution grids at the secondary substation level (low voltage). This collaboration consists in activating flexibility of the energy community to solve congestion issues at the transformer.
- **HLUC5 – Operation of energy hubs consisting of interacting housing associations**. Control and management of heterogeneous energy resources with the aim of optimizing energy flows in an energy community, or energy hub, consisting of several housing associations. The optimization process operates at two levels: Firstly, within individual buildings owned by housing associations. Secondly, the optimization extends to the energy community level.
- **HLUC6 - Public-Private collaboration: Local energy communities (LEC)**. Master plan for promoting the creation of Local Energy Communities (LEC) constituted around a PV plant installed in a public equipment to share production among neighbours. Municipalities, as owners of the public facility where PVs are placed, lead the project. They define the mechanisms to select an energy community manager and to provide legal coverage to the local energy community and their members, facilitate the access to generation and demand data and also the appropriate mechanisms to manage the community, facilitate energy accounting at the community and the individual level and promote new energy and flexibility services.
- **HLUC7 - Intergenerational engagement for community building at local scale**. Fostering behavioural change through intergenerational exchanges between older and younger adults. The goal is to explore social contagion effects and intergenerational learning processes between older generations and younger adults through schools to influence individuals' energy behaviour and participation in energy communities.
- **HLUC8 – Citizen engagement for community building at broad scale through gamification and rewarding**. Increase awareness and motivation among citizens towards their participation in energy communities through gamification.
- **HLUC9 - Interactive communication and collaborative participation oriented to foster joint initiatives and investments**. Encompasses the tracking of energy and flexibility performance of buildings and elaboration of dashboards to support decision making based on existing information from other buildings, estimates on return of investment (ROI) and an active participation of community members.
- **HLUC10 - Benchmarking and gamification with the inclusion of rewards/incentives**. Use of gamification strategies based on the exploitation of real energy data from community members.

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Comparative analysis (benchmarking) of energy uses at community and individual level. Proposal of actions to improve performance and engagement during long periods based on gamification approaches.

- **HLUC11 - Adaptive communities: reacting to evolution of markets, regulations and contexts**. The establishment of new energy community projects as well as the extension of activities that are foreseen to be conducted by existing energy communities, helping to anticipate the impact of legal and policy reform on both business and operational environments.

Description of uses cases has been done following main guidelines of IEC 62559-2:2015 with the objective of having a unified description and facilitating sharing within the consortium and assuring a broader dissemination.

1.2 Contribution of partners

This document has been elaborated with the collaboration of all the RESCHOOL partners under the coordination of the project coordinator. The following table shows the responsibilities and roles taken by the partners in the elaboration of the Use Cases and the documentation associated.

Table 1 Contribution of partners to this deliverable

Partner	Contribution
OR	Coordination and elaboration of HLUC1 and HLUC2 (Pierre Kill)
KMo	Coordination and elaboration of BUC4, HLUC1 and HLUC2 (Javier Muñoz, Giulia Torri, Xavi Massa)
BBEN	Coordination and elaboration of HLUC3 (Toni Company, Adrian Brasero, Cristina Corchero)
RESF	Coordination and elaboration of BUC2 and HLUC4 and internal review of the document (David Plomp, Hugo Niesing, Marc Cañigueral).
ELEC	Coordination and elaboration of BUC3 and HLUC5 (Annie Albåge, Josefin Danielsson, Jörgen Lööf).
DdGi	Coordination and elaboration of HLUC6 (Anna Camp)
CERTH	Coordination and elaboration of HLUC8, internal review of the document (Ioanna-Mirto Chatzigeorgiou, Tasos Papazoglou-Chalikias)
LCLF	Coordination and elaboration of HLUC9 (Hossein Shahrokni, Ong Qingzhe)
UU	Coordination and elaboration of HLUC10 (Ioannis Lampropoulos, Jan Dirk Fijnheer, Hossein Nasrollahi, Anton Belinskiy)
EREF	Coordination and elaboration of HLUC11 (Johannes Vollmer)
COEN	Coordination and elaboration of BUC1 (Alexandros Chronis)
UdG	Main editor and coordinator of the elaboration of the document (Joaquim Meléndez). Elaboration of HLUC0 (Joaquim Meléndez, Sergio Herraiz) and HLUC7 (Albert Sabater, Anaïs Varo), HLUC4 (Marc Cañigueral), Revision of all BUCs and HLUCs (Joaquim Meléndez, Sergio Herraiz)

1.3 Report Structure

This deliverable is composed of seven chapters. A description of the methodological principles used in the description of Use Cases follows this chapter. Next, Chapter 3 includes the description of BUCs, aiming to identify interactions with stakeholders in the energy sector at business level. Chapter 4 is focused on Technical HLUCs, mainly covering BUC1 and BUC2 related to energy management challenges of communities. These include self-sufficiency and collective generation, participation in flexibility programmes including DSO interaction (e.g.: congestion avoidance) or aggregated access to markets or energy communities composed by housing associations with multiple energy vectors. Next, chapter (chapter 5) is devoted to Socioeconomic and engagement HLUCs developing BUC3 and BUC4. These tackle issues related to public-private collaboration, the

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use of serious games and gamification as engagement and participative strategies, intergenerational training and learning or adaptation of communities to changing context. The document ends with the Conclusions, a list of acronyms, the references section and two annexes: Annex 1, includes the list of Key Performance Indicators (KPIs) proposed to assess the Use Cases; and Annex 2 contains a template of the Use Case structure used to report both BUCs and HLUCs.

1.4 Links to other WPs and tasks

This deliverable follows *D1.1- Energy management framework for communities in the EU* and its elaboration has run in parallel with *D1.3 - Guidelines for pilot planning and impact assessment*. The three complete the report of activities in WP1. D1.1 presents a range of energy community challenges and opportunities identified in the reviewed literature together with relevant aspects identified by pilots regarding energy community management and national regulations. Business Use Cases (BUCs) described in this document feed on these challenges and after they are decomposed in High level Use Cases (HLUcs). BUCs and HLUCs are used by pilot owners to explore new possibilities for the communities they are developing. Subscription of a pilot to a specific HLUC allows identifying main actors and interactions; and from these, the necessity of provisioning new assets, developments, or integrations. HLUCs (D1.2) together with the support of SSH and tech developers are the basis to elaborate the pilot's deployment plans reported in D1.3.

At Work Package level, this document has a direct influence on WP2 and Wp3. HLUCs falling in the category of technical Use Cases (HLUC0 to HLUC5) mainly define requirements for the developments in work package WP3 whereas those falling in the socioeconomic and engagement category (HLUC6-HLUC11) are conceived to push definition of engagement strategies and developments in work package WP2.

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2 Methodology

2.1 Context

The directive [Directive EU 2019/944] defines a set of provisions that put the consumer at the centre of the clean energy transition. An Energy Community (EC) is one of these mechanisms. Thus, ECs are open and voluntary and combine non-commercial aims with environmental and social community objectives. At EU level ECs are currently defined as legal entities in three directives [RECAH] with slight differences.

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

These definitions coincide in the main purpose (social and environmental benefits) and activities they can exercise around the energy (i.e.: generation, aggregation, storage, distribution, consumption, provision of services, supply and sharing) of EC. CECs mainly operate in the electricity sector and are technologically neutral (renewables but also fossil fuel sources) whereas renewable energy communities embrace a broad range of activities around renewables. The definitions emphasise the participation (and control) of citizens (i.e.: households), local authorities and smaller businesses that are not in the energy sector. Stakeholders involved in large-scale commercial activity where energy is the primary economic activity can participate in CECs but not take decisions. Participation must be open and voluntary (to enter and leave). The directives do not force ECs, either RECs or CECs, to adopt specific legal formulas, nor detail economic activities related to energy management that are supposed to carry out; and level of transposition to national rules differs from country to country.

2.2 Use case methodology: General principles

Use Cases are a means for specifying required usages of a system. They are used to capture the requirements of a system (what a system is supposed to do).

2.2.1 Definitions

Use Case: 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 [Unified Modelling Language's (UML) specification]. A use case describes a function that a system performs to achieve the user's goal.

Actor: An actor specifies a role played by an external user, or any other external system, that interacts with the subject (system under consideration to which the Use Cases apply). Actors can be a human user of the designed system, or another system, application, or device [Unified Modelling Language's (UML) specification]. Actors interact with Use Cases.

Party: Legal entities, i.e.: either natural persons (a person) or judicial persons (organizations) that can bundle different roles according to their business model.

Role: Represents the intended external behaviour (i.e.: responsibility) of a party. Parties cannot share a role. Parties carry out their activities by assuming roles, e.g.: system operator, trader. Roles describe external business interactions with other parties in relation to the goal of a given business transaction (e.g.: Balance Responsible Party, Grid Operator, Market Operator).

Relationship: Represent the interrelations between parties or roles (logical connections, such as association, aggregation, generalization, etc.).

2.2.2 Classification of Use Cases

The main classification of Use Cases, adapted from [SGCG 2014], proposed for RESCHOOL is the following:

Business Use Case (BUC) models the business requirements and the required interactions between the stakeholders. BUCs omit the technical interactions and focus on scenario/s to reach the goals.

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High Level Use Case (HLUC) represents a general idea by defining the actors involved, their roles and responsibilities but not the underlying business models. The target audience is system engineers, business developers, regulators, and key experts in standardization. A HLUC represents a common vision reached among all the interested parties regarding the high-level goals of the new function and provides enough information to identify and model the lower-level requirements and interactions between the systems that implement the various roles of the involved actors (i.e.: usually referred to as technical actors).

Primary Use Case (PUC) represents one or many goals or activities described in HLUCs. A HLUC can include one or several PUCs and these PUCs can be reused by other HLUCs to achieve specific goals.

Scenarios: when there is the necessity to specify variations or alternatives in the context of the same use case (usually at HLUC or PUC level), these can be identified as scenarios. In that case, the conditions that trigger the different scenarios must be identified.

2.2.3 General structure for documenting Use Cases

The description of a use case (mainly refers to HLUCs) comprises the following sections (details in Annex 2):

- **Scope** presents the main subject each HLUC deals with and defines its boundaries/limits.
- **Objectives** identify the business goal(s) to be served with respect to business analysis.
- **Actors** identify the list of logical actors involved to realize each use case.
- **Short Narrative** provides an overview of the key concept of the use case outlining the main functionalities of each use case.
- **Complete Narrative** details the functionalities and actor interactions of each use case describing what occurs when, why, with what expectation, and under what conditions.
- **PUCs** the relative subset of RESCHOOL functionalities required to implement each HLUC.
- **Preconditions and Assumptions** identifies the general assumptions about systems' configurations and state of actors/activities prior to the use case's initiation.
- **Use case diagram** refers to the UML diagram elaborating the understanding of the HLUC by illustrating the correlation among actors and functionalities.

2.3 Template and content of BUCs and HLUCs (See Annex 2)

The following diagram (Figure 2) illustrates the links between different categories of Use Cases and the project goals. The main purpose of reporting Use Cases is to have a hierarchical structure describing actions to be executed to reach the project goals.

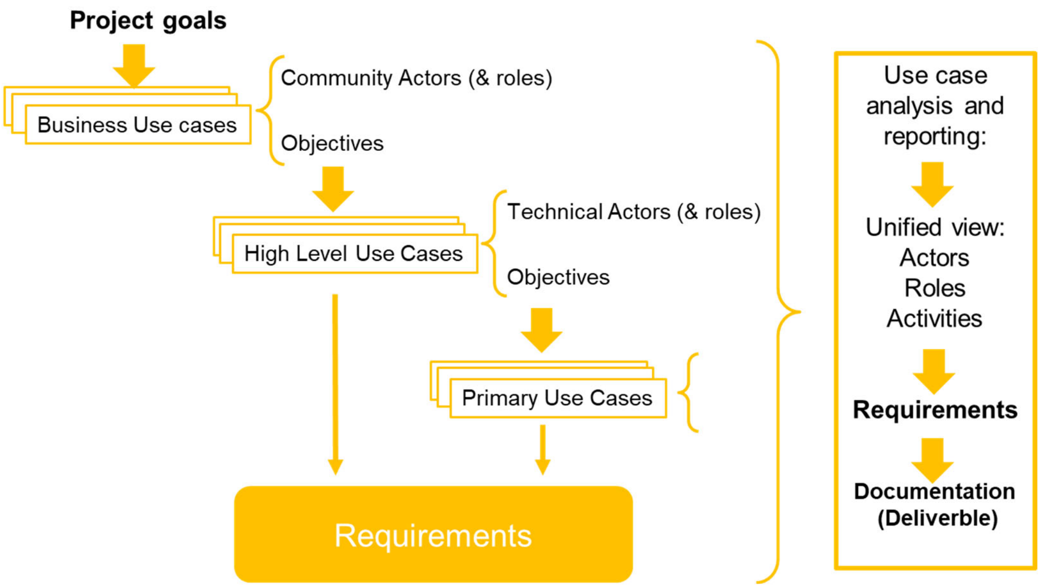

Figure 2 Use Cases organisation.

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The same document structure will be used to report BUCs and HLUCs. However, not all the sections will be considered for some of them. For PUCs, only a short description is included since they refer to specific functionalities commonly agreed by the participants of a HLUC that do not imply additional interactions for their implementation. Table 2 summarises the expected content for different types of Use Cases. Details of the general structure and content of sections can be consulted in Annex 2.

Table 2 Use case documentation: structure and sections.

	BUC	HLUC
1. Description of Use Cases	X	X
• **General Information**	X	X
• **Scope, Objectives and Boundaries of Use case**	X	X
• **Narrative of Use Case**	X	X
• **Key Performance Indicators**	X	X
• **Use Case Conditions**		(X)
2. Actors and Use Case diagram	X	X
• **Actor list**	X	X
• **Use case diagram**		X
3. Step-by-step analysis		X
• **Scenarios**		X
• **Step by step analysis**		X
• **Sequence / activity diagrams**		X
4. Information exchanged		X

2.4 RESCHOOL Use Cases: General structure and dependencies

RESCHOOL goals have been split into 4 BUCs from which a set of HLUCs have been identified and elaborated. The purpose of BUCs is to link energy community goals with main business actors and stakeholders in the sector, whereas High Level Use Cases allow identifying technical actors and requirements needed for the development and further deployment of solutions that implement the BUCs.

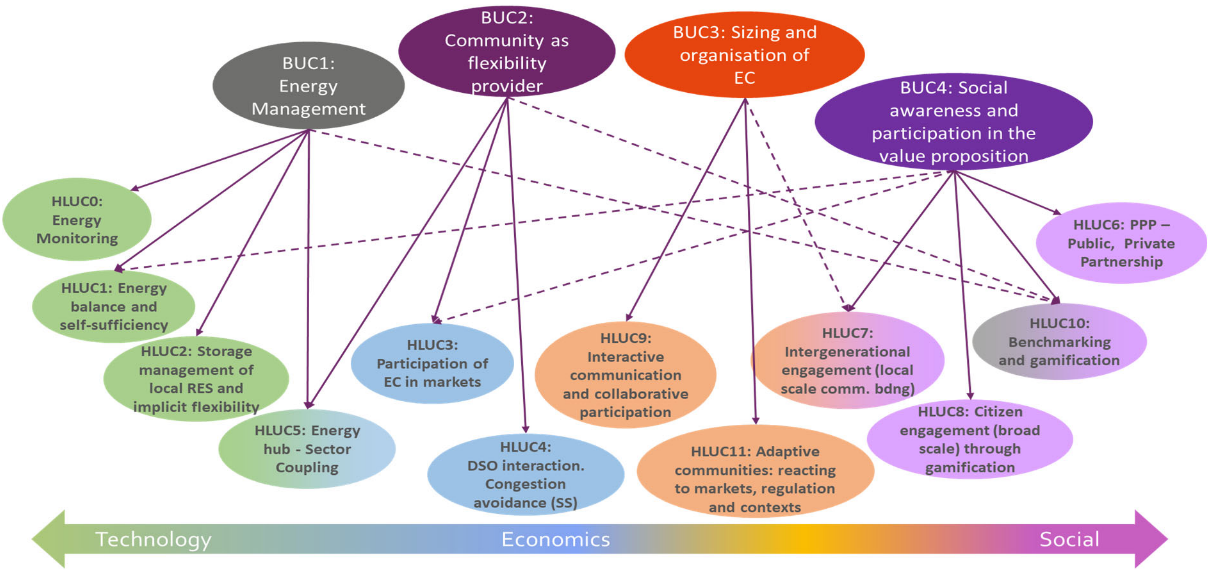

Figure 3 RESCHOOL use case structure: Dependencies among Business Use Cases (BUCs) and High Level Use Cases (HLUCs)

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Identified BUCs include: BUC1-Energy management (intra community), Buc2-Community as flexibility provider, BUC3-Sizing and organisation of energy communities, and BUC4-Social awareness and participation in the value proposition of communities. From these, twelve HLUCs have been identified. They have been organised in two categories: technical (HLUC0-HLUC5) and socioeconomic and engagement Use Cases (HLUC6-HUC11) to support the further developments in work packages WP3 and WP2 respectively. Figure 3 represents these dependencies between BUCs and HLUCs. Finally, the set of PUCs that are required to implement the HLUCs in these two categories have been identified. Complete description of BUCS is included in Chapter 3 and these two categories of HLUCs correspond to Chapter 4 and 5. These chapters also include a short description of PUCs.

3 RESCHOOL Business Use Cases

This section includes the description of BUCs skipping any technical detail related to the implementation and focusing on actors, roles, and activities to be carried out to achieve the desired goals focusing on the interaction among actors. Table 3 summarises the proposed BUCs, from which a set of actors has been identified. , This set includes actors defined in the Harmonised Electricity Role Model (HERM) and is complemented by others that are either specific to or, at the very least, relevant for the management of energy communities. Next section presents these actors and then follows a specific section devoted to each BUC.

Table 3 BUCs: general description

UC	Title	Objectives
BUC1	Energy management (intra community)	Valorisation of energy management strategies at community level.
BUC2	Community as flexibility provider	Assess the capacity of energy communities to provide (aggregated) flexibility and its potential to participate in the flexibility value chain (i.e.: aggregator, markets, bilateral contracts, DSOs, etc.) under different approaches.
BUC3	Sizing and organisation of energy communities	Define business models to guarantee economic sustainability of the energy community and establish a reference framework in terms of energy managed and/or participants involved.
BUC4	Social awareness and participation in the value proposition of communities	Foster the social awareness of energy communities as a social and economic driver and exploit it as a true value proposal.

3.1 Business actors

Relevant business actors identified for energy communities are listed in Table 4. A member of an energy community can be associated with a *party connected to the grid* of the HERM (Table 5), with capacity to consume energy (consumer, according to HERM), produce energy (producer, according to the HERM), usually renewable resource (RES), or both (prosumer).

Table 4 RESCHOOL Business Actors

Actor name	Role
Energy Community Member (M)	Member of an energy community usually is a party connected to the grid (HERM), with capacity to consume energy (consumer, according to HERM), produce energy (producer, according to the HERM), usually renewable resource (RES), or both (prosumer). Several typologies of members can be identified depending: • Households • Housing Associations • Small Business

	• Collective self-consumers/producers (PV shared production, District Heating) • Public administration • etc.
Energy Data Provider (EDP)	A third-party enabling access to metering data and usually also some accounting services (e.g.: retailers).
Retailer (R)	Accounting and billing of energy exchanged with the grid.
Energy / Flexibility Community Manager (ECM)	Responsible for accessing and managing energy data from/to the prosumers and energy assets. Energy and flexibility management responsibilities, including interaction with Aggregators when flexibility is offered to markets.
Aggregator (A)	Aggregates flexibility from distributed energy sources and trades it in local (or global) flexibility markets. Local flexibility markets focus on supporting DSOs flexibility programmes (i.e.: congestion management, voltage control), whereas global refers to traditional energy markets (TSO level). In some countries this role is also assigned to local agents, that also supports energy management at community level and are referred to as Local System Operator (LSO).
Distribution System Operator (DSO)	Responsible for the distribution and management of energy from the generation sources to the final consumers. It manages the grid infrastructure, ensuring quality and safety of supply.
Local Flexibility Market (LFM)	Enables the local flexibility trading that the management of distributed energy assets (RES, load shifting / curtailment, storage, etc.) can offer to the system operator (DSO).
Public Electric Vehicle Charging Operator (PEVCO)	Responsible for operating public electric vehicle charging stations
Collaborative Services Provider (CSP)	Technical partner that provides technical support to facilitate interaction among community members and sharing community information.
Social Engagement Actor (SEA)	Social drivers to enhance engagement and participation of community members. In RESCHOOL the following SEAs have been identified: • **Gaming Provider (GP)**: Responsible for providing awareness/engagement games to community members. • **Public Administration (PA):** Implements public policies. • **Educational Entity (EE)**: Schools, universities. • **Innovation and Participation managers (IPMs):** Entity or actor devoted to organising participation events and to support the execution of innovative strategies. • **Experts (E):** Professionals that can advise and provide expert support for decision making at community level.
Public Body (PB)	Any public administration (municipality, local or regional government) or agency in charge of developing policies and master plans to manage energy transition in a specific area (e.g.: local, regional, national).
Policy Maker (PM)	Public body in charge of making policies and taking policy decisions.
Municipality	Local authority with responsibilities in sustainability development and management of a local area (municipality, city, village) where the energy community is located and operates.

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The following two diagrams represent the roles of different actors when interacting. Figure 4 is a simplified representation, whereas Figure 5 includes the *Party Connected to the Grid* actor defined in HERM (subsection 3.1.1 briefly contextualises this actor with the ECs) and also considers a generalisation of flexibility markets instead of only local energy markets.

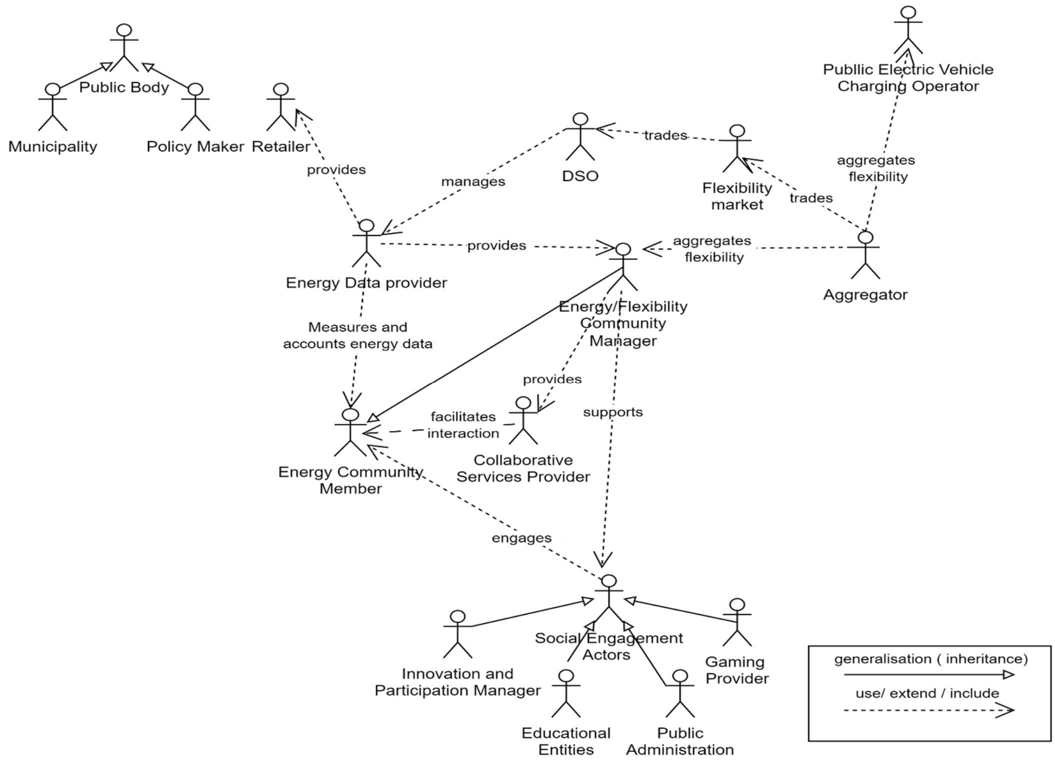

Figure 4 Business actors and dependencies

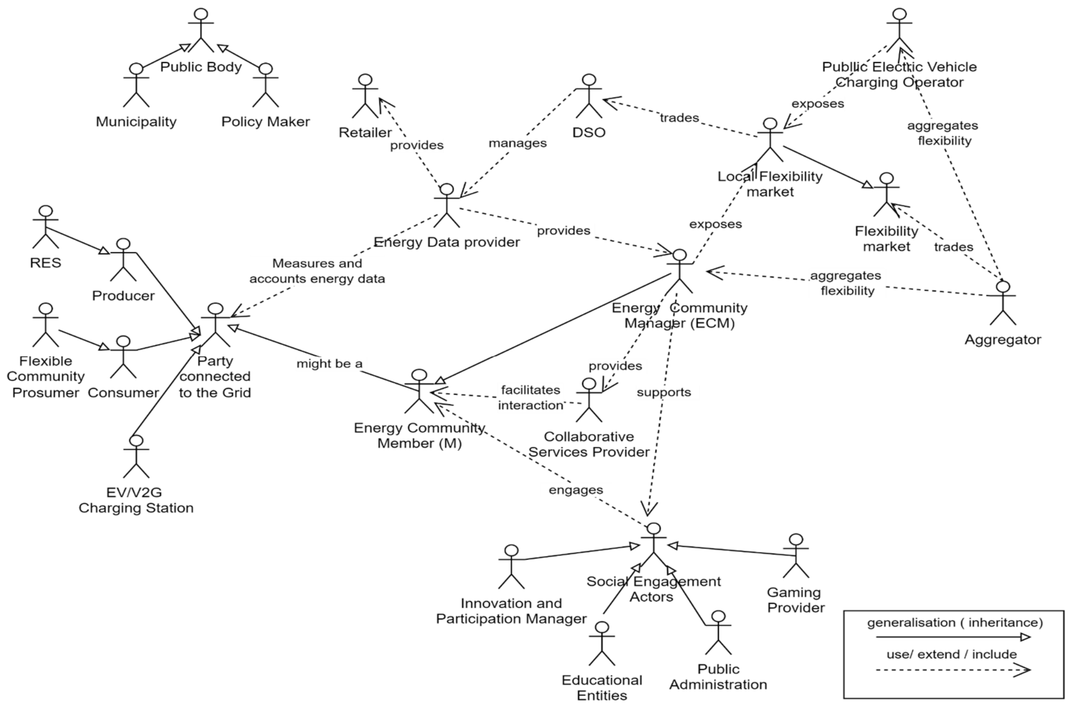

Figure 5 Business actors and dependencies. Extended version.

Section 3.2 details these interactions among actors in a complete description of the BUCs.

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3.1.1 Links with the Harmonised Electricity Market Role (HEMR) model

Energy community members (M) that are connected to the grid play the role of *Parties Connected to the Grid* defined in the harmonised electricity market role model (HEMR), that include the *Producer* and *Consumer* roles. In the HEMR, this connection to the grid is associated to the class *metering point* (i.e.: it has a *Meter)* from which the specialisations *Accounting Point* and *Exchange point* derive and where other actors interact with the *Metered Data Administrator* (among others), who is responsible for storing and distributing validated measured data [ENTSOE 2022].

Thus, the *Metered Data Administrator* defined in the HEMR is compatible with the role of the Energy Data Provider (EDP) proposed in this document and guarantees this connectivity with the overall HEMR. However, other actors can also take this role providing aggregated/disaggregated data (e.g.: sub metering data, weather forecasts, third party energy management systems, etc.).

Table 5 Actors and roles in the Harmonised Electricity Market model

Actor name	Role
Party connected to the grid	A party that contracts for the right to take out or feed in energy at an accounting Point (Harmonised Electricity Role Model, HERM)
Producer	A party that generates electricity (HERM)
Consumer	A party that consumes energy (HERM)

3.2 BUC1 - Energy management (intra community)

3.2.1 General Information

Use Case Id	BUC1
Title	Energy management (intra community)
Authors	COEN
Version	V0.1
Date	03/03/2023

3.2.2 Scope, Objectives and Boundaries of Use case

Scope	Describe the business processes and strategies for managing energy within an energy community, the energy sharing mechanisms, benefits, and benefit distribution as well as the responsible entities to perform the necessary actions.
Business roles and Objectives	According to European directives, energy communities aim to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates [Directive (EU) 2019/944], [Directive (EU) 2018/2001]. With this framework the following business role has been identified: BR: To assure an efficient and effective management of energy flows inside of the community under a collective approach. With this aim, the following particular objectives have been stated: ● Ob1) Increase the self-sufficiency and self-consumption at the community level. ● Ob 2) Increase energy efficiency at the community level.
Relation to other Use Cases	This BUC is directly influenced these two BUCs: ● BUC2: Complementary to this BUC ● BUC3: Economic reward of internal energy management

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	Developed in: ● HLUC1: Energy balance and accounting ● HLCU2: Storage management of local RES ● HLUC5: Energy hub – sector coupling Can be influenced by: ● HLUC10: Benchmarking and gamification

3.2.3 Narrative of Use Case

Short description	The use case describes how the energy exchanges within the energy community are managed, from a business perspective, addressing strategies such as energy sharing mechanisms, flexibility aggregation and provision, storage, and EV management. The business models and benefit allocation from the operation of the mentioned activities are defined by this use case.
Complete Description	A centralised approach supported by the figure of the **energy community manager** (ECM), in charge of optimizing the energy exchanges within the community such the electric energy sharing and/or trading (HLUC1), the management of storage of renewable production excess in the community (HLUC2) and the operation of other multi-vector energy assets in benefit of a major energy efficiency within the community (HLUC5). **Energy community members (Ms)**, will facilitate the **ECM** the access to the energy data of the owned energy assets (e.g.: RES production, storage, loads or EVs) through the metering/sub-metering and/or control infrastructure either through a direct communication or in collaboration with third parties (**retailers, through DSO** or other **EDPs**) with the purpose of facilitating the energy accounting and management at community level. Countries with smart meter rollout strategy, access to metering infrastructure could be provided by DSOs. However, this does not provide neither acting capabilities nor sub-metering, that usually is achieved in collaboration with third parties (**EDPs**). The **ECM** will be responsible to activate the required mechanisms to optimally operate the energy assets according to specific objectives agreed by the community members, and to perform the corresponding accounting, at community and individual level, to report the results and benefits of this management.

Main actors and associated roles are represented in Figure 6.

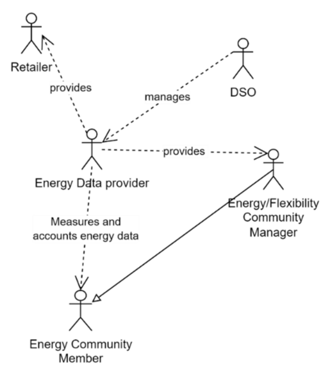

Figure 6 BUC1: Actors and role model

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3.3 BUC2 - Community as flexibility provider

3.3.1 General Information

Use Case Id	BUC2
Title	Community as flexibility provider
Authors	RES
Version	V0.2
Date	08/03/2023

3.3.2 Scope, Objectives and Boundaries of Use case

Scope	Energy communities constitute the main opportunity of prosumers to participate in the energy value chain and contribute to a most efficient, secure and clean energy system by interacting with other energy stakeholders. Thus, energy communities can be presented as the first level of aggregation of prosumers with certain capacity to manage and offer flexibility. This flexibility can be exposed either to traditional energy markets (wholesale, balancing, system support and reserves markets), by means of aggregators, but also directly to DSOs through bilateral contracts or local flexibility markets in order to improve the operation of distribution grids. This is usually referred to as explicit flexibility, in contrast to implicit flexibility that results from individual reaction to external signals (e.g.: price) [SEDEC, 2016]. At the same time, the scope of the flexibility requirement can have different dimensions. In that sense, two scenarios are envisioned for this Use Case: first, the interaction with the distribution grid and consequently bounded to a geographical area where the community is located; and second a wider scope addressing the challenge of participating in energy markets. In the former, the focus is set at substation level and aims to exploit energy community flexibility, in collaboration with other stakeholders in the same geographical area (e.g.: public EV charging operator) when needed, to increase performance of the distribution grid by helping to avoid congestions, peak shaving (i.e.: demand peak reduction) and/or contributing to a reduction of transport losses. Second scope embraces the participation of energy communities in energy markets which requires major aggregation and consequently the access to the market should be through an aggregator.
Business roles and Objectives	Flexibility management is a business opportunity for energy communities as long as the change of consumers' behaviour (load dis/connection or shifting, storage management, etc.) can be packed as flexibility and sold in local energy markets, or simply rewarded through bilateral contracts to solve technical problems at the distribution level (i.e.: congestions or voltage variations). BR: The role of the energy community is to coordinate the management of energy assets in order to offer aggregated flexibility to third parties (i.e.: markets or DSOs) and get a return (economic) for this. From this perspective, the following objectives have been derived: • Ob1) Estimate the amount of flexibility that a community can systematically expose to different markets and the economic return that can be derived from this participation.

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	• Ob2) Contribute to improve the operation and efficiency of distribution grids by offering flexibility to avoid congestion (e.g.: scenarios with large penetration of EV) and/or peak reduction at transformer/ substation level. • Ob 3) Enabling sector coupling at domestic level as a means of increasing flexibility.
Relation to other Use Cases	This BUC is directly influenced these two BUCs: • BUC1: Complementary to this BUC • BUC3: Economic profit of flexibility management Developed in: • HLUC3: Automated participation of energy communities in energy markets • HLUC4: DSO interaction: Avoidance of congestions at secondary substations • HLUC5: Energy hub – sector coupling Can be influenced by: • HLUC10: Benchmarking and gamification

3.3.3 Narrative of Use Case

Short description	Participation of the energy community as a single entity providing flexibility. It implies energy management (e.g.: activation / deactivation of loads, storage management or load shifting and curtailment) to provide a service (i.e.: congestion avoidance) or to participate in energy markets and get a reward.
Complete Description	Energy communities can only participate in flexibility programmes if they are capable of managing enough energy to impact on the system, either the distribution grid or the markets. Flexibility services usually imply acting on an amount of energy that when referring to consumers requires aggregated and coordinated actuation. The **energy community manager (ECM)** will react to a demand of flexibility with a flexibility provision that will be economically rewarded. Two scenarios are envisioned: • Bilateral contracts with flexibility demander (DSOs): direct agreement between **DSO** (flexibility demander) and the energy community as flexibility provider, or in collaboration with third parties (e.g.: p**ublic EV infrastructure operator**) with or without the participation of an **aggregator**. The agreement will address the collaboration in specific programmes, as congestion avoidance or peak reduction, and should be established before the occurrence of flexibility demand with a clear identification of conditions of flexibility provision and rewards (economic) (HLUC4). • Market enabled: Provision of flexibility based on competitive market mechanism. Participation to general markets will be enabled by aggregators since usually major amount of energy is required for participating; whereas participation in (**local) flexibility markets (LFM)**, to provide energy services to DSOs**,** could be either through an aggregator or directly through the energy community if it has the capacity (amount of energy and technology). This project mainly focuses on the interaction of energy communities with these local flexibility markets. Thus, agreements are reached following a bidding process (flexibility offers) where different actors can participate (HLUC3).

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	The **ECM** will be in charge of computing (or coordinating the execution of the required operations, according to HLUCs) the best coordination action to be executed by **energy community members (Ms)**. Implementation will require the availability of specific hardware and software to both monitor and activate flexibility that will be accessible through an **energy data provider (EDP)**. Electric flexibility can be increased by considering thermal loads (space heating, thermal reservoirs, etc.) and other multi-vector energy intensive assets (mobility, district heating, machinery, etc.) (HLUC5).

Main actors and associated roles are represented in Figure 7.

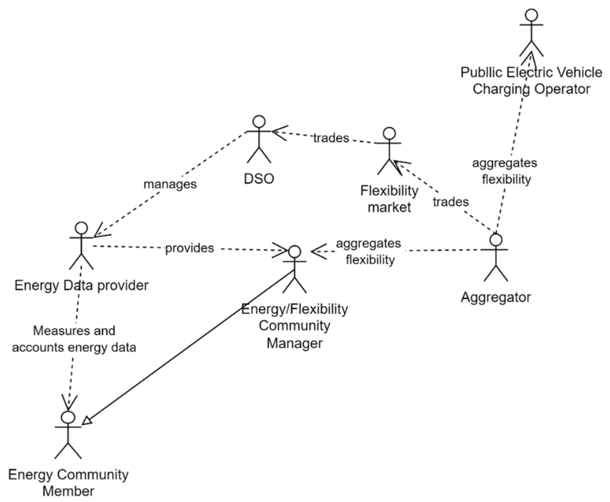

Figure 7 BUC2: Actors and role model

3.4 BUC3 - Sizing and organisation of energy communities

3.4.1 General Information

Use Case Id	BUC3
Title	Sizing and organization of energy communities
Authors	ELEC
Version	V1.0
Date	3/3/23

3.4.2 Scope, Objectives and Boundaries of Use case

Scope	According to European directives, energy communities aim to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates [Directive (EU) 2019/944], [Directive (EU) 2018/2001]. The achievement of similar goals is tied to the business model behind the activities of the community and the execution capacity that can be influenced by many factors such as the type of legal entity, internal organization, sizing, regulation (with ongoing reforms in the EU electricity market design), technical capacity or the collaborative principles.

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	With this perspective in mind, this use case wants to establish a framework to assess the business models that support the energy communities with emphasis on the impact of efficient energy management and importance of participants involved.
Business roles and Objectives	This use case aims to provide guidelines to convert the underlying principles of cooperation and sustainability that define energy communities into trustable business models embedded in the energy value chain. The following objective have been stated: ● Ob1) Define a framework to support the decision-making process during creation, growing and management of energy communities in a context of energy transition with ongoing reforms in the EU electricity market design. ● Ob2) Monitor the business models around the different energy management strategies within evolving communities. ● Ob3) Drive interactive communications of community members around the progress towards community goals and foster collaborative initiatives and joint projects and investments.
Relation to other Use Cases	This BUC is directly influenced these two BUCs: ● BUC1: Exploitation of energy management strategies within the community ● BUC2: Exploitation of flexibility services in cooperation with third parties (DSO, aggregators) or through market Developed in: ● HLUC9: Interactive communication and collaborative participation oriented to foster joint initiatives and investments ● HLUC11: Adaptive communities: reacting to evolution of markets, regulations and context And can be influenced by: ● HLUC7: Intergenerational engagement for community building at local scale

3.4.3 Narrative of Use Case

Short description	The use case describes the sizing and organization of energy communities in terms of creation, collaborative approach and monitoring and economic sustainability. The business models for the energy community will be defined and reference frameworks will be established in terms of energy management and roles for involved participants.
Complete Description	**Creation of energy communities (HLUC9 and 11)** When establishing an energy community (EC) in an existing neighbourhood or community the chosen organizational form, and type of legal entity, should be based on the community's mission, goals and ambitions and enable active participation of its members. According to current directives ECs can be engaged in a variety of activities around energy management, that encompass electricity production, distribution, consumption, aggregation, storage and energy efficiency services, flexibility services, generation of renewable electricity, charging services for electric vehicles, sharing energy in local grids between members, or providing other energy services to its members and/or other stakeholders. Since an EC is based on cooperation between members a suitable starting point can be found in principles used by cooperatives all over the world: 1. Voluntary and open membership

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2. Democratic member control (one member, one vote)
3. Members' financial participation
4. Independence and independence
5. Education, skills development and information
6. Cooperation with other organizations
7. Social vision (to work for sustainable development)

The **energy community members (M)** can have different profiles (e.g.: households, housing associations, small local business, etc.). The energy community will be established by representatives from the participant entities.

An early decision is what type of organization to establish, for example a non-profit association. To start an association, it is wise to start with a small number of founding members (e.g.: 8 housing associations) who set the foundation. During further development of the energy community, more housing associations as well as local businesses can join. The organization will therefore continue to develop organically over time based on needs, requirements and inputs from its members.

The first tasks for the founding members of the energy community are to constitute the association (i.e.: form of legal entity), appoint a Board, adopt statutes and establish a framework for administration and finances under the agreement of the participants that will become energy community **members (M)**. Main responsibilities of the Board include taking **decisions** on choice **of energy community manager (ECM)**, local system operator (LSO) if any, and providers of technical solutions as well.

An energy community can be formed with the single purpose of producing more renewable electricity together and that can be done with a low level of technical integration and active cooperation. In an energy community that in addition to this has targets to jointly reduce capacity needs, do peak shaving and work together to reduce energy consumption members need a high level of technical integration that give for instance information on energy and capacity used, renewable energy produced and tools to automatically steer energy resources in the buildings. This technology will develop over time, it needs to be managed and maintained and even replaced if better options present itself in the future.

For the energy community **members (M),** responsibilities include investments in energy assets, infrastructure for future integration of data through an **Energy Data Provider (EDP)** and devices and integrations of energy resources to enable steering.

Collaborative approach and monitoring (HLUC9)

Further progression of the energy community is that the **members (M)** themselves drive the development by forming working groups that get compensated for their work, focusing on different areas of the energy community. It is important that clear goals are set for each member and also the energy community as a whole, such as energy performance in buildings and other energy and sustainability KPIs. The KPIs will be accessible either through the **energy/flexibility community manager (ECM)** or a **collaborative services provider (CSP)**, where the members can share knowledge and experiences amongst each other in a platform. Thus, the ECM will be in charge of optimizing the distributed energy resources whereas the CSP will enable behavioural changes and social interactions among residents and ECMs in the energy community. Thus, the collaborative platform simplifies decision-making for energy

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	community members at different levels (residents on a household, building, and community) and allows informing them about upcoming events that require a response (e.g.: peak event and what specifically they can do to reduce their peak loads during the event). The energy community can also involve **experts** in order to gain required knowledge and resources, for example regarding laws and regulations. **Economic sustainability (HLUC11)** Profitability of energy communities is affected by several parameters aligned with community goals that must be defined by the community **members (M)** and managed by the **ECM**. Incentives to the community members, will be identified to understand how economically sustainable business models can be achieved at community and individual level. Assessment and impact of legislation in terms of taxes and fees (e.g.: local administration) and how the concept of energy communities is received by policy makers. How the energy communities should be organized in terms of operation and roles for the members will be defined as well as collaborations with aggregators and DSOs. The goal is that the energy community in the long run is financed by the benefits it provides.

Main actors and associated roles are represented in Figure 8.

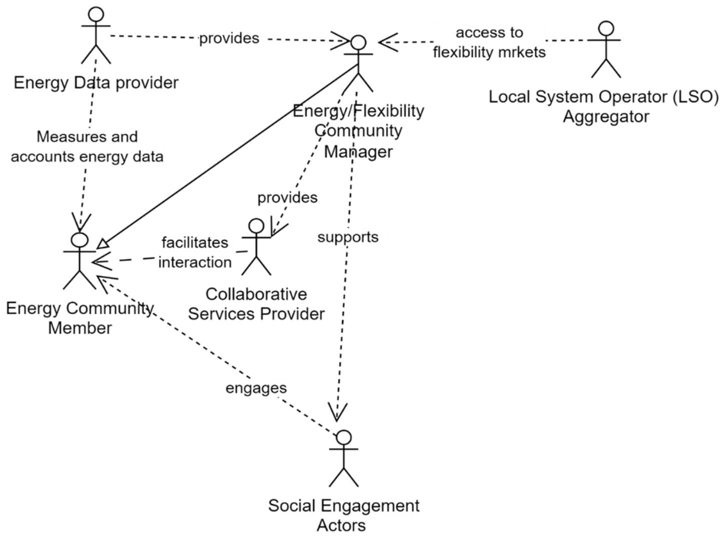

Figure 8 BUC3: Actors and role model

3.5 BUC4 - Social awareness and participation in the value proposition of communities

3.5.1 General Information

Use Case Id	BUC 4
Title	Social awareness and participation in the value proposition of communities
Authors	KMo
Version	V2.0
Date	09.03.2023

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101096490

3.5.2 Scope, Objectives and Boundaries of Use case

Scope and boundaries	Explore, implement and test strategies (e.g.: training at multi educational levels, gamification, communication campaigns and interactions) to increase the knowledge of citizens towards energy topics, and to foster their active participation in the energy communities. Test different gamification dynamics, especially through digital apps, and assess their effectiveness in raising awareness and engaging citizens. The focus will also be on the effectiveness of the intergenerational exchange of information, especially from schools to families. The final goal of all these actions will be the achievement of economic savings by all the participants, and will be evaluated through the monitoring of economic performances.
Business roles and Objectives	**Community building** • Ob1) Boost the interest of citizens in energy topics, and the awareness on benefits of participating in an energy community. **Benchmarking and gamification** • Ob2) Increase individual participation towards cooperation, to achieve community goals, through engagement schemes such as gamification based on benchmarking. **Intergenerational exchange** • Ob3) Increase of intergenerational communication between citizens on energy topics (especially from school to families), to increase engagement of citizens in the energy community.
Relation to other Use Cases	This BUC is directly influenced these two BUCs: • BUC1: Energy management (intra community). Valorisation of energy management strategies at community level. • BUC3: Sizing and organisation of energy communities. Developed in: • HLUC6: Public-Private collaboration. • HLUC7: Intergenerational engagement for community building at local scale. • HLUC8: Citizen engagement for community building at broad scale through gamification and rewarding. • HLUC10: Benchmarking and gamification with the inclusion of rewards/incentives. Can be influenced by: • HLUC1: Energy balance and accounting for communities. • HLUC3: Automated participation of energy communities in energy markets.

3.5.3 Narrative of Use Case

Short description	The final goal is to promote the optimal implementation and operation of energy communities and their economic viability by boosting social awareness and participation. This implies the collaboration with social engagement actors (i.e.: schools and educational institutions, public administration or innovation managers), and by assessing the effects of intergenerational exchange within families. Energy

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	community members will be engaged through gamification dynamics that will boost virtuous behaviours when comparing individual and aggregated performances to benchmarks (both internal and external to the community). It will be crucial to highlight the real savings and benefits people can access by being an active member.
Complete Description	Energy communities have an intrinsic social nature, and the success of their operation highly depends on the willingness of their members to actively participate. Thus, the creation of energy communities and the interest of citizens will be pursued through social dynamics, including ones that rely on intergenerational involvement. In addition, citizens will be engaged in the energy communities through tools developed to increase their awareness on energy topics and to facilitate their active participation in energy management, also highlighting the economic benefits that this can involve (both to individuals and to the whole group). The **energy community manager (ECM)** will engage with **collaborative service providers (CSP)** to develop tools aimed at facilitating the *hands-on* comprehension of energy concepts through a user-friendly exposition of **energy community members (M)** to energy data, training materials, advice, and collaborative initiatives. Energy community members will thus understand the strength of collaborating as a community and the benefits (e.g.: economic savings, self-sustainability, energy sharing), etc. that each participant can achieve by being part of it. Moreover, an effective engagement requires the cooperation of other **social engagement actors (SEA)**. Learning by doing, especially through digital tools that rely on gamification dynamics internal to the community, will make the process more engaging and fun to the members, and will allow them to feel part of the same project that keeps challenging itself. Moreover, this will help translate the perspective of energy topics as an issue into an opportunity. In this sense, the developed tools provided by a gaming provider will include community goals (such as a certain percentage of self-consumption to be achieved, or economic savings, or simply a challenge to other members/communities) and benchmarking capabilities, allowing the users to understand how ambitious their goals are, and how satisfactory the performances are if compared with the previous situation or with other users/communities. (HLUC10). This double dynamic will involve single citizens and will increase the feeling of belonging to the community. These mechanisms can also be accompanied by economic benefits, that reward the citizens whose performances are higher than the benchmark ones, or community benefits achieved when goals are fulfilled. These rewards would also act as a practical demonstration of the benefits of being actively engaged in the community (HLUC8, HLUC10). All this process can be promoted by different types of **social engagement actors (SEA)**. First, the tools to be used will be developed by **gaming providers (GP)**. Moreover, it is important to create an environment in which these topics can be shared and interiorized. In this sense, it is important to involve in this process **educational entities (EE)**, in primary schools. In fact, kids and young students are extremely sensitive to environmental topics, and often get enthusiastic about these types of initiatives. It will thus be useful to develop activities in these entities, to sensitize and empower young people through sessions and games. Then, it will be

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	interesting to investigate how effective it is to take advantage of the communication within the community and especially within families, also between different generations (from children to parents and grandparents) to promote these ideas and involve the whole population in the creation and evolution of energy communities. In addition to this, other types of groups active on the territory could be involved. Examples are **non-profit entities**, such as associations, cooperatives, NGOs and other types of local clubs. In this case, the entities represent aggregation points for the population (not only the youngest ones). The trust towards these groups, as well as the sense of belonging already established, could be an interesting starting point to organize events in which the members can learn about these topics, and where to share ideas and projects. Finally, it is crucial to remember the role of **public administration** in the community activities of local citizens. It can be useful to involve municipalities and local institutions to support through local policies and initiatives, and to facilitate the promotion of the organized projects, in order to spread more effectively the information, give credibility to the project (for example, by organizing events in the local theatre, workshops in cultural centres, advertising in public spaces, etc.) and promote economic incentives (tax policies, sustainability plans, confound RES investment, assignment of public space/equipment/roofs, etc.) (HLUC6).

Main actors and associated roles are represented in Figure 9.

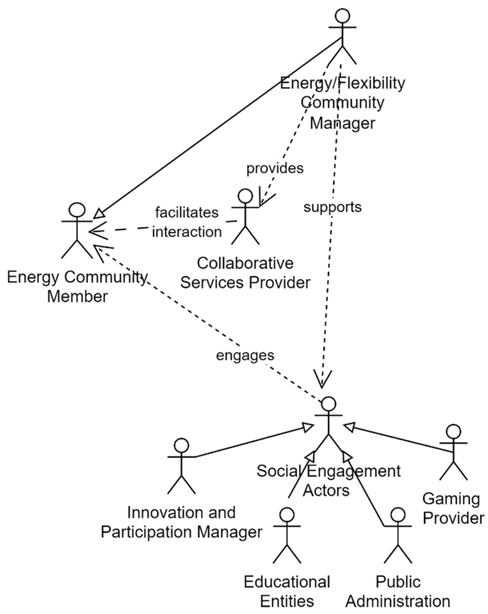

Figure 9 BUc4: Actors and role model

3.6 HLUCs in the context of BUCs

The following table links the BUCs with the HLUCs that are required to implement them. Assignment indicates that the implementation of HLUCs is driven by the objectives of the associated BUC. Those marked within parenthesis (HLUC) indicate that it is primarily linked to another BUC (Figure 3).

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Table 6 BUCs and HLUCs association

UC	Title	General Objectives	HLUCS
BUC1	Energy management (intra community)	Valorisation of energy management strategies at community level.	HLUC0, HLUC1, HLUC2, HLUC5, (HLUC10)
BUC2	Community as flexibility provider	Assess the capacity of energy communities to provide (aggregated) flexibility and its potential to participate in the flexibility value chain (i.e.: aggregator, markets, bilateral contracts, DSOs, etc.) under different approaches	HLUC3, HLUC4, HLUC5, (HLUC10)
BUC3	Sizing and organisation of energy communities	Define business models to guarantee economic sustainability of the energy community and establish a reference framework in terms of energy managed and/or participants involved.	HLUC9, HLUC11, (HLUC7)
BUC4	Social awareness and participation in the value proposition of communities	Foster the social awareness of energy communities as a social and economic driver and exploit it as a true value proposal.	HLUC6, HLUC7, HLUC8, HLUC10, (HLUC1), (HLUC3)

4 Technical Use Cases

4.1 Actors

Description of technical actors involved in HLUCs 0 to 5 (Table 7) and interactions (Figure 11)

Table 7 Technical actors (HLUC0-HLUC5)

Actor name	Actor type	Role
Energy Community Manager (ECM)	Business	Responsible for accessing and managing energy data from/to the prosumers and energy assets. Energy and flexibility management functionalities.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed, and whose energy habits can be modified according to the suggestions received or consent to controlling their flexible loads.
Energy Management System (EMS)	System (software)	A system that facilitates the execution of specific energy services according to energy goals.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Energy Asset Metering and Control System (AMCS)	Device	Hardware interface that provides energy data and has permanent access to energy variables and parameters associated either to energy assets (e.g.: PV generator, battery, load, appliances etc.) or to systems (e.g.: metering system of households, building/factory energy management system, PV inverter, etc.).

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Energy Asset Management System (EAMS)	Device	System that manages a specific energy asset (i.e., PV, heat pumps, batteries) and is in charge of assuring the correct and safe behaviour of it. It exchanges operational information (energy data and orders) of the energy assets as batteries or flexible loads through standard interfaces.
Third Party Software	Software	Extensions of the ECMP that allows advanced capabilities either extending functionalities of the ECMP towards a complete Energy Management System or simply to external applications that interact with the ECMP to get data.
Energy Optimisation System (EOS)	System (software)	A system that provides advanced energy management services to the energy community, by analysing data in real time and identifying periods in which flexible consumption could be useful.
Energy Forecasting (EF)	System (software)	A system that provides energy production and consumption forecasting for a specified time horizon.
Weather Data Provider (WDP)	System (software)	A third-party or agency that provides weather data and weather forecasts. Usually accessible through a web service (WS / SaaS).
Building Energy Management System (BEMS)	Device	A specific EAMS that manages energy of buildings, and consequently has access to control and manage all the energy subsystems of the building.
Aggregator - Market Agent (AMA)	Business	Pools electricity supply and/or demand and sells capacity and direct flexibility in the electricity markets.
Aggregator - Platform (AP)	Software service	Software platform that integrates all the services required to model, aggregate, forecast, schedule and dispatch flexibility. It also provides brokerage mechanisms to trade this flexibility.
Market	Business	A neutral party that operates the flexibility trading in a general sense. It implements the matching between flexibility demand and offers and clearing activities. It embraces local flexibility markets for congestion avoidance and balancing/reserve markets.
Distribution / Transmission System Operator (DSO/TSO)	Business	Responsible for the distribution/transmission and management of energy from the generation sources to the final consumers. It manages the grid infrastructure, ensuring quality and safety of supply. Participates in local flexibility markets by demanding flexibility to support grid management (e.g.: congestion avoidance).
Local System Operator (LSO)	Business	This is the entity in charge of operating the local energy market in some countries and adopts the role of aggregators (AP+AMA) leveraging the participation of consumers in other energy markets.
Facility Manager (FM)	Business	A kind of ECM in charge of operation and management of a building.

For simplicity energy data has been associated with a generic actor named Asset Metering and Control System (ACMs) that can be implemented by any device or system with direct access to energy data. This includes direct access to smart meters and/or submeters and PV meters (i.e.: direct access to the inverter), for example, but also access to metering data indirectly provided by DSOs through specific queries or APIs interfacing the MDMS (Metering Data Management System) and also access through any specific energy asset management system (EAMS) including Building energy management systems (BEMS), Home energy management systems (HEMS), Factory energy management systems (FEMS) or Battery management systems (BMS) as exposed in Figure 10.

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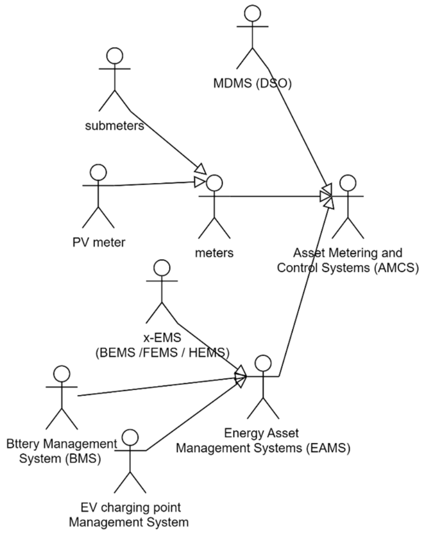

Figure 10 Asset metering and control system (ACMS) actors and hierarchies

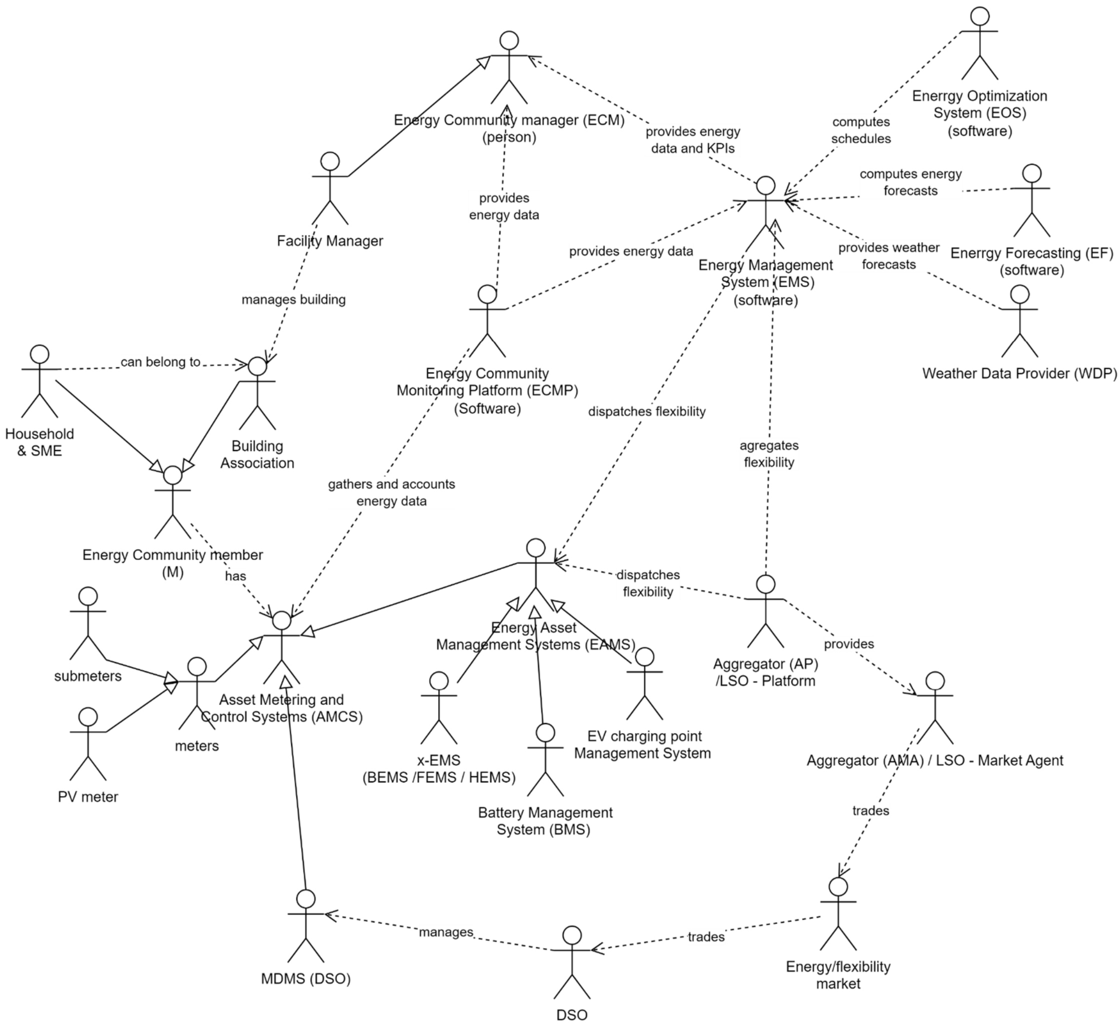

Figure 11 Technical actors and dependencies (extended)

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4.2 HLUC0 – Energy monitoring

4.2.1 Description

Table 8 HLUC0: General Information

Use Case Id	HLUC 0
Title	Energy monitoring
Authors	UdG
Version	V1.0
Date	30.07.2023

Table 9 HLUC0: Scope, Objectives and Boundaries of Use case

Scope and boundaries	The use case describes how energy data from the field devices in the energy community are gathered and made available to the energy community manager and members as well as to other applications/systems.
Business roles and Objectives	Monitoring of power/energy consumption/generation in the energy community. • Ob1) Provide measurements of consumption and generation energy data to be used for energy monitoring and in other HLUCs.
Relation to other Use Cases	All Business Use Cases. Have an impact on all the other High Level Use Cases.
Pilots	ES, GR, NL, SE

Table 10 HLUC0: Narrative of Use Case

Short description	Energy community manager and energy community members can monitor power/energy consumption and generation at their premises
Complete Description	HLUC0 deals with energy data gathering and management at community level. It is the base use case for other HLUCs defined in the project that require use of energy data (embracing both technical and social Use Cases). Monitoring local consumption/generation is achieved by a software platform (Energy Community Monitoring Platform, ECMP) with capabilities to access to heterogeneous devices (e.g.: smart meters, inverters, submeters or power analysers), systems (e.g.: building energy management system or battery energy management systems), installed either at individual consumer premises or common generation/storage plants within the community, through specific Energy Asset Metering and Control Systems (AMCS) and connectors that implement standard protocols, APIs queries or similar strategies to get direct or indirect access to energy data. The ECMP is also in charge of storing and managing historic energy data and computing basic KPIs associated to the energy use at individual and community level. The ECMP provides gathered energy data and KPIs to the different users within the community (i.e.: energy community manager, energy community members) through specific graphical and user-friendly interfaces, and also exchanges specific data with third parties and stakeholders that interact with the energy community to provide enhanced services (for example to optimise the use of local renewable generation, improving the efficiency of the community, to implement tools/games to increase engagement and awareness or to facilitate the participate in flexibility programmes).

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Associated KPIs: See Annex 1

Table 11 HLUCo: Use Case Conditions

Assumptions
• Access to the installed metering (smart meters, PV generation, meters, etc.) and control devices and systems (BMS, BEMs) required to monitor and manage energy in the community.
Preconditions
• Availability of live field data through standard ICT infrastructures and protocols from required generation and consumption devices (e.g.: smart meters, PV inverters, BMS, BEMS, meters, etc.).

4.2.2 Actors and Use Case diagram

Table 12 HLUCo: Actor list

Actor name	Actor type	Description
Energy Community Manager (ECM)	Business	Person with technical knowledge that have access to the information on consumption, generation and storage of energy community members, and to data on the response of members to the suggestions.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed, and whose energy habits can be modified according to the suggestions received.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Energy Asset Metering and Control System (AMCS)	Device	Hardware interface that provides energy data and has permanent access to energy variables and parameters associated either to energy assets (e.g.: PV generator, battery, load, appliances etc.) or to systems (e.g.: Metering system of households, building/factory energy management system, PV inverter, etc.).
Third Party Software	Software	Extensions of the ECMP that allows advanced capabilities either extending functionalities of the ECMP towards a complete Energy Management System or simply to external applications that interact with the ECMP to get data.

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Use case diagram

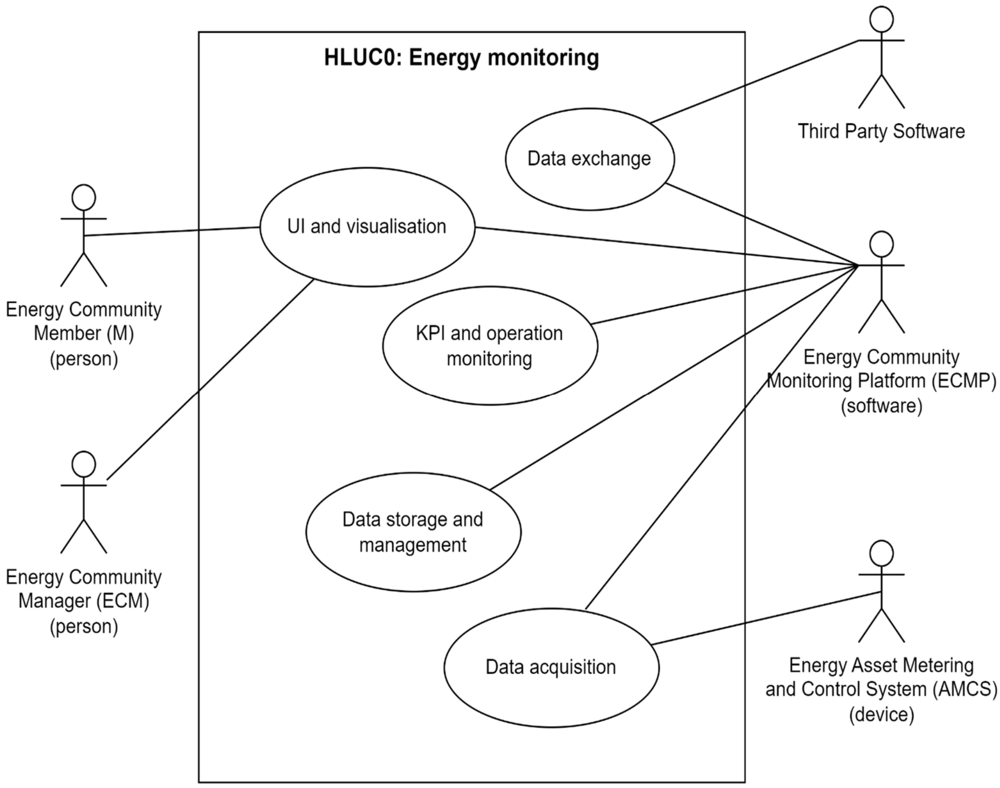

Figure 12 HLUC0: Energy Monitoring

4.2.3 Step-by-step analysis

Table 13 HLUC0: Scenarios

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Data acquisition and storage	Data is acquired from field devices (AMCS) and stored	ECMP	Periodic	Metering devices	Data ready for other scenarios
Data and KPIs visualization	ECM or M monitors the performance of the system (can visualize stored data and KPIs computed from them)	M ECM	On demand	Stored data (consumption, generation)	Graphic representation of energy data
Data exchange	ECMP exchanges data with external applications	ECMP	On demand	Stored data (consumption, generation)	-

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Table 14 HLUC0: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Data acquisition and storage						
1	Periodic request	ECMP	Request gathered data by a field device in order to be stored	ECMP	AMCS	-
2	Data request	AMCS	Field device provides data to be stored	AMCS	ECMP	Energy (consumption and generation) data
3	Data reception	ECMP	Data is stored in a database	ECMP	ECMP	Energy (consumption and generation) data
Data and KPIs visualization						
1	ECM or M request to visualize energy data or a KPI	ECM M	Request to visualize stored data or KPI	ECM M	ECMP	-
2	Request data or KPI	ECMP	Visualization of data or KPI	ECMP	ECM M	Energy (consumption and generation) data KPIs
Data exchange						
1	Third party software requests energy data	ECMP	Energy data is supplied	ECMP	Third party software	Energy (Consumption and generation) data
2	Data reception	ECMP	Response to data received	Third party software	ECMP	Acknowledge message

4.2.4 Information exchanged

Table 15 HLUC0: Information exchanged.

Name	Description
Energy (Consumption and generation) data	Energy data on generation and consumption for specific time period.
KPIs	Performance indicators computed at individual or aggregated level (community) about the use of energy.
Acknowledge message	Information about the reception of demanded data or time out

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4.3 HLUC1 – Energy balance and self-sufficiency

4.3.1 Description of HLUC1

Table 16 HLUC1: General Information

Use Case Id	HLUC 1
Title	Energy balance and accounting
Authors	KMo, OR, UdG
Version	V2.1
Date	11.09.2023

Table 17 HLUC1: Scope, Objectives and Boundaries of Use case

Scope and boundaries	Describes the promotion of sharing energy generated within the community, in order to maximise the rate of self-consumption. This includes energy assets such as generation, storage and loads (smart adaptation of consumptions) and the tools to monitor their match over time (of single participants and of the whole community) and to adapt the operation according to external and internal factors.
Business roles and Objectives	The business role is to optimally manage energy demand and generation within the community in order to maximize self-consumption in the community. ● Ob1) Provide user-friendly tools that enable community members to understand the real-time energy generation and consumption of the community, and to engage accordingly (interaction). ● Ob2) Implement a model able to value (also financially) the use and exchange of internally produced electricity within the Energy Community Members. ● Ob3) Implement an energy management strategy to maximize the self-consumption at community level.
Relation to other Use Cases	● BUC1: Energy management (intra community). Valorisation of energy management strategies at community level ● BUC3: Sizing and organization of energy communities Can impact: ● HLUC2: Storage management of local RES Can be impacted by: ● HLUC0: Energy monitoring ● HLUC2: Storage management of local RES ● HLUC3: Automated participation of energy communities in energy markets ● HLUC4: DSO interaction: Avoidance of congestions at secondary substations ● HLUC5: Energy hubs and sector coupling ● HLUC10: Benchmarking and gamification with the inclusion of rewards/ incentives
Pilots	ES, GR, NL, SE

Table 18 HLUC1: Narrative of Use Case

Short description	The use case describes strategies to facilitate the consumption of energy generated within the community, and to boost the exchange between members. Real-time energy generation/consumption data will be completed by forecasting algorithms and an optimal schedule of energy assets will be computed in order to increase self-

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	sufficiency. Activation of flexible assets is intended as suggestions sent to community members on how to behave (flexible consumptions). The engagement of community members will also be translated into economic savings and incentives.
Complete Description	A more efficient use of energy generated in the community is proposed by the Energy Management System (EMS) considering the optimal schedule of flexible loads inside the community based on energy and economic criteria fitting specific community goals (i.e., self-sufficiency). The system carries out the energy and financial accounting derived from the effective response to the optimal schedule of flexible assets. The EMS, activated by the Energy Community Manager (ECM), requires online information of energy demand and generation through the Energy Community Monitoring Platform (ECMP) and will estimate the generation forecast (invocation of EF) for specific time horizon (e.g.: 24 hours) based on weather forecast (provided by an external agent or weather data provider, WDP), energy data and a model previously trained with historic data. With this information, together with an inventory of flexible loads and operational constraints, the EMS will invoke the Energy Optimisation System (EOS) to compute the optimal balance for the forecasted period considering the constraints of flexible loads and specific maximisation objective (i.e.: energy self-sufficiency, economic revenue, etc.). The outcome of the EOS will be translated into customized flexibility requests and suggestions of actions that could increase the level of self-consumption within the community, and it is sent to each energy community member (M) by the EMS. The message will provide an indicative economic saving that the user could have by accepting the suggestion. The EMS will also provide to the consumers the option to actively interact, by following up the suggestion received through a notification. The EMS will monitor the actual change in energy consumption at individual level. The EMS will compute the effectiveness of these suggestions by computing simple performance indicators as the individual change and corresponding value, or the percentage of accepted suggestions over time (aggregated for the whole community) and sharing them through graphical interfaces. Each participant will be able to benchmark his/her own responsiveness and actual change and value with the total one. In addition, the EMS will show to the Energy Community the estimated savings related to the energy self-consumed within the community (for each energy community member and for the community as a whole). Remark: The output of the maximization of the savings/revenues of the owner of a load could be different from the maximization of the total savings at the community level (for example, the decision to postpone the charging of an EV could be beneficial for the community, but not feasible for the EV owner that decides to travel in the expected period). In addition, some decisions taken at the community level could affect single participants. Therefore, each specific case deserves a deep analysis and debate on these aspects, in order to find the best solution that applies.

Associated KPIs in Annex 1.

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Table 19 HLUC1: Use Case Conditions

Assumptions
• Access to all the metering (smart meters, PV generation, meters, etc.) and to the Energy Management System outputs (loads, BEMS, batteries activation scheduling) is available through the ECMP. • Access to the electricity tariffs and individual scheme of each participant for the estimation of potential economic savings. • Integration of EMS with forecasting and scheduling tools / apps / algorithms. • Historical data sets availability to train forecasting tools. • Access to weather forecasting providers.
Preconditions
• Availability of live field data measurements (smart meters with high granularity – at least every 15 minutes) for generation and consumption. • User interface for monitoring and control actions. • Availability of an inventory of flexible loads suitable to model the optimisation scheduling problem.

4.3.2 Actors and Use Case diagram

Table 20 HLUC1: Actor list

Actor name	Actor type	Description
Energy Community Manager (ECM)	Business (Person)	Person with technical knowledge that have access to the information on consumption, generation and storage of energy community members, and to data on the response of members to the suggestions.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed, and whose energy habits can be modified according to the suggestions received.
Energy Management System (EMS)	System (software)	A system that facilitates the execution of specific energy services according to energy goals.
Energy Optimisation System (EOS)	System (software)	A system that provides advanced energy management services to the energy community, by analysing data in real time and identifying periods in which flexible consumption could be useful.
Energy Forecasting (EF)	System (software)	A system that provides energy production and consumption forecasting for a specified time horizon.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Weather Data Provider (WDP)	System (software)	A third-party or agency that provides weather data and weather forecasts. Usually accessible through a web service (WS / SaaS).

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Use case diagram

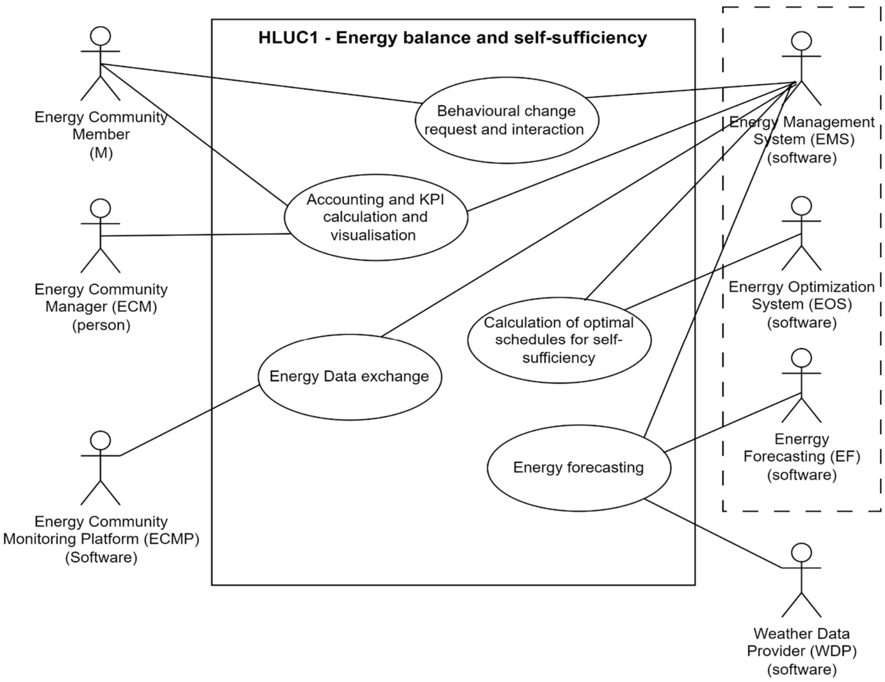

Figure 13 HLUC1 Use Case diagram: Energy Balance and self-sufficiency.

4.3.3 Step-by-step analysis

Table 21 HLUC1: Scenarios

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Behavioural change for optimal balance	Once the EOS develops the optimal scheduling for the flexible loads, the community members (M) responsible for these loads are sent a notification with suggestions on how to adapt their behaviour to the optimized option.	EMS	Periodically On demand	Inventory of flexible assets per user	Activation of flexible loads at individual level

Table 22 HLUC1: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Behavioural change for optimal energy balance						
1	Periodically or under request	EMS	Request of energy data	EMS	ECMP	Id energy assets
2	After 1	EMS	Sends energy data	ECMP	EMS	Energy data

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3	After 1	EMS	Request of weather forecast	EMS	WDP	Location
4	After 3	WDP	Sends Weather forecast	EMS	EF	Weather forecast
5	After 2 and 4	EMS	Request of energy forecasts	EMS	EF	Energy data Weather forecast
6	Under request	EF	Computes energy forecasts	EF	EF	Energy forecast
7	After 6	EF	Sends energy forecasts	EF	EMS	Energy forecast
8	After 7	EMS	Requests schedules of flexible assets to maximise self-consumption	EMS	EOS	-
9	Under request	EOS	Computes optimal schedules	EOS	EOS	Schedules of flexible loads
10	After 9	EMS	Sends Schedules	EOS	EOS	Schedules of loads
11	Availability of schedules	EMS	Elaborates customised messages with suggestions on how to modify customer behaviour	EMS	EMS	Customised action messages
12	After 11 Repeat for all M	EMS	Sends messages to customers with suggested actions	EMS	M	Customised action messages
13	After 12 Repeat for all M	M	Customers interacts with the message	M	M	Acceptance/interaction message
14	After 13 Repeat for all M	EMS	Returns feedback informing about the acceptance of the suggestion (action, activation, or not, of the load)	M	EMS	Acceptance/interaction message
15	After 14	EMS	Request of energy data	EMS	ECMP	Id energy assets
16	After 15	EMS	Sends energy data	ECMP	EMS	Energy data
17	After 16	EMS	Compute KPIs and effectiveness of the interaction with the members	EMS	EMS	KPIs
18	After 17	EMS	Shares performance results	EMS	ECM, M	KPIs

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Sequence / activity diagrams

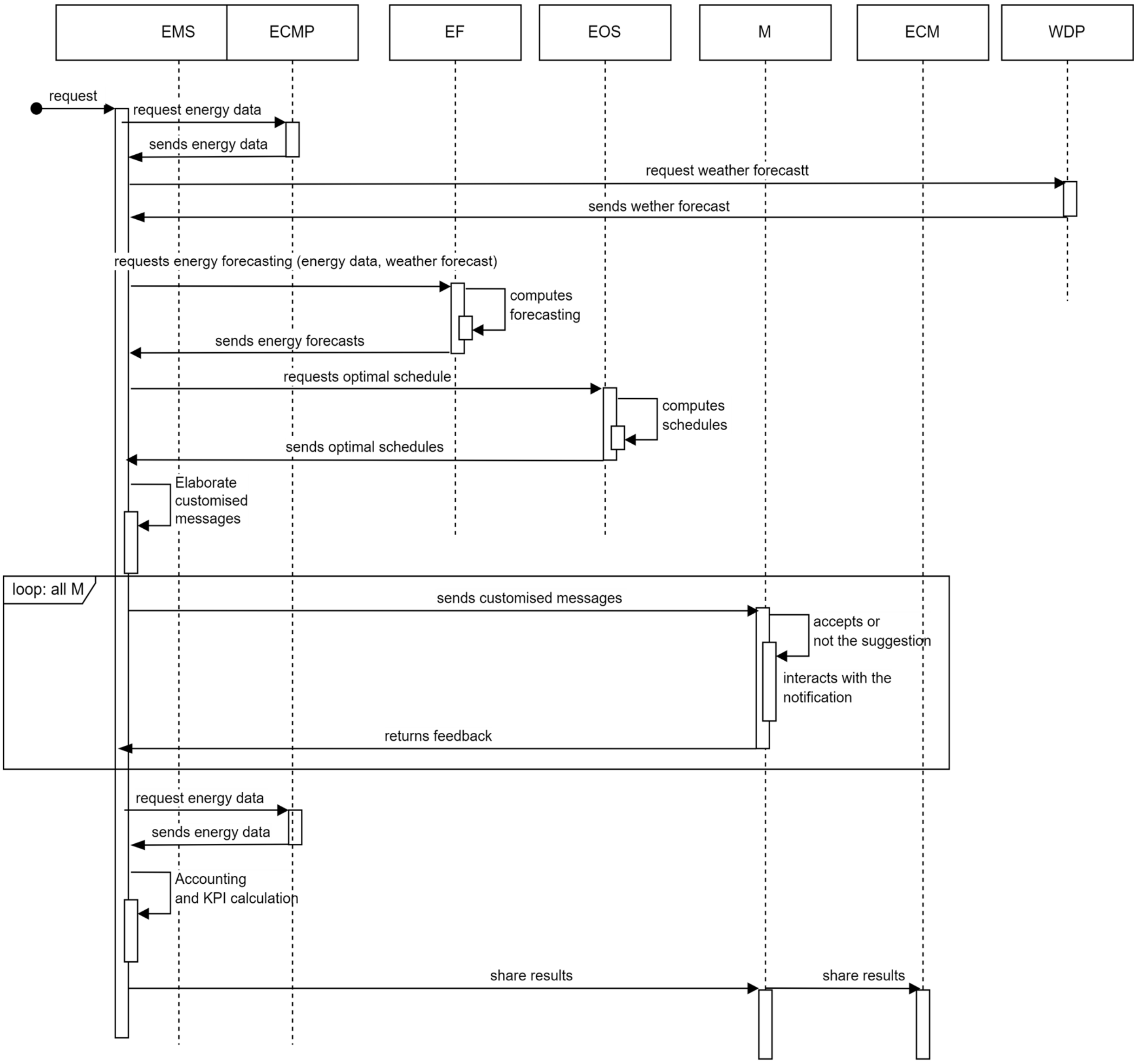

Figure 14 HLUC1: Sequence Diagram

4.3.4 Information exchanged

Table 23 HLUC1: Information exchanged

Name	Description
Id energy assets	Identifier of energy assets (e.g.: meters, devices, generators, loads, etc.) for which energy data is required.
Energy data	Generation and consumption data. Historical and/or on line depending on the request.
Location	Coordinates or identifiers of locations for which weather forecast is required.
Weather forecast	Day-ahead weather forecasting at the same granularity as energy data.
Energy forecast	Day-ahead estimation of generation and demand.

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Schedules of flexible loads	Schedules of flexible loads calculated by the EOS in a day-ahead scenario considering both non-flexible and flexible loads.
Customized action messages	Messages requesting to modify the operation of the flexible loads, according to the optimal scheduling. A message is sent to each member.
Acceptance/Interaction message	Notification from each member/flexible load, to confirm (or not) the implementation of the suggested action.
KPIs	Key performance indicator used to monitor the impact of actions executed.

4.3.5 Requirements and general remarks

Participants: The use case applies to all the energy community members (M) that want to have an active participation in the energy performance of the community. Access to the energy data is required and basic information of available flexible assets is required.

Time frame: This use case is expected to operate with online data preferable gathered with a time granularity of 15 min.

Energy Forecasting (EF): Energy forecasting requires historic data associated with the forecasting point and weather forecasts with the same forecasting horizon and granularity of energy data. This can be provided by weather agencies through APIs.

Energy Optimisation System (EOS): It requires an inventory of the flexible loads that participate in the community and their operative to be used as constraints when modelling the optimisation problem. Required information includes the power installed, the type of action to be implemented in order to operate the load (activation, deactivation, shifting in time) and the potential duration of the action (if applicable).

4.4 HLUC2 – Optimal management of energy assets in energy communities with PV generation and implicit flexibility management

4.4.1 Description

Table 24 HLUC2: General Information

Use Case Id	HLUC2
Title	Optimal management of energy assets in energy communities with PV generation
Authors	OR, KMo, UdG
Version	V2.1
Date	11.09.2023

Table 25 HLUC2: Scope, Objectives and Boundaries of Use case

Scope and boundaries	The use case focuses on managing flexible loads including local storage (batteries) to optimally manage the use of locally generated electricity.
Business roles and Objectives	Self-consumption (self-sufficiency) of the energy community: • Ob1) Schedule operation of storage assets and flexible loads to maximise the use of locally (inside the community) produced energy based on energy forecasts.
Relation to other Use Cases	• BUC1: Energy management (intra community). Valorisation of energy management strategies at community level. Can impact: • HLUC1: Energy balance and accounting for communities • HLUC3: Automated participation of energy communities in energy markets

	• HLUC4: DSO interaction: Avoidance of congestions at secondary substations
Pilots	SE, NL, GR & ES (depends on availability of batteries)

Table 26 HLUC2: Narrative of Use Case

Short description	The use case describes how local storage and demand (flexible loads) are managed to maximise the use of locally (inside the energy community) produced energy and/or minimise the energy community costs (implicit flexibility management). The whole system is expected to be managed by the energy management system (EMS) with access to energy demand and generation data, electricity prices and to the status and control of the electrical flexible loads and storage (e.g.: batteries).
Complete Description	The energy management system (EMS) will schedule the charge and discharge of electrical storage elements (batteries), the activation and deactivation of flexible loads, and the notifications to individual users requesting to shift consumption in time in order to maximise the benefits of renewable energy produced in the energy community. With this aim, the Energy Management System (EMS) will retrieve live data from all the monitored loads and generators through the Energy Community Monitoring Platform (ECMP) and the status of storage and flexible elements directly from the Asset Energy Management System (AEMS) when not integrated in the ECMP. With generation and demand metering data, and other contextual data, such as weather forecast (provided by weather data providers, WDP) and calendar, a demand and generation forecasting, for a 24-hour time horizon, will be performed by using forecasting models trained with historic data. Energy demand and generation forecasting, together with agile tariffs (i.e.: electricity price signals) and the status of the storage elements and flexible loads, will be used to optimally schedule or control the charge/discharge operation of these batteries and setpoints for flexible loads during the specified time horizon, as well as request individuals to postpone consumption Schedules will be computed by optimisation algorithms (Energy Optimisation System, EOS) tuned to maximise the use of RES within the community also considering the external energy (electricity) prices (i.e.: implicit flexibility management). Energy Management System (EMS) will dispatch the corresponding power setpoints to the flexible elements (batteries or loads) according to schedules through specific energy asset management systems (e.g.: BMS, HEMS and BEMS). The result of this operation will be accounted by the EMS and made available to the energy community manager (ECM) and members (M).

Associated KPIs in Annex 1.

Table 27 HLUC2: Use Case Conditions

Assumptions
• Live access to all the metering (smart meters, PV generation, meters, etc.) and status of storage and controllable assets through the ECMP and/or specific AEMS (BEMS, BMS, etc.). • Integration of EMS with forecasting and scheduling tools /apps / algorithms. • Historical data sets availability to train forecasting models. • Access to electricity tariffs. • Access to weather forecasting providers. • Availability of flexible load models, in special batteries, suitable to be used in the optimisation scheduling problem.

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Preconditions
• ECMP and AEMS are up and running. • Energy community manager (ECM) together with energy community members (M) should define a retributive schema based on agile tariffs that consider the energy and flexibility prices. • Forecasting models trained.

4.4.2 Actors and Use Case diagram

Table 28 HLCU2: Actor list

Actor name	Actor type	Description
Energy Community Manager (ECM)	Business	Person with technical knowledge that have access to the information on consumption, generation, and storage of energy community members.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed, and whose energy habits can be modified according to the suggestions received.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Energy Management System (EMS)	System (software)	A system that facilitates the execution of specific energy services according to energy goals.
Energy Optimizations System (EOS)	System (software)	A system that provides advanced energy management services to the energy community.
Energy Asset Management System (EAMS)	Device	A subcategory of AMCS that manages a specific energy asset (i.e., batteries, HVACs) or energy system (e.g.: HEMS/BEMS) and is in charge of assuring the correct and safe behaviour of it. It exchanges operational information (energy data and orders) of the energy assets as batteries or flexible loads through standard interfaces.
Building Energy Management System (BEMS)	Device	A specific EAMS that manages energy of buildings, and consequently has access to control and manage all the energy subsystems of the building.
Energy Forecasting (EF)	System (software)	A system that provides energy production and consumption forecasting for a specified time horizon.
Weather Data Provider (WDP)	System (software)	A third-party or agency that provides weather data and forecasts. Usually accessible through a web service (WS / SaaS).

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Use case diagram

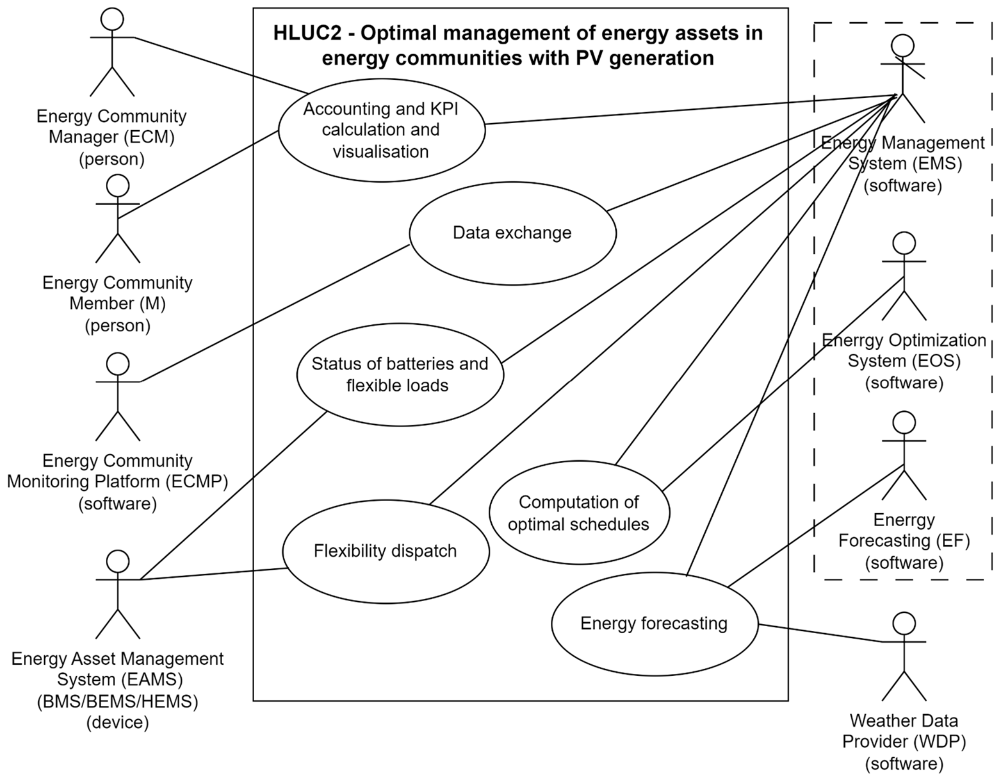

Figure 15 HLUC2: Use Case Diagram: Optimal management of energy assets in energy communities with PV generation.

4.4.3 Step-by-step analysis

Table 29 HLUC2: Scenarios

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Optimal scheduling and dispatch schedules	Calculating optimal scheduling for storage devices and flexible loads	EMS	Periodic	Available data from EMS	Optimal scheduling dispatched

Table 30 HLUC2: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Optimal scheduling and dispatch schedules						
1	Periodically (daily)	EMS	Request energy data	EMS	EMCP	Id Energy assets
2	Under request	EMS	Sends energy data	EMCP	EMS	Energy data

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3	Periodically (daily)	EMS	Request status of storage and flexible loads	EMS	EAMS	Id Energy assets
4	Under request	EMS	Sends status of flexible loads	EAMS	EMS	Status of flexible loads
5	Periodically (daily)	EMS	Request weather forecast	EMS	WDP	Location
6	Under request	EMS	Sends weather forecast	WDP	EMS	Weather forecast
7	After 2 and 6	EMS	Request energy forecasts	EMS	EF	Energy data Weather forecast
8	After 7	EF	Computes energy forecast	EF	EF	-
9	After 8	EF	Sends energy forecast	EF	EMS	Energy forecast
10	After 9	EMS	Request optimal schedules	EMS	EOS	Energy forecast Status of flexible assets
11	After 10	EOS	Computes optimal schedules	EOS	EOS	-
12	After 11	EOS	Sends optimal schedules of flexible loads	EOS	EMS	Schedules of flexible loads
13	After 12	EMS	Sends schedules	EMS	EAMS	Schedules of flexible loads
14	After 13	EAMS	Dispatch schedules	EAMS	EAMS	Schedules of flexible loads
15	After 14	EAMS	Validates the application of schedules	EAMS	EMS	Validation of dispatched schedules
16	After 15	EMS	Request energy data	EMCP	EMS	Energy data
17	After 16	EMS	Computes KPI and accounting	EMS	EMS	-
18	After 17	EMS	Shares KPIs	EMS	ECM, M	KPIs

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Sequence / activity diagrams

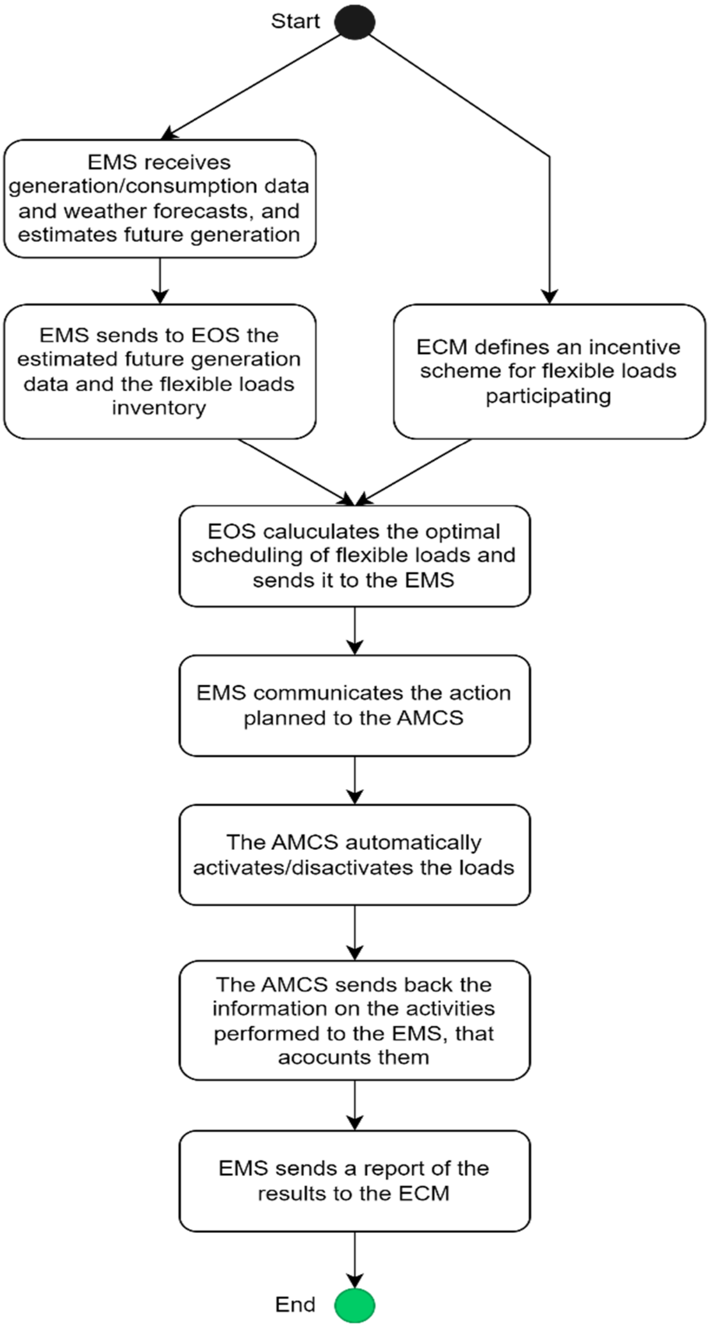

Figure 16 HLUC2: Optimal scheduling and dispatch schedules: Activity diagram

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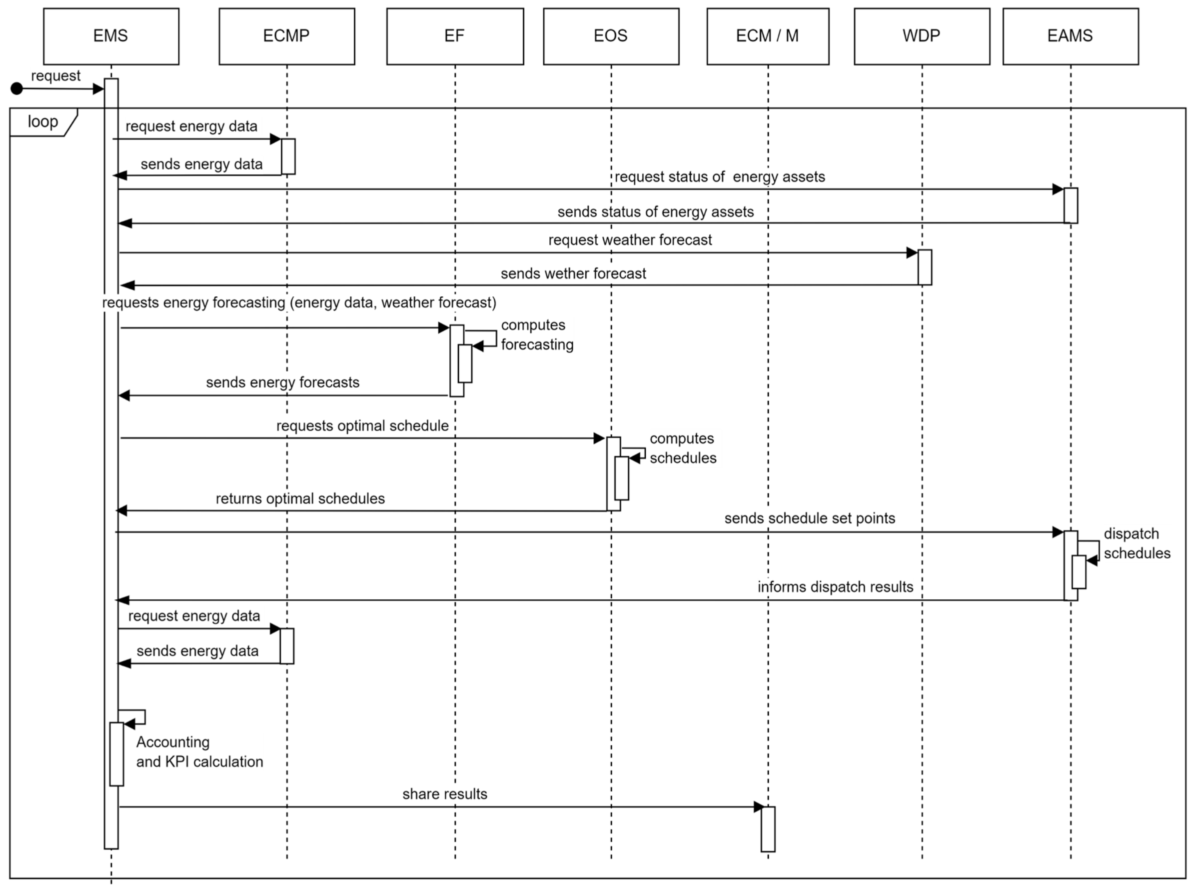

Figure 17 HLUC2: Sequence Diagram

4.4.4 Information exchanged

Table 31 HLUC2: Information exchanged

Name	Description
Id energy assets	Identifier of energy assets (e.g.: meters, devices, generators, loads, etc.) for which energy data is required.
Energy data	Generation and consumption data. Historical and/or on line depending on the request.
Location	Coordinates or identifiers of locations for which weather forecast is required.
Weather forecast	Day-ahead weather forecasting at the same granularity as energy data.
Energy forecasting	Day-ahead estimation of generation and demand.
Status of flexible loads	Status of flexible loads, especially for storage elements (e.g.: state of charge of batteries) and those whose continuous operation depends on previous states.
Schedules of flexible loads	Schedules of flexible loads calculated by the EOS in a day-ahead scenario considering both non-flexible and flexible loads. Schedules vary according to the flexible loads. Thus, batteries usually include charging /discharging magnitude (energy/ power) and time (starting / duration), whereas shiftable loads could be scheduled by on/off commands at specific times or durations and thermal loads by the operational set point during specific times.

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Validation of dispatched schedules	Report on real operation of flexible loads with respect to scheduled operation (e.g.: on/off time, charged/discharged energy, etc.).
KPIs	Performance indicators relative to the impact of flexibility activation.

4.4.5 Requirements and general remarks

Flexible loads which have a storage function, as well as electrochemical storage devices (i.e.: batteries), have limited life cycles. Moreover, they are not 100% efficient while charging and discharging. Therefore, optimisation, if based on cost optimization, needs to consider the levelized cost of storage.

4.5 HLUC3 – Automated participation of energy communities in energy markets

4.5.1 Description

Table 32 HLUC3: General Information

Use Case Id	HLUC3
Title	Automated participation of energy communities in energy markets
Authors	BBEN
Version	V2.0
Date	11/9/23

Table 33 HLUC3: Scope, Objectives and Boundaries of Use case

Scope and boundaries	Identify and activate flexibility products at community level to be offered to third parties through explicit demand response mechanisms. The use case focuses on the potential of aggregated flexibility of communities and the mechanisms to identify and activate it individually inside the community.
Business roles and Objectives	Activation of flexibility at community level to lever the participation of energy communities in energy markets. The following objectives have been identified: • Ob1) Identification and quantification of flexibility potential that communities can offer to third parties. • Ob2) Enabling flexibility for market optimisation and to participate in the frequency balance markets. • Ob3) To aggregate energy resources, pool electricity supply and/or demand and sell flexibility in the electricity markets levering the participation of consumers in the energy value chain.
Relation to other Use Cases	• BUC2: Community as flexibility provider Can impact: • HLUC1: Energy balance and accounting for communities • HLUC4: DSO interaction: Avoidance of congestions at secondary substations
Pilots	SE, ES[1]

[1] Simulation of flexibility markets

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Table 34 HLUC3: Narrative of Use Case

Short description	Assessment of the flexibility capacity that the energy community can offer. Aggregated flexibility of the energy community is traded to third parties enabled by market mechanisms. It includes the mechanisms to leverage participation of energy communities in energy markets and interaction with other stakeholders to exploit community flexibility.
Complete Description	Flexibility capacity that an energy community can provide is estimated to participate in energy markets. An aggregator platform with online access to energy data implements a set of services to estimate flexibility and design optimal aggregation to respond to flexibility demands. Trading is performed between the platform and the community energy manager by means of negotiation (broker) mechanism. The aggregator platform (e.g.: Bamboo[2]) should have access to flexible assets (data and management) in order to dispatch the negotiated flexibility schedules (supported by specific Energy Management Systems) and also to the power demand of all community members. A detailed assessment (flexibility audit) of the flexibility capacity that the community can offer to the system, as well as a study on how this is activated to be as significant as possible should be performed previously to the automated participation (precondition). Energy balance and optimal operation of distributed energy assets will be studied to offer aggregated services to optimize costs and improve local energy markets. The Energy Management System (EMS) of the community coordinates the access to the energy data. Energy data (generation and consumption) from community members will be accessed through the Energy Community Monitoring Platform (ECMP) for monitoring purposes and flexibility forecasting purposes. When required, the status of flexible devices (e.g.: batteries, HVACs and thermal devices, EVs and PVs) will be done directly through the specific Energy Asset Management System (EAMS). EMS will coordinate the calculation of energy forecasting and scheduling of flexible energy assets, on a daily basis and according to community goals, supported by the specific energy forecasting (EF) and Energy Optimisation Services (EOS). Then, based on the calculated schedules, energy forecasts and status of energy assets, the aggregation platform (AP) estimates flexibility forecasts and optimal aggregations of flexibility to participate in explicit demand response programmes. Schedules to participate in balancing markets require trading explicit flexibility. Participation on those markets is performed through an aggregator market agent (AMA) who is in charge of elaborating the flexibility offers and launching associated bids to the Market. After the market clearing the finally accepted offers are sent back to the AP and this to the EMS for dispatching. Dispatch is managed by every energy asset management system (EAMS). After execution the EMS will account and compute the performance (KPIs) of trading flexibility and will share them with energy community members (M) and the energy community manager (ECM).

Associated KPIs in Annex 1.

[2] Bamboo is a prototype of aggregation platform capable to interact with energy markets.

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Table 35 HLUC3: Use Case Conditions

Assumptions
• Online access to flexible loads: energy data and activation. • Existence of enough flexibility in the community to be aggregated to participate in flexibility markets. • Market accessibility to get flexibility demands.
Preconditions
• Flexibility capacity must be audited in order to configure the inventory of flexible assets in the platform: The Energy Community (i.e., every energy community member) will be audited in collaboration with the Energy Community Manager (ECM) in order to better understand the existing flexible assets and their ability to answer the different existing and foreseen ancillary services. • Access energy data and energy asset management systems will be required in this audit process. • Access to markets and set up through the aggregator platform.

4.5.2 Actors and Use Case diagram

Table 36 HLUC3: Actor list

Actor name	Actor type	Description
Aggregator - Market Agent (AMA)	Business	Pools electricity supply and/or demand and sells capacity and direct flexibility in the electricity markets.
Aggregator - Platform (AP)	Software service	Software platform that integrates all the services required to model, aggregate, forecast, schedule and dispatch flexibility. It also provides brokerage mechanisms to trade this flexibility.
Energy Community Manager (ECM)	Business	Person with technical knowledge that have access to the information on consumption, generation, and storage of energy community members.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed and intend to change their behaviour or consent to controlling their flexible loads, to provide a service to the DSO.
Energy Management System (EMS)	System (software)	A system that facilitates the execution of specific energy services in the community according to energy goals.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Energy Asset Management System (EAMS)	Device	System that manages a specific energy asset (i.e., PV, heat pumps, batteries) and is in charge of assuring the correct and safe behaviour of it. It exchanges operational information (energy data and orders) of the energy assets as batteries or flexible loads through standard interfaces.
Energy Forecasting (EF)	System (software)	A system that provides energy production and consumption forecasting for a specified time horizon.
Energy Optimizations System (EOS)	System (software)	A system that provides advanced energy management services to the energy community.
Weather Data Provider (WDP)	System (software)	A third-party or agency that provides weather data and weather forecasts. Usually accessible through a web service (WS / SaaS).

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Market	Business	A neutral party that operates the flexibility trading in a general sense. It implements the matching between flexibility demand and offers and clearing activities. It embraces local flexibility markets for congestion avoidance and balancing/reserve markets.
Distribution / Transmission System Operator (DSO/TSO)	Business	Responsible for the distribution and management of energy from the generation sources to the final consumers. It manages the grid infrastructure, ensuring quality and safety of supply. They demand flexibility traded in flexibility markets.

Use case diagrams

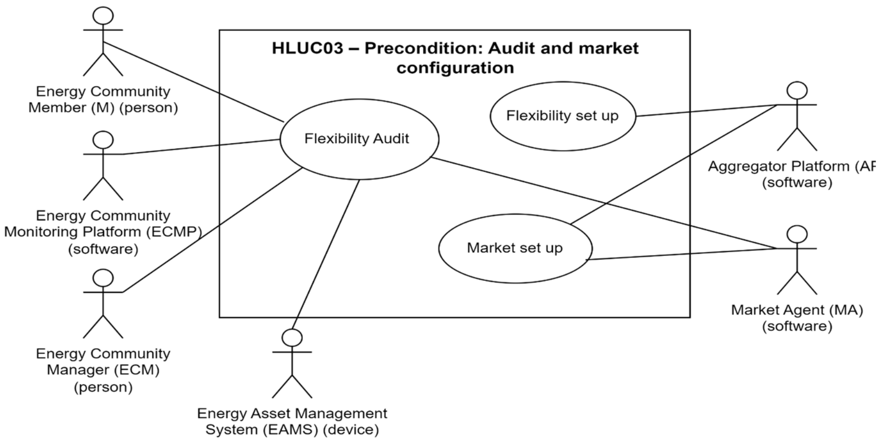

Figure 18 HLUC3: Use case diagram. Precondition: Audit and market configuration

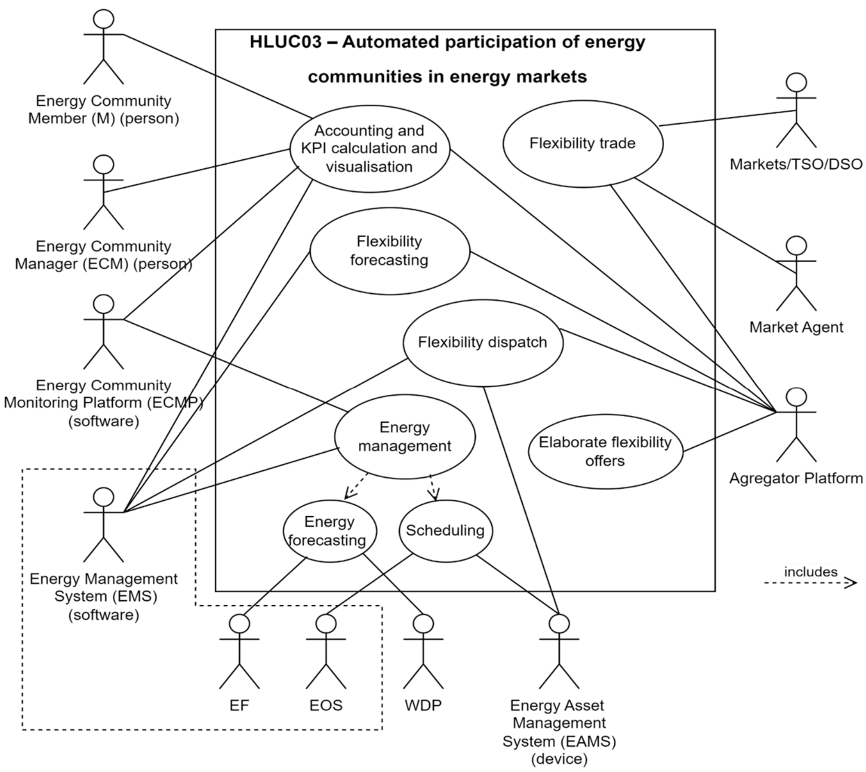

Figure 19 HLUC3: Use case diagram. Automated participation of energy communities in energy markets

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4.5.3 Step-by-step analysis

Table 37 HLUC3: Scenarios

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Automated participation in markets	Enabling the participation of energy communities in flexibility markets by computing schedules of flexible loads for an aggregated participation	AP	Daily	Flexibility audit Flexibility and market set up	Aggregated flexibility traded

Table 38 HLUC3: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Automated participation in markets						
1	Periodically (daily)	EMS	Request energy data	EMS	ECMP	Id energy Asset
2	After 1	ECMP	Sends energy data	ECMP	EMS	Energy data
3	Periodically (daily)	EMS	Request weather forecast	EMS	WDP	Location
4	After 3	WDP	Sends weather forecast	WDP	EMS	Weather forecast
5	After 2 & 4	EMS	Requests energy forecasting	EMS	EF	Energy data Weather forecast
6	After 5	EF	Computes Forecasts	EF	EF	Energy forecasts
7	After 6	EF	Sends Forecasts	EF	EMS	Energy forecasts
8	Periodically (daily)	EMS	Request status of storage and flexible loads	EMS	EAMS	Id Energy Asset
9	After8	EAMS	Sends status of flexible loads	EAMS	EMS	Status of flexible loads
10	After 9	EMS	Request optimal schedules	EMS	EOS	-
11	After 10	EOS	Computes schedules	EOS	EOS	Schedule of flexible loads
12	After 11	EOS	Sends schedules	EOS	EMS	Schedule of flexible loads
13	After 12	EMS	Exposes flexibility to aggregator	EMS	AP	Energy forecasts Schedule of flexible loads
14	After 13	AP	Computes flexibility forecasts	AP	AP	Flexibility forecasts
15	After 14	AP	Elaborates flexibility offers for participation in explicit demand	AP	AP	Flexibility offers

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			response programmes			
16	After 15	AP	Sends flexibility offers	AP	AMA	Flexibility offers
17	After 16	AMA	Elaborates bids	AMA	AMA	Flexibility bids
18	After 17	AMA	Sends flexibility bids to the market	AMA	Market	Flexibility bids
19	After 18	Market	Market clearing	Market	AMA	Accepted flexibility bids
20	After 19	AMA	Sends final schedules of explicit flexibility	AMA	AP	Flexibility schedules (explicit)
21	After 20	AP	Sends final schedules	AP	EMS	Schedule of flexible loads
22	After 21	EMS	Dispatch flexibility	EMS	EAMS	Schedule of flexible loads
23	After 22	EAMS	Execute schedules	EAMS	EAMS	Schedule of flexible loads
24	After 23	EMS	Request energy data	EMS	ECMP	Id energy asset
25	After 24	EMS	Sends energy data	ECMP	EMS	Energy data
26	After 25	EMS	Computes KPIs	EMS	EMS	KPIs
27	After 26	EMS	Shares performance results	EMS	ECS, M	KPIs

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Sequence / activity diagrams

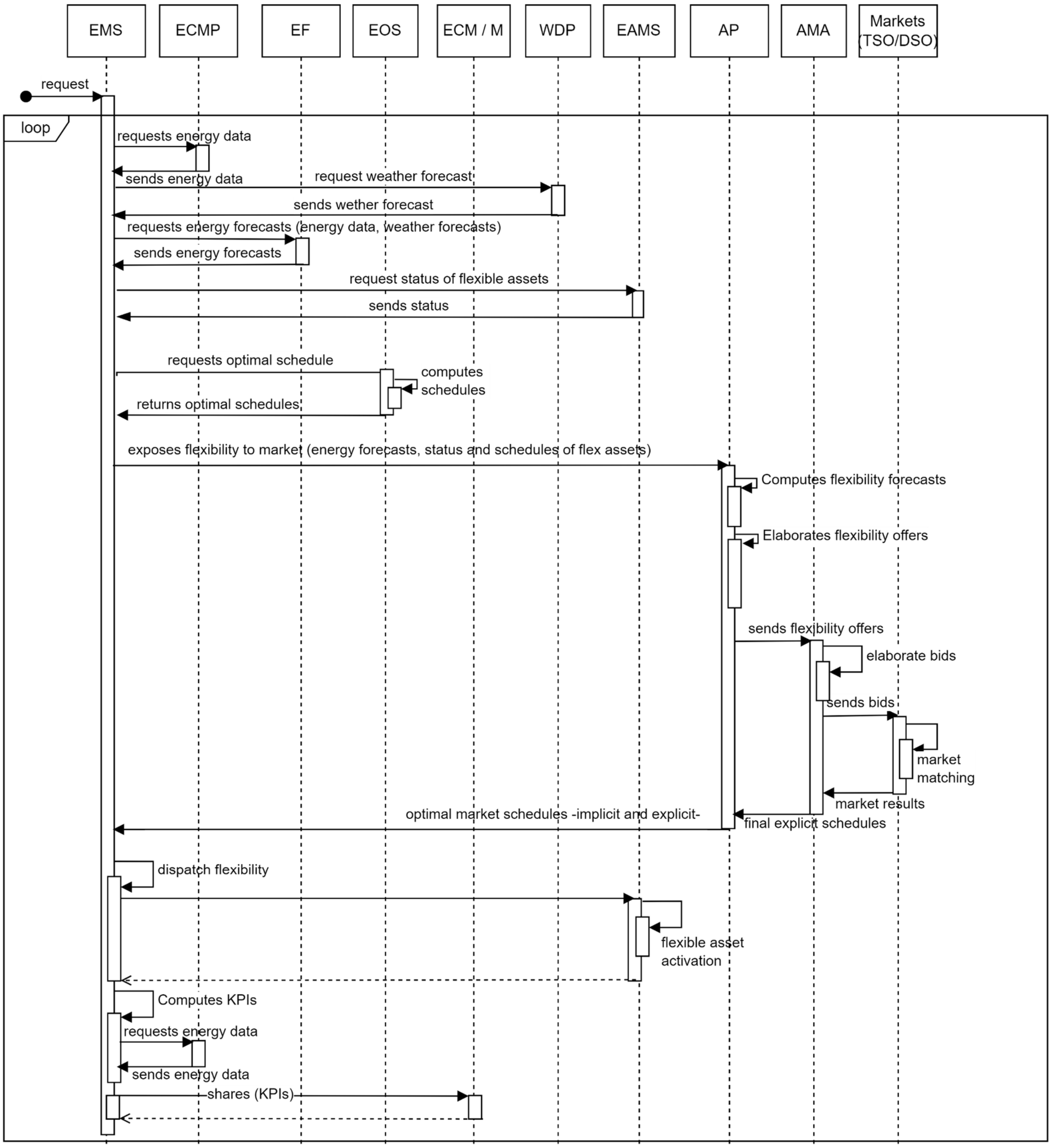

Figure 20 HLUC3: Sequence Diagram

4.5.4 Information exchanged

Table 39 HLUC3: Information exchanged

Name	Description
Id energy asset	Identifier of energy assets (e.g.: meters, devices, generators, loads, etc.) for which energy data is required.
Energy data	Generation and consumption data. Historical and/or on line depending on the request.

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Location	Coordinates or identifiers of locations for which weather forecast is required.
Weather forecast	Day-ahead weather forecasting at the same granularity as energy data.
Energy forecasting	Day-ahead estimation of generation and demand.
Status of flexible loads	Status of flexible loads, especially for storage elements (e.g.: state of charge of batteries) and those whose continuous operation depends on previous states.
Schedules of flexible loads	Schedules of flexible loads according to their operational constraints. Thus, batteries usually include charging / discharging magnitude (energy/ power) and time (starting / duration), whereas shiftable loads could be scheduled by on/off commands at specific times or durations and thermal loads by the operational set point during specific times.
Flexibility forecasts	Estimation of individual flexibility based on the model of flexible assets and their schedule for specific time horizons.
Flexibility offers	Estimation of aggregated flexibility in a specific horizon available for trading.
Flexibility bids	Elaborated (completed with required market attributes) flexibility offer, ready for bidding in specific markets.
Accepted flexibility bids	Bids accepted after market clearance.
Flexibility schedules	Flexibility corresponding to accepted bids representing aggregated flexibility.
KPIs	Performance indicators relative to the impact of flexibility activation.

4.6 HLUC4 – DSO interaction: Avoidance of congestions at secondary substations

4.6.1 Description

Table 40 HLUC4: General Information

Use Case Id	HLUC 4
Title	DSO interaction: Avoidance of congestions at secondary substations
Authors	BBEN, RESF
Version	V1.1
Date	07.03.2023

Table 41 HLUC4: Scope, Objectives and Boundaries of Use case

Scope and boundaries	Collaboration of energy communities with Distribution System Operators (DSO) aims to improve the operational safety of distribution grids at the secondary substation level (low voltage). This collaboration consists in activating flexibility of the energy community to solve congestion issues at the transformer.
Business roles and Objectives	Energy community acts as a flexibility service provider to support operation of distribution grids in presence of possible congestions or voltage issues. As a result of this flexibility service, a deferral of investments on the DSO infrastructure is expected. This results in cost savings for the DSO that partially should be dedicated to reward the flexibility management of the energy community. The following objectives have been identified:

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	• Ob1) Enable the participation of energy communities as flexibility providers to the DSO. • Ob2) Estimate the flexibility of community members and its aggregated value.Ob3) Coordinate the activation of enough flexibility to respond to DSO demand (amount of energy and time of activation) • Ob4) Define a rewarding strategy to incentive the participation of community members in the flexibility programme.
Relation to other Use Cases	• BUC2: Community as flexibility provider • BUC3: Sizing and organization of energy communities • BUC4: Social awareness and participation in the value proposition of communities Could impact: • HLUC2: Storage management of local RES • HLUC3: Automated participation of energy communities in energy markets • HLUC7: Intergenerational engagement for community building at local scale. • HLUC9: Interactive communication and collaborative participation oriented to foster joint initiatives and investments. • HLUC10: Benchmarking and gamification with the inclusion of rewards/ incentives.
Pilots	ES, NL

Table 42 HLUC4: Narrative of Use Case

Short description	Participation of energy communities in explicit flexibility programmes. Activation of flexible loads in a coordinated and aggregated manner to provide the expected change on the energy balance at the point of common coupling (PCC). Rewarding community members to participate in the flexibility programme. The flexibility (such as demand-response, electrical storage or smart charging) that arises from the energy communities will be pooled to provide services to the DSO. These services avoid and solve local predicted congestion as a specific example of the value that the community can create to the DSO and to the whole electricity system. Flexibility through the utilization of energy storage will be studied, aiming to explore new electricity services and business models, which will serve both the energy community and the DSO.
Complete Description	Traditionally, a DSO operates the electricity network independent of its (small scale) users. As long as a user - a household connected to the grid - consumes within the contracted capacity, there is no interaction with the DSO. This scenario has changed to the sudden massive growth of distributed generation (mainly solar PV) and electrification of mobility (electric vehicles) and heating/cooling with heat pumps. This causes several problems in the distribution grid as for example a reverse flow (when generation is greater than demand), grid and/or transformer congestion due to excess of demand at peak hours (e.g.: caused by EV charging) or voltage variations due to variability of demand. Moreover, a DSO cannot always accommodate these new energy flows with new infrastructure. Therefore, there is a need to unlock the flexibility potential of households. This dampens social costs (on new infrastructure) and enables new households (or solar panels) to be connected to the grid. This HLUC aims to establish a direct collaboration between the DSO and an EC to use the potential flexibility of the EC to operate the low voltage grid. The use case cases

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	focus is put on solving congestion problems at the transformer level. Thus, the HLUC consists of a collective commitment of an energy community to maintain demand under a predefined threshold in order to avoid congestions at the secondary substation level. This way, the grid is used in a better way and investments in new infrastructure can be postponed and better planned. To manage the situation the DSO defines a maximum power at the point of common coupling (PCC) where all the community members are connected (e.g.: transformers in the secondary substation), that is informed to the energy community manager (ECM) through the energy management system (EMS). The energy management system (EMS) gathers energy data from the Energy Community monitoring platform (ECMP) and requests forecasts of both aggregate demand and generation for a specified time horizon through the energy forecasting (EF). Forecasts will consider previous consumption patterns and weather influence in both generation and demand and will be used to assess the probability of overpassing the operational limit assigned by the DSO during the specified time horizon and inform the energy community manager (ECM). In case of forecasting a possible excess of the net balance of the community, the EMS will request specific energy community members (M) to react to that situation. Selection of flexible members will be based on the estimation done by the EMS. This will consider the availability of flexible loads as EV charging stations or heat pumps and their status, directly provided by accessing the respective energy asset management system (EAMS). In case of acceptance, the flexibility will be activated either manually by the owner or automatically by direct access to the controller performed by the EMS. Participation in the flexibility programme will be rewarded (e.g.: energy points) and the EMS will account the contributions of every participant. At the same time, avoiding congestions at secondary substation level can defer investments in new grid infrastructure.

Associated KPIs in Annex 1.

Table 43 HLUC4: Use Case Conditions

Assumptions
• The community members agree that their live energy data is used to calculate the collective behaviour of the community. • Access to the electricity tariff scheme of each participant for the estimation of potential peak reduction. • Availability of information from the DSO about how much the infrastructure is used. • Existence or elaboration of a bilateral contract or agreement between the DSO and the energy community where the exchanged information should be specified. • User interface for monitoring and control actions.
Preconditions
• Prequalification of community members including audit of flexible assets. • An incentives / rewarding schema has to be defined to assure participation of community members. • Communication with energy management system associated to flexible energy assets

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4.6.2 Actors and Use Case diagram

Table 44 HLUC4: Actor list

Actor name	Actor type	Description
Energy Community Manager (ECM)	Business	Person with technical knowledge that have access to the information on consumption, generation, and storage of energy community members.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed and intend to change their behaviour or consent to controlling their flexible loads, to provide a service to the DSO.
Distribution System Operator (DSO)	Business	Responsible for the distribution and management of energy from the generation sources to the final consumers. It manages the grid infrastructure, ensuring quality and safety of supply.
Energy Management System (EMS)	System (software)	A system that facilitates the execution of specific energy services according to energy goals.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Energy Asset Management System (EAMS)	Device	System that manages a specific energy asset (i.e., PV, heat pumps, batteries) and is in charge of assuring the correct and safe behaviour of it. It exchanges operational information (energy data and orders) of the energy assets as batteries or flexible loads through standard interfaces.
Energy Forecasting (EF)	System (software)	A system that provides energy production and consumption forecasting for a specified time horizon.
Weather Data Provider (WDP)	System (software)	A third-party or agency that provides weather data and forecasts. Usually accessible through a web service (WS / SaaS).

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Use case diagram

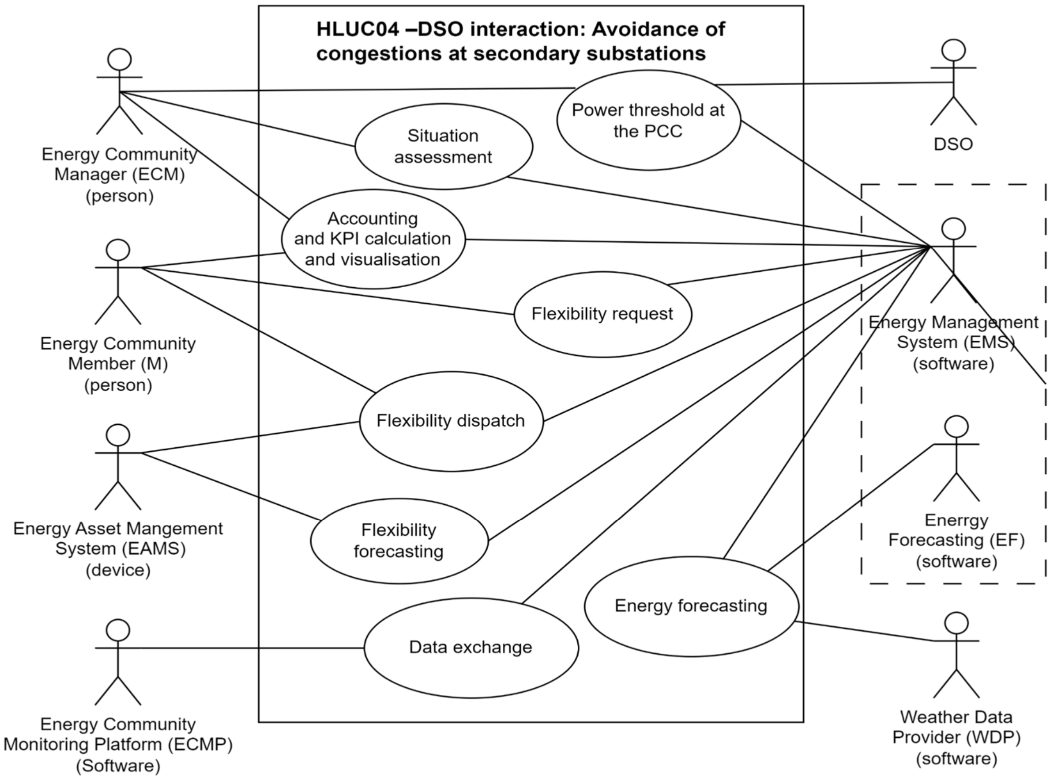

Figure 21 HLUC4: DSO interaction: Avoidance of congestions at secondary substation

4.6.3 Step-by-step analysis

Table 45 HLUC4: Scenarios

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Avoidance of congestion	Requirement of flexibility to avoid congestions at secondary substations	DSO	Daily On demand	Communication to EMS (control of flexible energy loads)	Dispatch of setpoints of flexible loads

Table 46 HLUC4: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Avoidance of congestion						
1	Daily or on demand	DSO	Request activation of flexibility to the community	DSO	EMS	Operational threshold at the PCC
2	After 1	EMS	Inform and visualise flexibility demand	EMS	ECM	Operational threshold at the PCC

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3	After 1	EMS	Request energy (generation and demand) data	ECMP	EMS	Energy data
4	After 3	EMS	Request weather forecast	WDP	EMS	Weather forecast
5	After 3 and 4	EMS	Request energy forecast	EMS	EF	Energy data Weather forecast
6	After 5	EF	Computes energy forecast	EF	EF	Energy forecasts
7	After 6	EF	Sends energy forecast	EF	EMS	Energy forecast
8	After 5	EMS	Request status of flexible loads	EAMS	EMS	Status of flexible loads
9	After 7 and 8	EMS	Assess the situation, select flexible customers and calculate setpoints for flexible loads	EMS	EMS	-
10	After 9	EMS	Sends flexible request to participate to energy community members	EMS	M	Flexibility request
11	After 10	M	Acceptance	M	EMS	Acceptance to participate
12	After11	EMS	Dispatch setpoints of flexible loads	EMS	EAMS (automatic) or M (manual)	Schedules of flexible loads
13	After 12	EAMS (automatic) or M (manual)	Execute scheduled setpoints	EAMS or M	EAMS or M	-
14	After 13	EAMS or M	Informs results of dispatch	EAMS or M	EMS	Validation of dispatched schedules
13	After 12	EMS	Request energy (generation and demand) data	ECMP	EMS	Energy data
14	After 13	EMS	Accounts and computes KPIs	EMS	EMS	KPIs
15	After 14	EMS	Informs about accounting and performance	EMS	ECM, M	KPIs

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Sequence / activity diagrams

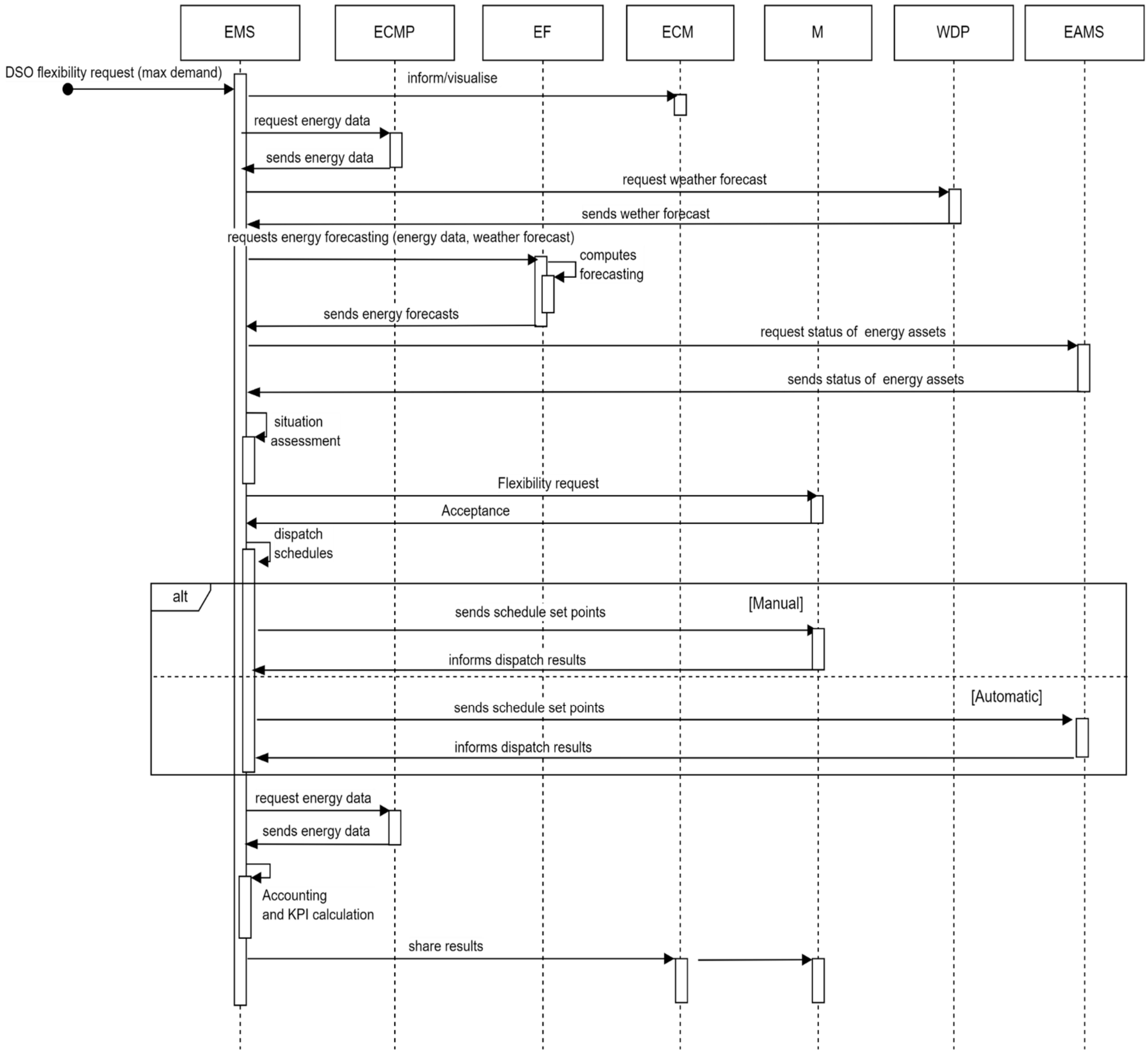

Figure 22 HLUC4: Sequence Diagram

4.6.4 Information exchanged

Table 47 HLUC4: Information exchanged

Name	Description
Energy data	Generation and consumption data.
Weather forecast	Weather forecasting at the same granularity as energy data for specific horizons (e.g.: 24h / day ahead).
Energy forecast	Estimation of generation and demand for specific horizon (e.g.: 24h / day ahead).
Status of flexible loads	Status of flexible loads (i.e., on /off, state of charge of batteries).
Schedules of flexible loads	Schedules of flexible loads that can contribute accomplish the demand set point specified by the DSO at the transformer level.

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Validation of dispatched schedules	Report on real operation of flexible loads with respect to scheduled operation (e.g.: on/off time, charged/discharged energy, etc.).
KPIs	Performance indicators relative to the impact of flexibility activation.
Operational threshold at the PCC	Signal with maximum demand (e.g.: current, power) assigned to a specific point of the grid or the point of common coupling (PCC) with the community.
Flexibility request	Message requesting the participation in a specific flexibility programme / activity. Could include information of required participation.
Acceptance to participate	Acknowledgement (or not) to participate in specific flexibility (demand responses) campaigns.

4.7 HLUC5 - Operation of energy hubs consisting of interacting housing associations

4.7.1 Description

Table 48 HLUC5: General Information

Use Case Id	HLUC5
Title	Operation of energy hubs consisting of interacting housing associations
Authors	ELEC
Version	V3.0
Date	28/9/23

Table 49 HLUC5: Scope, Objectives and Boundaries of Use case

Scope	Control over several energy resources within an energy community consisting of several building associations where multi vector resources are operated.
Business roles and Objectives	The objectives are to: • Ob1) Perform optimal management of energy resources in the community based on several parameters.
Relation to other Use Cases	• BUC1: Energy management • BUC2: Community as flexibility provider Can impact: • HLUC1: Energy balance and accounting for communities • HLUC0: Energy monitoring • HLUC2: Storage management for optimal consumption of locally generated RES. • HLUC3: Automated participation of energy communities in energy markets • HLUC 9: Interactive communication and collaborative participation oriented to foster joint initiatives and investments.
Pilots	SE

Table 50 HLUC5: Narrative of Use Case

Short description	HLUC5 describes the control and management of various energy resources in order to optimize energy flows in an energy community, or energy hub, consisting of several housing associations and shared resources. The optimization process

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	operates at two levels: firstly, within individual buildings owned by housing associations and, secondly, the optimization extends to the energy community level.
Complete Description	The aim is to control and steer several energy resources, not limiting to electrical assets but including other energy vectors (e.g.: geothermal heating, storage) and interaction with other sectors (e.g.: mobility by acting on EV chargers). Algorithms managed by a software system will be used to optimize energy flows on two operation levels. The first level is within individual buildings which are apartment buildings owned by the housing associations. The second level is at community level, considering the aggregated behaviour of these buildings together with other common energy assets (e.g.: large storage systems, EV charging stations or district heating systems). Every building association is equipped with its own building energy management system (BEMS) with capabilities to acquire energy data and actuate on energy assets and operated by a facility manager (FM). The FM supported by the BEMS will manage the operation of the energy assets at each housing association that can be equipped with heterogeneous energy assets including geothermal heating, heat pumps, ventilation, air conditioning, PVs, EVs and storage solutions. Different housing associations also have different needs and conditions (e.g.: based on energy consumption patterns), meaning that different approaches and parameter adjustment are required to operate each building. The second level of management is the optimization of operation of these buildings together with shared resources, as for example large batteries, PV parks and generators or district heating systems, or any others which operation can interact with the energy flows of these buildings. The objective is to optimise the operational costs at the community level. An energy community monitoring platform (ECMP) will concentrate energy data from different building associations, through the respective BEMS, and other energy assets, through the respective AEMS. Next steps, coordinated by an energy management system (EMS) will implement the optimisation strategy for a given time horizon. Under request, or periodically (e.g.: daily), the EMS will request energy data (generation and demand) that will be used to compute forecasts of demand and generation in a specific time horizon (e.g.: day ahead). The EMS also updates the status of flexible assets (directly from AEMSs/BEMs) and prices of different energy vectors and flexibility programmes. EMS will manage the computation of optimal schedules of flexible assets by invoking a specific energy optimisations service (EOS) that will consider energy prices and availability of flexible resources within the community. Schedules will be validated by the LSO and sent to the respective BEMS and AEMS for dispatching under the supervision of facility managers (FM) who will provide feedback on activation through the BEMS/AEMS. Once dispatched, the EMS will account and compute KPIs that will be shared with the ECM and community members.

Associated KPIs in Annex 1

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Table 51 HLUC5: Use Case Conditions

Assumptions
• Every housing association in the community is equipped with a building energy management system (BEMS) with capabilities to gather energy data and operate energy assets, especially those that can be involved in flexibility programmes. These BEMS are managed by a facility manager who operates and manages the building. • Energy data (generation and demand) will be integrated from different building associations and shared resources will be integrated in a single energy community monitoring platform (ECMP). However, access to the status of specific flexible assets will be managed directly through the respective AEMS. Integrated data, at community level, will be accessible to the local system operator (LCS) who acts as energy community manager (ECM) and at the same time can aggregate this demand and provide access to the markets.
Preconditions
• Optimisation goals, or their prioritisation, at community level (e.g.: maximize self-consumption, generate economic savings, participate in flexibility markets and/or support grid congestion avoidance) will be decided by the members of the energy community. • An energy community monitoring platform (ECMP), with access to all energy data (from BEMS and other shared energy through specific devices), up and running.

4.7.2 Actors and Use Case diagram

Table 52 HLUC5: Actor list

Actor name	Actor type	Description
Energy Community Manager (ECM)	Business	Person with technical knowledge that have access to the information on consumption, generation, and storage of energy community members. The ECM in charge of coordinating multiple building associations and shared flexible assets according to community goals
Local System Operator (LSO) / Aggregator	Business	This is the entity in charge of operating the local energy market in some countries and adopts the role of aggregators leveraging he participation of consumers in other energy markets.
Facility Manager (FM)	Business	A kind of ECM, in charge of operation and management of a building.
Energy Community Member (M)	Person	Community member, including building associations, whose energy data are collected and analysed and intend to change their behaviour or consent to controlling their flexible loads.
Energy Management System (EMS)	System (software)	A system that facilitates the execution of specific energy services according to energy goals.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members (including access to BEMS from building associations and other AEMS), store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Energy Asset Management System (EAMS)	Device	System that manages a specific energy asset (i.e., PV, heat pumps, batteries) and is in charge of assuring the correct and safe behaviour of

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		it. It exchanges operational information (energy data and orders) of the energy assets as batteries or flexible loads through standard interfaces.
Energy Optimizations System (EOS)	System (software)	A system that provides advanced energy management services to the energy community.
Energy Forecasting (EF)	System (software)	A system that provides energy production and consumption forecasting for a specified time horizon.
Weather Data Provider (WDP)	System (software)	A third-party or agency that provides weather data and weather forecasts. Usually accessible through a web service (WS / SaaS).

Use case diagram

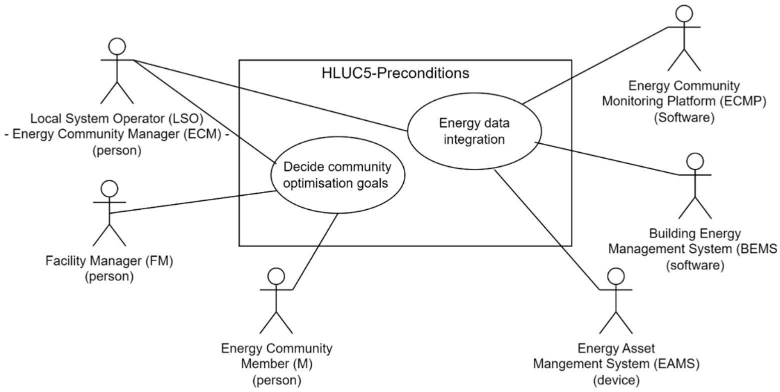

Figure 23 HLUC5: Precondition

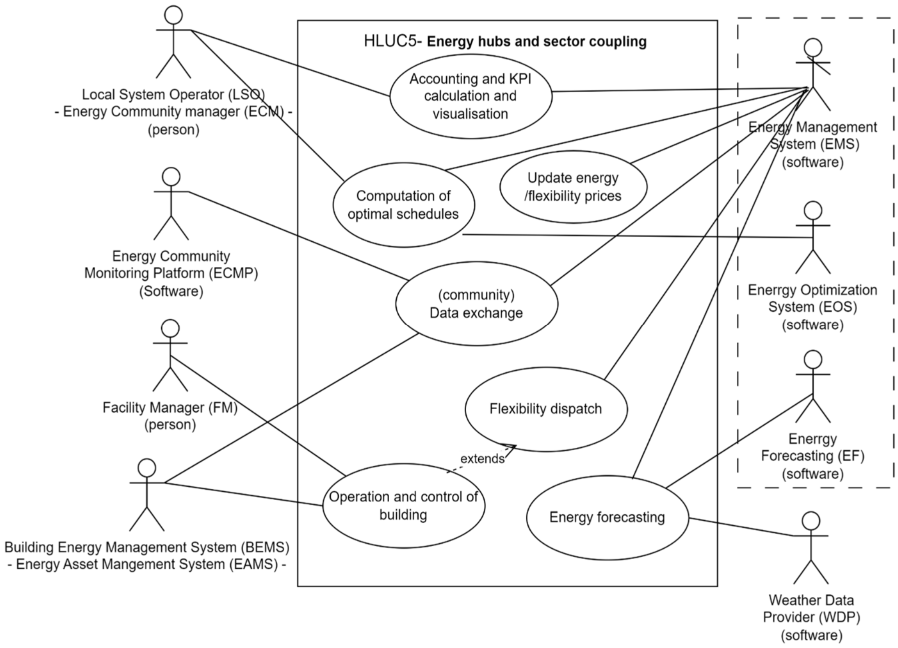

Figure 24 HLUC5: Energy hub and sector coupling

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4.7.3 Step-by-step analysis

Table 53 HLUC5: Scenarios

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Optimization of multi-vector energy resources	Real-time optimization	EMS	On request	Systems integrated	Activation of flexible resources

Table 54 HLUC5: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Optimization of multi-vector energy resources						
1	On demand or periodically (daily)	EMS	Request energy (generation and demand) data	ECMP	EMS	Energy data
2	After 1	EMS	Request weather forecast	WDP	EMS	Weather forecast
3	After 1 and 2	EMS	Request energy forecast	EMS	EF	Energy data Weather forecast
4	After 3	EF	Computes energy forecast	EF	EF	Energy forecast
5	After 4	EF	Sends energy forecast	EF	EMS	Energy forecast
6	After 5	EMS	Request status of flexible assets	EMS	EAMS and BEMS	Status of flexible assets
7	After 6	EAMS and BEMS	Send status of flexible assets	EAMS and BEMS	EMS	Status of flexible assets
8	After 3	EMS	Update energy and flexibility prices (tariffs)	Third party	EMS	Energy prices
9	After 7 and 8	EMS	Requests optimal schedules	EMS	EOS	Energy forecast Status of flexible assets Energy prices
10	After 9	EOS	Computes schedules	EOS	EOS	Schedules of flexible assets
11	After 10	EOS	Sends schedules	EOS	EMS	Schedules of flexible assets
12	After 11	EOS	Validates schedules	ECM (LSO)	EOS	Schedules of flexible assets
13	After12	EMS	Dispatch set points of flexible loads	EMS	BEMS & EAMS	Schedules of flexible assets

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14	After 13	BEMS & EAMS	Informs results of dispatch	FM (BEMS & EAMS)	EMS	Validation of dispatched schedules
13	After 14	EMS	Request energy (generation and demand) data	ECMP	EMS	Energy data
14	After 13	EMS	Accounts and computes KPIs	EMS	EMS	KPIs
15	After 14	EMS	Informs about accounting and performance	EMS	ECM (LSO) & M	KPIs

Sequence / Activity diagrams

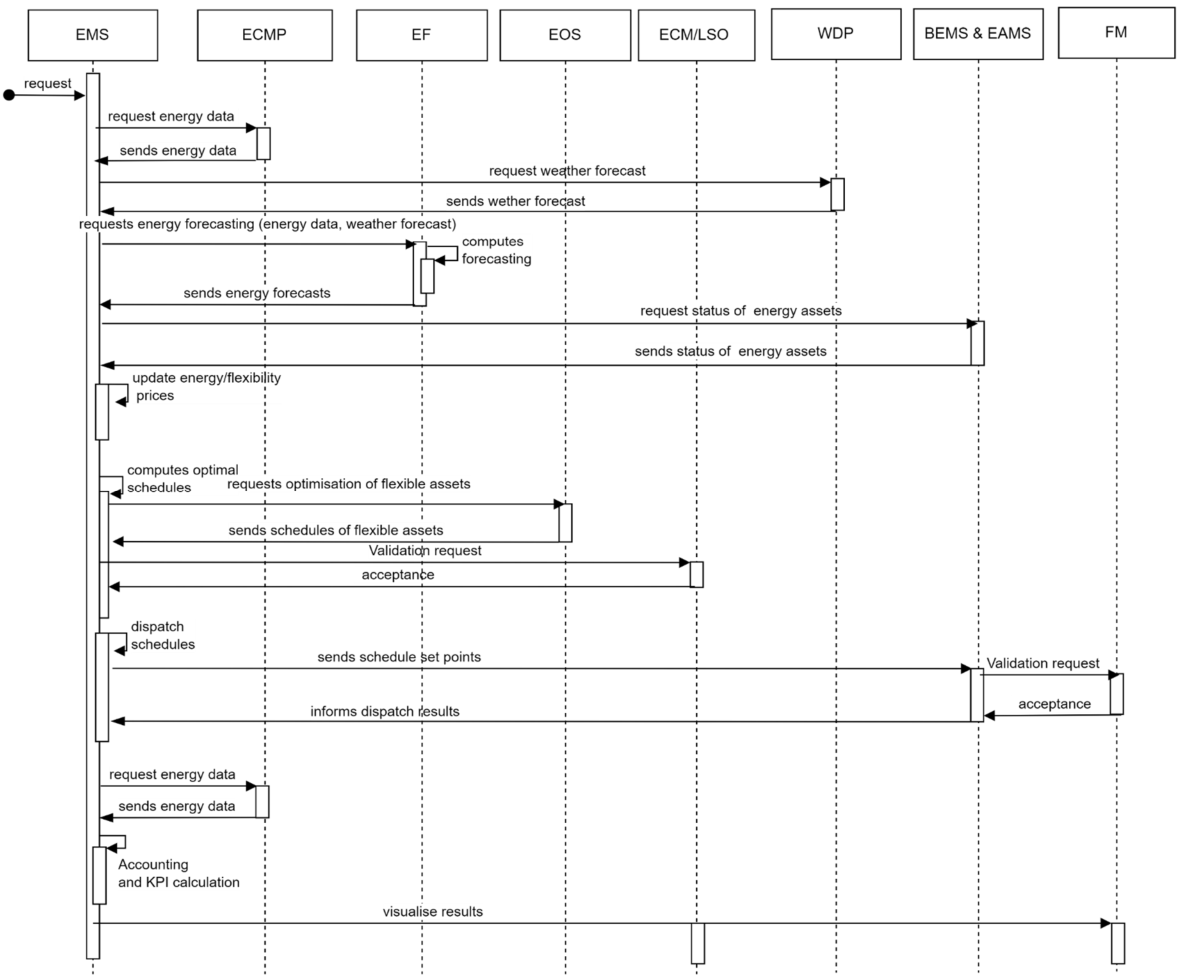

Figure 25 HLUC5: Sequence Diagram

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4.7.4 Information exchanged

Table 55 HLUC5: Information exchanged

Name	Description
Energy data	Generation and consumption data.
Weather forecast	Weather forecasting at the same granularity as energy data for specific horizon (e.g.: 24h / day ahead)
Energy forecast	Estimation of generation and demand for specific horizon (e.g.: 24h / day ahead)
Status of flexible loads	Status of flexible loads (i.e.: on /off state of charge of batteries)
Schedules of flexible loads	Schedules of flexible loads that can contribute to accomplish the energy community goals (e.g.: low energy and operation costs).
Validation of dispatched schedules	Report on real operation of flexible loads with respect to scheduled operation (e.g.: on/off time, charged/discharged energy, etc.)
KPIs	Performance indicators relative to the impact of flexibility activation.
Energy prices	Prices (real or estimated) of all energy vectors in the optimisation time horizon. It includes possible revenues due to participation flexibility programmes and different energy markets.

4.8 Technical Primary Use Cases

The Table 56 summarises actions required to implement technical use cases (HLUC00-HLUC05) conceived as primary use cases (PUCs).

Table 56 Technical PUCs

PUC	Description
Data acquisition	Access to energy variables and parameters associated either to energy assets (e.g.: PV generator, battery, load, appliances etc.) or to systems (e.g.: metering system of households, building/factory energy management system, PV inverter, etc.).
Data storage and management	Storage of variables and parameters retrieved from energy assets or systems.
Data exchange	Exchange of stored variables and parameters with a third-party software.
KPI and operation monitoring	Calculation of KPIs to monitor the operation of an energy community or an energy community member.
UI and Visualization	User interface to monitor and visualize the operation of an energy community or an energy community member.
Flexibility request and suggestion	Request of suggestions on how to modify customer behaviour to maximize self-consumption or provide a service to the DSO
Energy forecasting	Calculation of energy production and consumption for a specified time horizon.
Calculation of optimal schedules for self-sufficiency	Optimal schedules of flexible assets in order to maximise the local generation in the energy community.
Behavioural change request and interaction	Request an energy community member to reduce / increase his consumption in order to optimise the operation of the energy community.
Accounting and KPI calculation and visualisation	Assessment of an implemented action (e.g.: response of a user to a requested behaviour change or automatic management of a flexible asset) according to a defined goal.

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Status of batteries and flexible loads	Provides the status of a battery (state of charge) or a flexible load (e.g.: setting point of a cooling system).
Computation of optimal schedules (Scheduling)	Optimal scheduling of the flexible assets in an energy community (e.g.: battery charge/discharge power) to reach a defined goal.
Flexibility dispatch	Send a signal (parameter) to the system that manages a flexible asset in order to execute a flexibility request.
Flexibility audit	Study and assessment of the flexibility assets that exist in an energy community and how they can participate in flexibility markets.
Elaborate flexibility offers	Offer of capacity and direct flexibility in the electricity markets.
Flexibility trade	Interaction between an aggregator/market agent (flexibility offer) and a market/TSO/DSO (flexibility request).
Energy management	Provides actions to monitor and control the operation of a system to maximize the use of renewable energy resources, reduce costs and increase efficiency.
Flexibility forecasting	Estimation of available flexibility for a given time horizon.
Power threshold at the PCC	Definition of the maximum power in the low voltage side of a secondary substation.
Situation assessment	Assessment of the operational conditions of the electric power grid (secondary substations).
Energy data integration	Integration of data corresponding to different energy vectors (electricity, geothermal…).
Decide community optimisation goals	Definition of the goal that the community wants to achieve.
Operation and control of the building	Management of assets in a building by means of a BEMS/AEMS.

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5 Socio-economic and engagement Use Cases

5.1 Actors

Table 57 Socio economic Use Cases. List of actors

Actor name	Actor type	Role
Energy Community Manager (ECM)	Business	Responsible for accessing and managing energy data from/to the prosumers and energy assets. Energy and flexibility management functionalities.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed, and whose energy habits can be modified according to the suggestions received or consent to controlling their flexible loads.
Energy Community Monitoring platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Collaborative Services Platform (CSP)	System (software)	A system that is able to facilitate interactions within energy communities surrounding recommendations on proposed measures.
Building Energy Simulator (BES)	System (software)	A third party that generates simulations (digital twins) for each building and recommends measures.
Social Engagement Actor (SEA)	Person	Social drivers to enhance engagement and participation of community members.
Gaming Provider (GP)	Person	Specific social engagement actor, responsible for providing awareness/engagement games to community members.
Innovation and Participation Manager (IPM)	Person (academic)	Person with socio-technical knowledge about intergenerational transfers for energy demand reduction and for participation in energy communities. Academic profile.
Schoolchildren (younger generation) (S)	Person (children)	Students aged 10-12 (primary stage, basic or elementary schools) and / or aged 12-13 (first year of secondary stage, high schools).
Families (older generation) (F)	Person (families)	Parents and other relatives (e.g.: grandparents) of the schoolchildren.
School Manager (SM)	Person (education)	Person with knowledge about the education system that provides access to pupils within schools as well as their families/parents. Educational profile.
Family School Association Manager (FSAM)	Person (families)	Person outside schools with knowledge about the activities taking place at schools who is also involved in a variety of (extra) school activities.
Teaching Staff (TS)	Person	Teachers or trainers in charge of implementing the educational activities and using materials at school with the schoolchildren.
Local Council Manager (LCM)	Person	Person with knowledge about the conditions for intergenerational engagement for community building at local scale. Administration profile.
Player (P)	Person	The individuals around and outside the energy communities.

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Public Body (PB)	Entity	Any public administration (municipality, local or regional government) or agency in charge of developing policies and master plans to manage energy transition in a specific area (e.g.: local, regional, national).
Policy Maker (PM)	Entity	Public body in charge of making policies and taking policy decisions.
Municipality	Entity	Local authority with responsibilities in sustainability development and management of a local area (municipality, city, village) where the energy community is located and operates.
Building Association (BA)	Business	Board members of Homeowners or Building association that have access to the information of their building and have the understand and make decisions for their buildings
Distributor System Operator (DSO)	Business	Responsible for the distribution and management of energy to the final consumers. It manages the grid infrastructure, ensuring quality and safety of supply. Participates in local flexibility markets by demanding flexibility to support grid management (e.g.: congestion avoidance).
Serious Game Application (SGA)	System (software)	Application that implements the serious game logic and interacts with the energy data of the community, computes performance and rewards.
SGA Optimiser	System (software)	A sub-component of the SGA responsible for processing energy data, benchmarking members' performances, and suggesting missions
Project Developer (PD)	Business	Responsible for checking that the energy community project follows the existing regulatory framework.

5.2 HLUC6 - Public-Private collaboration: Local energy communities (LEC)

5.2.1 Description of HLUC6

Table 58 HLUC6: General Information

Use Case Id	HLUC6
Title	Public-Private collaboration: Local Energy Communities (LEC)
Authors	DdG
Version	3
Date	21.06.2023

Table 59 HLUC6: Scope, Objectives and Boundaries of Use case

Scope	Nowadays local governments, enterprises and citizens have difficulties to get all the information on how the local energy community operates and there are barriers that limit their engagement and/or empowerment in such a community. Public-private collaboration framework defined by a master plan, dotted with specific funds, aiming to incentive municipalities to impulse the creation of energy communities, reduce technical difficulties to get energy data and reduce the gap of an underdeveloped regulation.

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	This use case aims to foster the creation and scaling up of energy communities by funding an initial installation of PV for collective use in public buildings (or identifying public roofs) that can be used by local energy communities (associations or cooperatives) to install PV panels for a shared-self consumption use. The scenario is being defined according to current Spanish regulation.
Business roles and Objectives	Foster the creation of energy communities around public buildings. • Ob 1) To break technical barriers that exist in the management of energy communities. • Ob 2) To overcome legal barriers that exist in the creation and management of energy communities. • Ob 3) To break financial barriers that exist in the creation and enlargement of energy communities.
Relation to other Use Cases	HLUC0, HLUC1, HLUC2, HLUC3, HLUC7, HLUC8, HLUC9, HLUC10, HLUC11
Pilots	ES

Table 60 HLUC6: Narrative of Use Case

Short description	Definition of master plan for the creation and management of local energy communities promoted by municipalities. Local energy communities will be constituted around a PV plant installed in public equipment and sharing production among neighbours. Municipalities, as owners of the public facility where PV are placed, lead the project, and defines the mechanisms to select an energy community manager. Both collaborate to provide legal coverage to the local energy community and their members, facilitate the access to generation and demand data and appropriate mechanisms to manage the community, facilitate energy accounting at community and individual level and promote new energy and flexibility services.
Complete Description	The use case aims to overcome some barriers derived from an insufficient regulation to promote the creation and growth of energy communities (EU Directive, 2019/ 944 and EU Directive 2018 / 2001) by proposing a public-private collaboration in the local ambit. Since the proposal is not limited to large municipalities but mainly aims to incentive small ones and rural areas, it requires the participation of a public body (PB) or supra-municipal administration with financial capacity (e.g.: energy agencies, regional government, province administration, etc.) to set and fund a master plan. The resulting energy communities are participated and somehow led by municipalities, who benefit and manage the investments. They are labelled as "Local Energy Communities (LEC)" to highlight this dependency with local government. The public body (PB) defines a master plan and allocates a budget to fund the installation of collective self-consumption plants in a municipal facility that will serve as seed for the creation of the energy communities. Local authorities (Municipalities) will get access to funds to set a collective RES installation (PV) under a competitive schema by applying to public calls launched by the PB. Proposals of municipalities should include a local strategic plan to create energy communities based on collective RES. The strategic plan will identify different implementation stages and detailed information for the collective RES project to be funded by the grant. This should cover the identification different public buildings to install PV production, number of households that can be engaged in each installation, energy poverty

	framework of each municipality, e-mobility characteristics (e-charging stations, e-cars, etc.), batteries that can be installed, electricity demand and coverage of generation installation, an analysis of the best legal option to engage the citizens interested in being members of the energy community. The municipality will be responsible for develop the initial project to create the LEC. First step involves coordinating the installation of PV panels in specific municipal buildings and specific energy assets (e.g.: batteries, e-charging station) proposed in the funded project. Once deployed the technical project, the energy generated in this plant will be shared with the public buildings and the neighbours or SMEs, which will become members (M) of the Local Energy Community under contractual conditions. Public authority will propose the designation of an Energy Community Manager (ECM) who supports creation and management of the LEC. Creation of the LEC will imply the acceptance of conditions by all the members (M) and the corresponding ratio of generated energy will be specified for all the participants (e.g.: 0.5 – 1.5 kW/member). The ECM, in representation of the community members, will inform the DSO about the technical characteristics of the PV plant and ratios of generation assigned to the participants for approval. These ratios will be also informed to the retailer for individual accounting of energy balance and billing. Moreover, the Energy Community Members will have access to the energy information through the Energy Community Monitoring Platform either accessing the smart meter data through the DSO or using other metering infrastructure proposed in the project. The ECM together with the public authority will coordinate the procurement of required instruments and software to guarantee the access to the energy data and indicators at community and individual level through a common Energy Community Monitoring Platform (ECMP). Additionally, to the implementation of the technical project, the role of local authorities is: • Encourage the neighbours to create a stable structure (energy association or cooperative), define the management structure and the role of the energy community manager. • Provide technical, financial, and legal assistance to promote energy communities. • Bundle different initiatives and manage the data and the energy production from a supra-municipal level. • User of the platform as other energy community members. • Create specific tools to engage energy poverty collective. An Energy Community Manager (ECM) will be designed to manage the community and to act as representative of the community to interact with third parties. Some responsibilities of the ECM include: • Provide specific IT tools to empower citizens • Communication between the DSO and the retailer, it must be authorized by the citizens, municipalities and SMEs.

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	• Identify behaviour changes to optimize the energy consumption • Identify new potential members of the community • Identifying new elements and strategies that can provide revenues and empower the community (e-mobility, batteries, street lighting, etc.). The energy community manager and local authorities must encourage the neighbours to create a stable structure (energy association or cooperative) to increase the number of participants of the community, and to identify private roofs to install the solar PV and private investors, in order to overcome the limited capacity of public roofs of the municipality and the grants available to finance the investments.

Associated KPIs in Annex 1.

Table 61 HLUC6: Use Case Conditions

Assumptions
• Access to all the metering (smart meters, PV generation, meters, etc.) and to the Energy Management System outputs (loads, BEMS, batteries activation scheduling) will be available to all the members through the ECMP. • ECMP will serve to share and integrate energy data with third parties when needed.
Preconditions
• Corresponding ratio of generated energy must be approved by the DSO and the retailer • Willingness Install meters to the houses.

5.2.2 Actors and Use Case diagram

Table 62 HLUC6: Actor list

Actor name	Actor type	Description
Public body (PB)	Local Authority	Administration or public agency with competences to define and manage a master plan and allocate specific budget to its implementation.
Municipality	Local Authority	Local authority with responsibilities in sustainability development and management of a local area (municipality, city, village) where the energy community is located and operates.
Energy Community Manager (ECM)	Business	Responsible for accessing and managing energy data from/to the prosumers and energy assets. Energy and flexibility management functionalities.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed, and whose energy habits can be modified according to the suggestions received or consent to controlling their flexible loads.
Energy Community Monitoring platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.

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Distribution System Operator (DSO)	Business	Responsible for the distribution and management of energy to the final consumers. It manages the grid infrastructure, ensuring quality and safety of supply. Participates in local flexibility markets by demanding flexibility to support grid management (e.g.: congestion avoidance).

Use case diagram

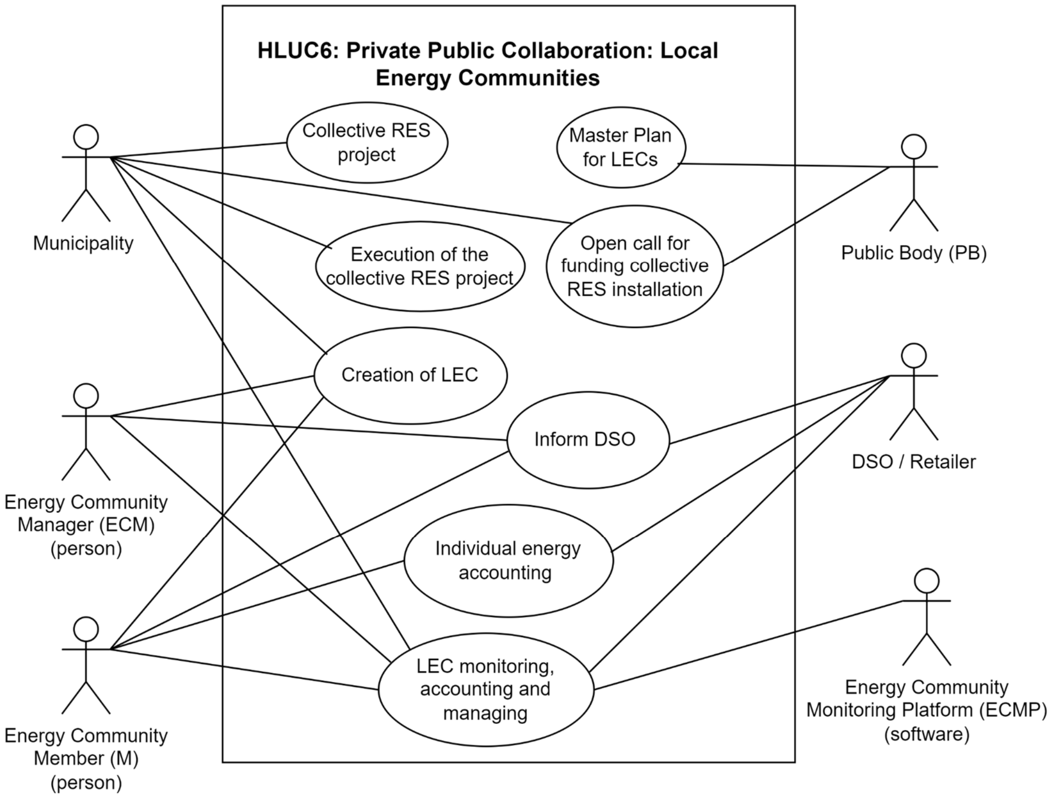

Figure 26 HLUC6: Use case diagram. Public-Private collaboration: Local energy communities (LEC)

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Activity diagram

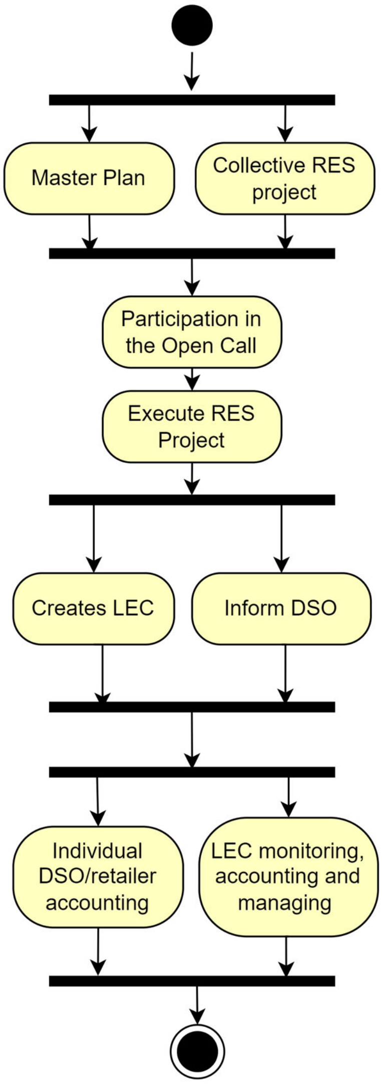

Figure 27 HLUC6: Activity Diagram

5.3 HLUC7 - Intergenerational engagement for community building at local scale

5.3.1 Description of HLUC7

Table 63 HLUC7: General Information

Use Case Id	HLUC7
Title	Intergenerational engagement for community building at local scale
Authors	UdG
Version	V2.0
Date	12.09.2023

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Table 64 HLUC7: Scope, Objectives and Boundaries of Use case

Scope and boundaries	Describe the process of intergenerational engagement as a driver shaping energy communities by putting schools and training strategies to embrace the overall society and influence older citizens' behaviour and attitude.
Business roles and Objectives	Dynamization of local energy communities through awareness and participation in the Energy Community: • Ob1) To provide engagement and training resources for schoolchildren. • Ob2) To implement engagement and participatory methods with school children and the older generation. • Ob3) To increase engagement of the older generation through intergenerational transfers.
Relation to other Use Cases	• BUC4 - Social awareness and participation in the value proposition of communities. Foster the social awareness of energy communities as a social and economic driver and exploit it as a true value proposal. Can impact: • HLUC8 - Citizen engagement for community building at a broad scale through gamification and rewarding. • HLUC9 - Interactive communication and collaborative participation oriented to foster joint initiatives and investments.
Pilots	SE, ES, NE, GR

Table 65 HLUC7: Narrative of Use Case

Short description	The use case describes how behavioural change through intergenerational exchanges between older and younger adults can be powerful mechanisms in influencing individuals' energy behaviour and participation in energy communities. Thus, the goal is to leverage social contagion effects and intergenerational learning processes between older generations and younger adults through schools to influence individuals' energy behaviour and participation in energy communities, where older adults are expected to be more energy-intensive than younger adults and both less likely to adopt energy-efficient technologies as well as skipping the importance of energy savings for environmental reasons.
Complete Description	The intergenerational engagement for community building at local scale will consider behavioural change processes through intergenerational exchanges between older and younger generations, using schools as spaces that embrace the overall society and influence older citizens behaviour and attitude. With this aim, five steps are proposed to be implemented sequentially: <u>Step 1: Initial diagnosis.</u> This initial design phase is critical to ensure that the intervention meets the needs of the target population in the pilot energy communities and will serve to better design and plan the intervention. The initial diagnosis will be carried out by the Innovation and participation manager (IPM) and supported by local authorities (municipality), through the designation of a Local Council Manager (LCM) and an Energy Community Manager (ECM) in the area under study.

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	Demographic and quantitative data to analyse the context and create the baseline is being collected in this phase. The specific information collected in this first step will be: • Demographic data at the municipal and/or regional level for the municipalities participating in the program through the schools. • Quantitative data from the baseline survey, which will serve as the reference starting point for evaluating and measuring intergenerational effects and learnings. <u>Step 2: Designing the intervention.</u> The next step in the process is to design the educational intervention in collaboration with the various stakeholders and agents involved in the use case. This collaborative process – led by an Innovation and Participation Manager (IPM) - will involve the schools through a key agent (School Manager or ScM), as well as other relevant actors (mostly teaching staff). The step includes the adaptation of the educational resources, and the scheduling of all activities for the subsequent phases in collaboration with the chosen schools. The co-production and adaptation of the educational materials will be carried out through active collaboration with schools (ScM) and feedback of other stakeholders when required. The IPM will adapt the RESCHOOL materials to the particularities (age, context, community, etc.) of school children (target group) in coordination with the ScM. The latter will be in charge of scheduling a set of interactive sessions with schoolchildren, including specific materials for them to be used with their parents or older adults at home (i.e.: older generation). <u>Step 3: Training sessions with Teaching Staff</u> The third step of the program will involve the consecution of training sessions with the teaching staff of the participating schools, which will be conducted by the IPM or the delegated project member for each of the pilots. The aim of these sessions is threefold: 1) to present the educational proposal and resources to the staff; 2) to detail the tools and methods for collecting data from the families of the participating children; and 3) to share the guiding principles with all participating schools to ensure a shared approach to adapting the educational resources and activities to each school's unique context. By doing so, we can ensure that the educational programs implemented, and data collected are as comparable as possible. <u>Step 4: Educational Intervention</u> The fourth step will be based on developing both training and social contagion effects for energy communities for school children. Our main assumption is that younger generations from schools can be particularly motivated to engage with sustainable energy practices when learning about the topic at school and by being given energy responsibilities and they will also be able to transfer valuable information about participation in energy communities to the older generation. The implementation of the educational proposal will be carried out directly by the teaching staff of instructors of the participating schools. In this phase, the IPM will play a role of support and monitoring in the training implementation with children. Additionally, the IPM will ensure consistency in the pedagogical methods employed across the schools and pilots.

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	<u>Step 5: Engagement and participatory methods of schoolchildren with the older generation</u> The Innovation and Participation Manager (IPM) will gather qualitative and quantitative information from families (i.e., parents/tutors from schoolchildren) to assess whether and how engagement in specific actions has changed their knowledge and understanding of sustainability generally and of energy communities in particular. During this step, a post-intervention survey will also be conducted to collect comparable information as the baseline survey. The survey will be designed to validate whether and, to what extent, intergenerational transfers regarding energy communities can leverage them directly and indirectly over time. The survey will mostly collect information on attitudes and behaviour of the older generation as well as sociodemographic and community data that will be used to explain compositional and contextual differences. To gather qualitative data, we propose conducting personal interviews with parents / tutors who have expressed their willingness to participate through the post-intervention survey. These interviews may take place in the household context and involve not only parents or adult family members, but also children. Our main assumption is that all the information given to schoolchildren in the previous step about general and specific issues regarding energy communities can be provided convincingly and, more importantly, we can gain deep, more meaningful insights into how the older generation receives the message from the younger generation, and what factors motivate their positive and negative reactions. The Innovation and Participation Manager (IPM) will collect qualitative information (thematic analysis) from the older generations to assess the children's capabilities to transfer information (younger generation) and awareness of key issues regarding the importance of sustainability, energy saving(s) and energy communities (older generation). The IPM will also inform the Family School Association and the School manager about the methods and the materials for general and specific input. Through the collected data we will then examine whether and how the view of the older generation about sustainability, saving energy and energy communities is more or less positive after giving them access to relevant information through intergenerational learning and transfers from the younger generation. Such approach will allow the investigation and practice of whether the younger generation can affect the older generation by means of "spillover" or "contagion" effects on key issues such as sustainability, saving energy and energy communities. Validation of this approach will be carried out through a triangulation of the qualitative information and the use of the survey. The IPM will be responsible for the collection of survey data from the older generation. The information collected in this fourth step will be: • Qualitative data to analyse the transfer of information and the social mechanisms involved in the intergenerational transmission process. Additionally, the qualitative data will be collected to explore the contextual elements required to ensure successful social contagion. • Quantitative data from the post-intervention survey that will be used to measure intergenerational effects and learnings after the educational intervention.

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	Step 6: Engagement of older adults through intergenerational transfers over time The final step of this process will be to examine the stability and lasting impact of the learnings potentially detected in the fourth step over an extended period. This step involves conducting a second post-intervention survey specifically designed to measure and collect data on the permanence of intergenerational effects after three months following the educational intervention. The second post-intervention survey will be a simplified version of the first one and will be administered to the older generation. Its objective will be to measure the retention and longevity of the intergenerational effects over time. The information collected in this final step will be quantitative data from the second post-intervention survey. Impact assessment and dissemination The results of the examination of intergenerational transfers are expected to provide significant knowledge and insights towards societal readiness to aid further research and innovation on energy communities for greater and better responsiveness. The IPM will inform the schoolchildren, the Family School Association, local public bodies (e.g.: Local Council Manager, Municipality) and Energy Community Managers about the main results after completion and analysis of the older generation survey as part of the overall participatory strategy.

Associated KPIs in Annex 1.

Table 66 HLUC7: Use Case Conditions

Assumptions
• A selection of participant schools has been performed according to their potential towards energy communities (e.g.: because of geographical location, existence of shared resources or other special interests) • The underlying hypothesis is that children are specifically motivated to save energy when giving them energy responsibilities to transfer, and at the same time older adults view saving energy more positively when framed as part of an intergenerational transfer with children. • Schools with access to energy communities are necessary to provide metrics and KPIs to assess the transfer of resources across generations and under different scenarios or contextual factors.
Preconditions
• Availability of schools with pupils, at least, aged 10-12 (primary stage, basic or elementary schools) and/or aged 12-13 (first year of secondary stage, high schools) with potential access to energy communities.

5.3.2 Actors and Use Case diagram

Table 67 HLUC7: Actor list

Actor name	Actor type	Description
Innovation and Participation Manager (IPM)	Person (Academic)	Person with socio-technical knowledge about intergenerational transfers for energy demand reduction and for participation in energy communities. Social engagement actor with an academic profile.

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Schoolchildren (younger generation) (S)	Person (Children)	Students aged 10-12 (primary stage, basic or elementary schools) and / or aged 12-13 (first year of secondary stage, high schools).
Families (older generation) (F)	Person (Families)	Parents and other relatives (e.g.: grandparents) of the schoolchildren.
School Manager (SM)	Person (Education)	Person with knowledge about the education system that provides access to pupils within schools as well as their families / parents. Educational profile.
Family School Association Manager (FSAM)	Person (Families)	Person outside schools with knowledge about the activities taking place at schools who is also involved in a variety of (extra) school activities
Teaching Staff (TS)	Person	Teachers or trainers in charge of implementing the educational activities and using materials at school with the schoolchildren.
Local Council Manager (LCM)	Person	Person with knowledge about the conditions for intergenerational engagement for community building at local scale. Administration profile.
Energy Community Manager (ECM)	Business	Responsible for accessing and managing energy data from/to the prosumers and energy assets. Energy and flexibility management functionalities.

Use case diagram

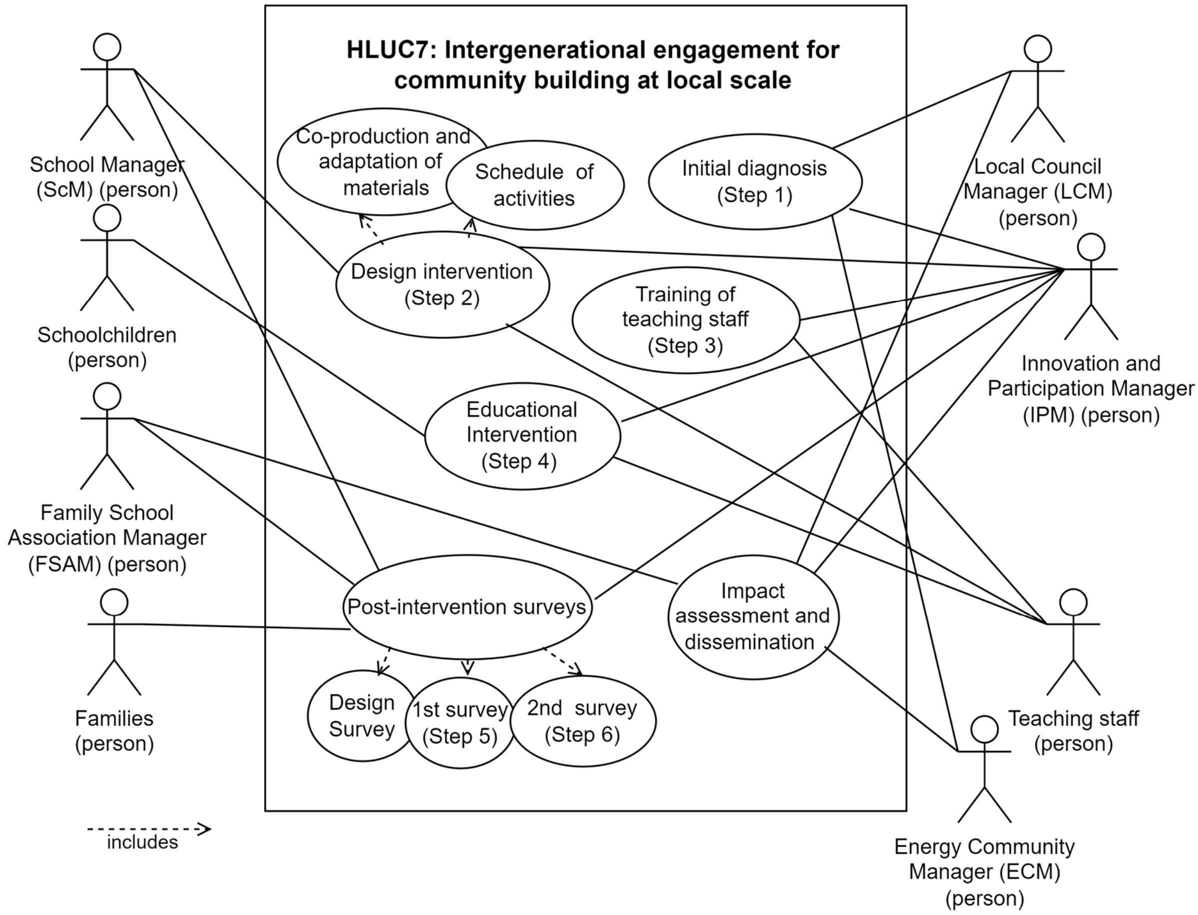

Figure 28 HLUC7: Intergenerational engagement for community building at local scale

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5.3.3 Step-by-step analysis

1. Design, coordination and preparation tasks (Step 1). This stage of the program includes various tasks involving all the collaborative design process for the intervention and research process, as well as all the coordination and preparation tasks. At these stages, all the relevant actors should be identified and contacted.
2. Teaching Staff training and baseline survey (Steps 2 and 3). During these parallel steps, two actions will be carried out. The first is a training session with the teaching staff, including all teachers and trainers who will be responsible for implementing the educational activities and using the materials at school with the students. In addition, a baseline survey will be administered to the participating families before any educational intervention takes place.
3. Intergenerational downward transfer (Step 4). This step involves providing schoolchildren with general and specific information about the main purpose of the project, in particular the role of energy communities at the local level. The primary actors are schoolchildren, the Innovation and Participation Manager (IPM) and School Manager (SM). The materials need to be tailored for pupils, at least, aged 10-12 (primary stage) and aged 12-13 (secondary stage).
4. Intergenerational upward transfer (Step 4). This step involves schoolchildren who have been in the process of downward transfers. This step assumes that intergenerational transmission situations and processes happen outside the controlled school environment. The context will be local within and outside energy communities. The primary actors are Families and Schoolchildren. This process requires pupils not only knowing about the role of energy communities at the local level, but also learning about the process of becoming persuasive agents to demonstrate the importance of energy communities.
5. The last steps entail data collection activities, involving both the schoolchildren and their families in the process of upward transfers (Steps 5 and 6). Through diverse data gathering activities, including qualitative interviews with families, and a post-intervention survey, qualitative and quantitative information will be collected to inform the final impact assessment. The primary actors in this step are the IPM, families, and schoolchildren.

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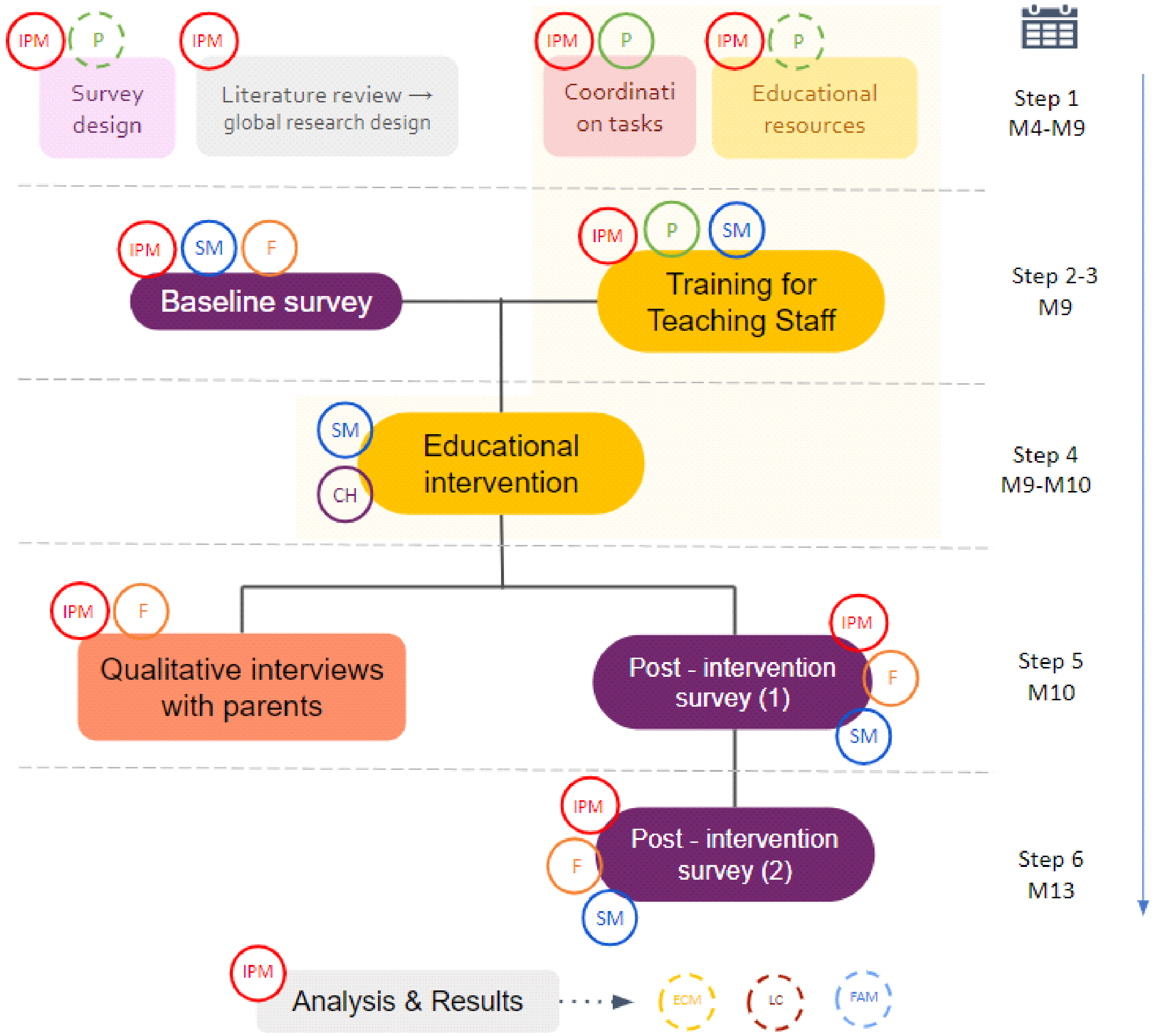

Legend[3]	Actor name	Actor type
IPM	Innovation and Participation Manager	Academic
P	Pilots	Project partners
CH	Schoolchildren (younger generation)	Students / Children
F	Families (older generation)	Families
SM	School Manager	Education
FAM	Family School Association Manager	Families
LC	Local Council Manager	Administration
ECM	Energy Community Manager	Business

Figure 29 HLUC7: Graphical summary of the process and actors

Activity Diagram

[3] The continuous or discontinuous lines of the symbols for each actor indicate the type of participation: direct (continuous line) or indirect (discontinuous line). Indirect participation refers to informative actions.

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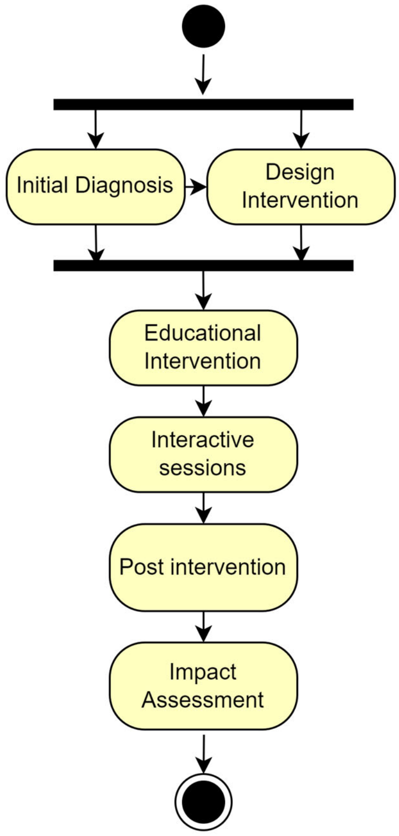

Figure 30 HLUC7: Activity Diagram

5.4 HLUC8 – Citizen engagement for community building at broad scale through gamification and rewarding.

5.4.1 Description of HLUC8

Table 68 HLUC8: General Information

Use Case Id	HLUC8
Title	Citizen engagement for community building at broad scale through gamification and rewarding
Authors	CERTH
Version	2.0
Date	26.5.2023

Table 69 HLUC8: Scope, Objectives and Boundaries of Use case

Scope and boundaries	Increase awareness and motivation among citizens towards their participation in energy communities through gamification, based on exemplars created by real data from running energy communities.
Business roles and Objectives	Obj1) To increase the individual awareness and responsiveness of energy use at household and community (in a broad sense) level through gamification strategies.

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	Obj2) To raise awareness and stimulate greater citizen engagement and interest in participating in energy communities.
Relation to other Use Cases	• BUC4: Social awareness and participation in the value proposition of communities. Foster the social awareness of energy communities as a social and economic driver and exploit it as a true value proposal. Can impact: • HLUC7: Intergenerational engagement for community building at local scale. • HLUC10: Benchmarking and gamification with the inclusion of rewards/ incentives.
Pilots	ES, GR, NL, SE

Table 70 HLUC8: Narrative of Use Case

Short description	This use case describes the development of serious game and gamification strategies that encourage citizen awareness and support community building towards the creation of energy communities.
Complete Description	Energy communities are instrumental in advancing sustainable energy practices and reducing carbon emissions. However, engaging citizens who are not already part of these communities remains a challenge. To bridge this gap, the implementation of serious games and gamification strategies offers a unique opportunity to educate and motivate a wider audience. The serious game and gamification strategies described in this use case aim to increase awareness and strengthen motivation among citizens to participate in energy communities. They will be primarily co-created, tested and evaluated with people 10 years old and older, living in the pilot areas but not belonging to the energy communities. The game or gamification strategies could be implemented in a number of different formats, e.g.: a manual for running gamified workshops or campaigns, gamified installations, an energy community kit, a board/card game, or a web-based digital game. The whole process is described in the following steps: <u>Step 1: Needs assessment:</u> In the first step, the public outreach priorities of the energy communities will be investigated by the corresponding Social Engagement Actor (SEA) which could be any of the following entities: Gaming Provider (GP), Public Administration (PA), Educational Entity (EE), Innovation and Participation managers (IPMs) or Experts. Then the most relevant gamification and serious game options, that each community can support and benefit from, will be chosen and implemented. <u>Step 2: Data collection</u> The SEA will request from the Energy / Flexibility Community Managers (ECM) the relevant energy and demographic data that will serve as input for the development of the gamification strategy. These could include production and consumption data, membership data, investment amounts and plans, and other. <u>Step 3: Co-creation of the gamification strategy</u> In this step, the SEA facilitates interviews and co-creation workshops involving the Energy Community Members (Ms), as well as other key stakeholders such as SEA representatives, Public Bodies, Policy Makers, and Municipalities. The objective is to customize the proposed gamification strategies to align with the specific needs and preferences of the energy community. These collaborative efforts extend beyond mere customization; they foster a sense of ownership and empowerment within the

	community. The inclusion of various stakeholders ensures that the strategies resonate with local policies, regulations, and broader sustainability goals. <u>Step 4: Implementation of the game/gamification strategy</u> The serious games/gamification strategies have the following intended learning outcomes: Intended Learning Outcomes: • Participants will demonstrate an understanding of the concept and purpose of energy communities, including their collective (environmental and economic) as well as individual benefits. • Participants will express increased motivation and interest in actively participating in energy communities and adopting sustainable energy practices in their daily lives. • Participants will improve their energy literacy including the production, storage and services options for energy communities, energy system structure, market, policies, and stakeholders. • Participants will feel empowered to take an active role in shaping their energy future and become informed, engaged citizens contributing to their energy communities. Depending on the game or gamified strategy chosen and tailored, one or a combination of the following gameplays will occur: • The Ps will be introduced to the structure and assets of an energy community through the exemplars and will be invited to take on the role of community members who are working together to run a specific sustainable energy community. • Ps will be challenged to create a new energy community and make decisions about different types of renewable energy sources, storage facilities, electric vehicles, etc., in which they can invest. They will also decide how to manage energy usage within the community and how to encourage their neighbors to participate in building a sustainable future. • Different energy communities will be introduced, and the Ps will analyze and compare them to achieve individual or collective goals. • The Ps will compete based on their relevant knowledge. • The Ps will collect clues and resources to uncover hidden opportunities for sustainable energy solutions and solve energy-related challenges. • The SEA will track how players progress through the game and reward them (with points or badges) for making sustainable decisions and contributing to the overall success of the energy community. Finally, the SEA that created/organized the serious game/gamification strategy computes performance indicators that are shared with the Ms and any other SEA interested in the impact of this gamification strategy to attract and motivate new Ms. Refs: [Boulanger., et al., 2021], [Bourazeri et al. 2017] , [Mylonas et al. 2021], [Wu et al. 2020]

Associated KPIs in Annex1

Table 71 HLUC8: Use Case Conditions

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Assumptions
• Access to real data of energy communities - exemplars. In case of no such data, the game will be based on artificial/synthetic/assumed data.
Preconditions
• Access to communication channels and to audiences interested in the concept/prospect of energy communities to attract participants.

5.4.2 Actors and Use Case diagram

Table 72 HLUC8: Actor list

Actor name	Actor type	Description
Energy Community Manager (ECM)	Business	Responsible for accessing and managing energy data from/to the prosumers and energy assets. Energy and flexibility management functionalities.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed, and whose energy habits can be modified according to the suggestions received or consent to controlling their flexible loads.
Player (P)	Person	The individuals around and outside the energy communities that actively interact with the game.
Social Engagement Actor (SEA)	Entity	Social drivers to enhance engagement and participation of community members. In RESCHOOL the following SEAs have been identified: • **Gaming Provider (GP)**: Responsible for providing awareness/engagement games to community members. • **Public Administration (PA):** Implements public policies. • **Educational Entity (EE)**: Schools, universities. • **Innovation and Participation managers (IPMs):** Entity or actor devoted to organising participation events and to support the execution of innovative strategies. • **Experts:** Professionals that can advise and provide expert support for decision making at community level.
Public Body (PB)	Entity	Any public administration (municipality, local or regional government) or agency in charge of developing policies and master plans to manage energy transition in a specific area (e.g.: local, regional, national).
Policy Maker (PM)	Entity	Public body in charge of making policies and taking policy decisions.
Municipality	Entity	Local authority with responsibilities in sustainability development and management of a local area (municipality, city, village) where the energy community is located and operates.

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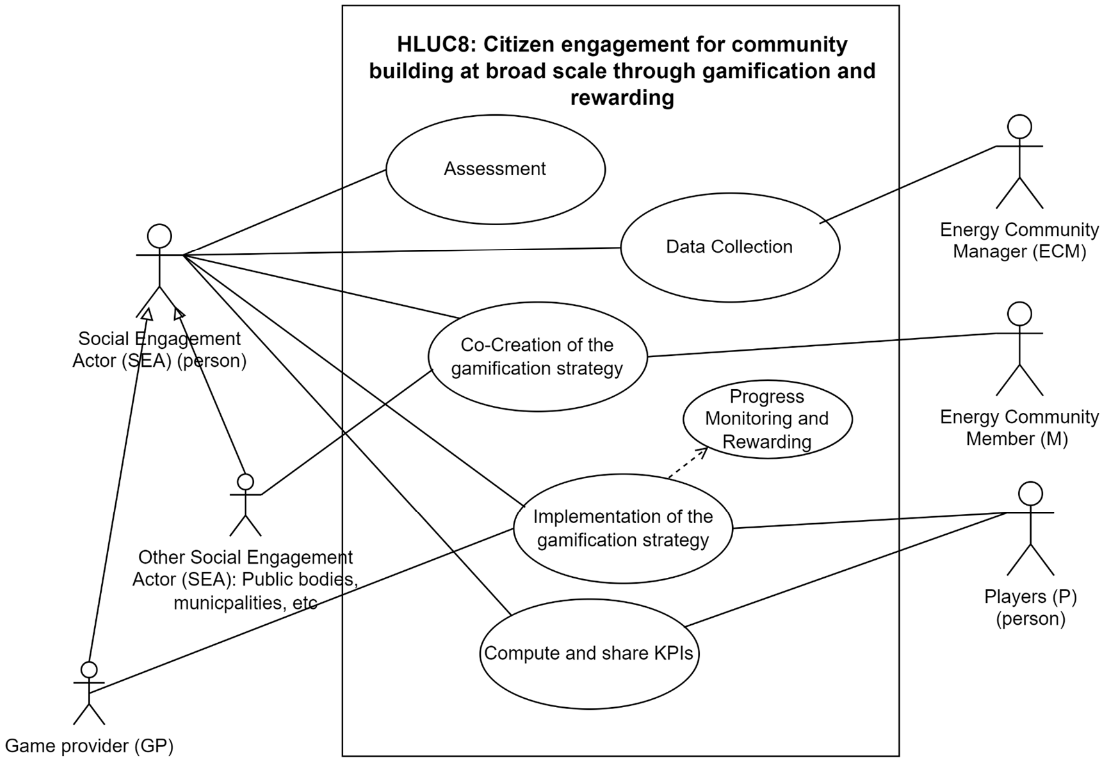

Figure 31 HLUC8: Citizen engagement for community building at broad scale through gamification and rewarding.

5.4.3 Step-by-step analysis

Table 73 HLUC8: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Applying gamified features for energy communities and the wider public						
1	Preparing the gamification strategy	SEA	Investigated the community's public outreach priorities	SEA	SEA	Target audience, actions needed, recruitment procedures, channels of communication , etc.
2	Access to Energy community data	ECM	Requests the internally needed data	ECM	SEA	Energy production and consumption data of all members of an actual energy community
3	Organizing co-creation sessions and	SEA		Ms, SEAs, Public Body, Municipality	SEA	

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	interviews to design the gamification strategy					
1	Attracting players	SEA	Informing and/or incentivizing players to play the game	SEA	P	Information about the benefits of playing the game and participating in energy communities
3	Introduction to the game	P	Overview of the energy sources available to the community, the challenges faced in managing energy demand, and the opportunities for players to make a positive impact.	SEA	P	Historical community data regarding each mission
4	Game Play	P	Community members play the game	P	SEA	In-game actions
5	Tracking progress	P	Determining the evaluation criteria for the community	SEA	P	Assigning rewards
6	Assigning rewards	SEA	GP determines the performance of the users based on their performance	SEA	P	Gamified features

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Activity diagram

Figure 32 HLUC8: Activity diagram

5.4.4 Information exchanged

Table 74 HLUC8: Information exchanged

Name	Description
Energy community data	Energy and demographic data of real energy communities.
In-game actions	Decisions on the selection and use of energy resources, storage and demand side management.
Assigning rewards	SEA evaluates and rewards Ps based on their performance.
Gamified features	In-game RES production, storage and energy shifting.

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5.5 HLUC9 - Interactive communication and collaborative participation oriented to foster joint initiatives and investments

5.5.1 Description

Table 75 HLUC9: General Information

Use Case Id	HLUC9
Title	Interactive communication and collaborative participation oriented to foster joint initiatives and investments
Authors	LCLF
Version	V1.0
Date	29.03.2023

Table 76 HLUC9: Objectives and Boundaries of Use case

Scope and boundaries	Benchmark energy performance of buildings (i.e.: home association buildings) and support of continuous improvement of energy performance of buildings by proposing interventions. Discovering other buildings that belong to the energy community and communication among the building owners / managers. Elaboration of monthly energy nudge. Mainly intended for energy communities formed by building associations (BA).
Business roles and Objectives	Support decision making and monitoring at building level by implementing recommendation systems based on benchmarking with other buildings, simulation of efficiency measures and their economic valorisation. Support for participative and collaborative decision making. This is split into the following sub objectives: • On1) Manage onboarding, consent, and data collection of energy community members. • Ob2) Track and benchmark energy performance and revenues from flexibility and related energy services. • Ob3) Simulate implementation of efficiency measures for the board and related ROIs. • Ob4) Facilitate interactions and communication among the energy community. • Ob5): Nudge all members of the community on a monthly basis with a short report.
Relation to other Use Cases	• BUC1: Energy management (intra community). Valorisation of energy management strategies at community level. Can impact: • HLUC1: Energy balance and accounting for communities • HLUC8: Citizen engagement for community building at a broad scale through gamification and rewarding.
Pilots	SE pilot comprehensively, and ability to implement a lighter version, in other pilots dependent on the specific needs and overlaps / synergies with other Use Cases

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Table 77 HLUC9: Narrative of Use Case

Short description	Tracking of buildings energy and flexibility performance, elaboration of dashboards for Building (Home Owner) Association (BA) board of directors with KPIs that are relevant to them including energy and flexibility performance, and revenues from flexibility. Elaboration of efficiency recommendations based on existing information about the building and estimates on return of investment (ROI) considering several measures. The BA is invited to an active participation within the energy community to seek advice, ask questions and collaborate with other BAs.
Complete Description	Interactive communication and participation assisted by a software platform (Collaborative Service platform, CSP) with capabilities to track energy data and suggest energy efficiency measures with an estimation of savings potential. BAs are the primary users of the service. Their role will be to use the service to direct the energy related issues of their building, through better decision support and monthly report, alone (at building level) but also together (at community level) with the other BAs in the energy community. The Building Association (BA) has to register to the Collaborative Services Platform, and give permissions to access energy data, and for countries where there are no existing data communication standards, the BA or a third party needs to make the building data available. Then, the CSP sets up the building account. To do this the CSP retrieves energy data (historic and current) from the Energy Community Monitoring Platform (ECMP) and invokes a building energy simulator (BES) that responds with information related to the Energy Performance Certificate (EPC). CSP also requires the BA, or the Energy Community Manager (ECM), to complete the set up with information related to investments on energy measures and equipment installed in the building. The CSP uses the retrieved information to elaborate a benchmarking with similar information gathered from other BA in the community. Benchmarking is accompanied with description of actions performed by other BA in the community in order to support decision making at building level. The CSP provides support to simulate the impact of energy efficient measures including the computation of ROI (Return Of Investment) ratio. Measures with better performance are suggested as possible recommended actions. Proposed measures are shared for discussion through the collaborative tool and BA who are invited to discuss and pose questions using the same environment. This active participation in the decision-making process increases the engagement of community members. CSP computes a set of KPIs of the community and reports the results to the community members (BA) through the collaborative tool. The service in this use case, provides monthly feedback at a building scale and community scale partitioned in the following sections. • An energy section. • A buildings section. • A community section. Within the Energy section, energy KPIs are visualized:

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	1. Energy data at various time frames – Weekly, Monthly, Yearly 2. A comparison between the current and previous electricity usage. 3. Insights on which day and time is electricity used the most. 4. Comparison amongst the neighbouring BAs. 5. Review of last month's Monthly Report Within the Building Section, 1. A map of BA location and other nearby participating BAs 2. Your building section that shows your BAs installed measures and suggested measures with the savings potential. 3. Discover your neighbouring BAs that show what measures they have installed and the board of directors contact. Within the Community Section, 1. A chat function where you can communicate directly with other board of directors from other BAs. 2. Posts where the members of the energy community can post, comment, and discuss about the newly installed measures, flexibility results, etc. to share experiences and provide recommendations.

Associated KPIs in Annex 1

Table 78 HLUC9: Use Case Conditions

Assumptions
• Access to all the metering (smart meters, PV generation, meters, etc.) and control systems (loads, BEMS, etc.) is available through the Energy management system. • Integration of EMS with forecasting and scheduling tools / apps / algorithms. • Historical data sets availability forecasting tool operation. • Access to weather forecasting providers.
Preconditions
• A clear comprehensive architecture for the energy community, with a clear structure, and interfaces for third parties. • Ability to get consents. • The interest and participation of the energy community members to set up their profiles.

5.5.2 Actors and Use Case diagram

Table 79 HLCU9: Actor list

Actor name	Actor type	Description
Collaborative Services Platform (CSP)	System (software)	A system that is able to facilitate interactions within energy communities surrounding recommendations on proposed measures.

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Building Energy Simulator (BES)	System (software)	A third party that generates simulations (digital twins) for each building and recommends measures.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable of collecting energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Building Association (BA)	Business	Board members of Home owners or Building associations that have access to the information of their building and have the understanding and make decisions for their buildings.
Energy Community Manager (ECM)	Business	Responsible for accessing and managing energy data from/to the prosumers and energy assets. Energy and flexibility management functionalities. ECM could also be representative of BA.

Use case Diagram

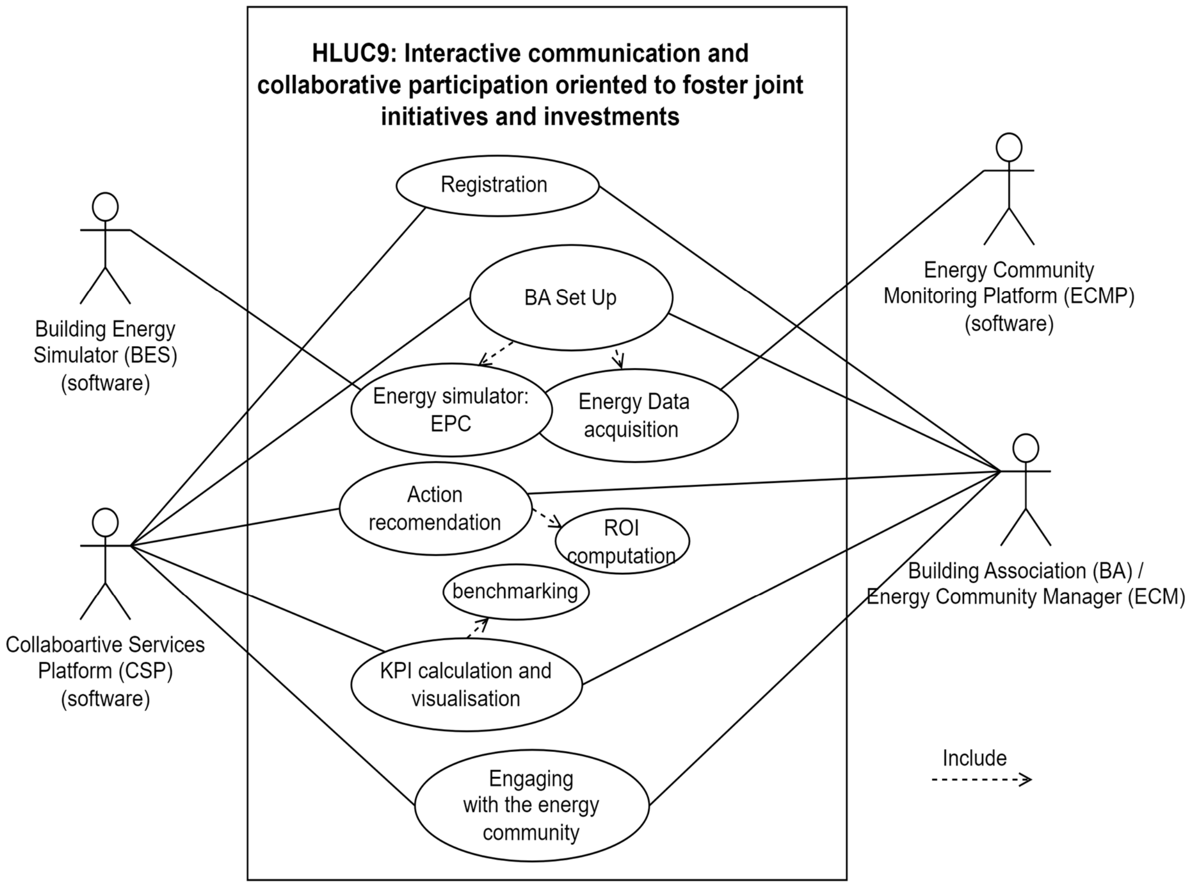

Figure 33 HLUC9: Interactive communication and collaborative participation oriented to foster joint initiatives and investments.

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5.5.3 Step-by-step analysis

Table 80 HLCU9: Scenarios

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Onboarding	Onboarding of a new building	Building Association / Energy Community Manager	Setting up account	All data, and calculations integrated and available	Building and board member registered
Monthly Energy Community Nudge	Generation of monthly energy report	CSP	End of the month (date)	Compilation of all data and calculations	Monthly energy report sent to all members

Table 81 HLUC9: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Onboarding						
1	Registration	BA	BA member provides identity and permissions for data processing	BA	CSP	Identity and Permissions
2	Setting up building and BA Member account	CSP	CSP requests access to all available data and simulations for building from BES	BES	CSP	Building energy data (historical energy data, current data, simulations, Energy Performance Certification - EPC- data)
3	Request for additional information	CSP	Requesting additionally needed data from BA member	BA	CSP	Additional missing data needed for building (e.g.: information about recent investments in

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						renewable energy and batteries)
4	Visualize and benchmark	BA	BA member learns about current performance, compared to other buildings in the energy community and discovers other actions they have taken	CSP	BA	Visualization and benchmarks
5	Action Recommend ation	BA	BA member learns about high quality simulations for energy efficiency measures for their building including their ROIs, as well as seeing whether or not the energy community has any pre-procured services available	CSP	BA	Recommended efficiency measures (simulations)
6	Introduction to energy community	BA	The BA member is now invited to participate in the energy community feed and engage in related discussions	CSP	BA	The topics of discussions in the energy community
7	Engagement and collaborative discussion and decision	CSP	The BA member engages with the energy community via questions or comments	BA	BA /ECM	Questions, posts, comments
Monthly Energy Community Nudge						
1	End of month	CSP	Computes all KPIs for energy community and re-runs simulations	CSP and BES	CSP	KPIs
2	Push notification to all energy	CSP	A push notification with this month's report is pushed out to	CSP	Energy community members	Monthly report

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	community members		all energy community members		and managers	

Sequence / activity diagrams

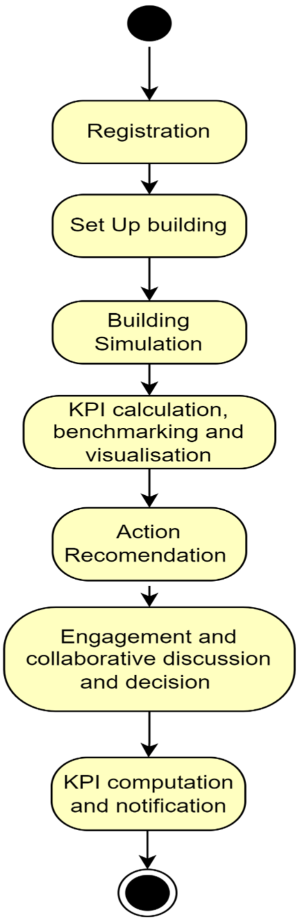

Figure 34 HLUC9: Activity diagram

5.5.4 Information exchanged

Table 82 HLUC9: Information exchanged

Name	Description
Identity and Permissions	Verified identity of BA member and their consents
Building energy data	Historical energy data, current data, simulations, EPC data
Additional missing data needed for building	E.g.: information about recent investments in renewable energy and batteries
KPI Visualization and benchmarks	Benchmarked KPIs

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Recommended efficiency measures	Calibrated results from energy plus simulations for efficiency measures on that building
The topics of discussions in the energy community	Overview of energy community feed and categories
Questions, posts, comments	Information exchanged by members within the energy community

5.5.5 Requirements and general remarks

This use case is primarily oriented towards Home Owner / Building Associations (BA) that have created an energy community, and their corresponding energy community manager.

5.6 HLUC10 - Benchmarking and gamification with the inclusion of rewards/incentives

5.6.1 Description

Table 83 HLUC10: General Information

Use Case Id	HLUC10
Title	Benchmarking and gamification with the inclusion of rewards/incentives
Authors	UU
Version	V1.1
Date	01.09.2023

Table 84 HLUC10: Scope, Objectives and Boundaries of Use case

Scope and boundaries	Utilizing gamification to motivate energy users to adopting sustainable energy practices. This is achieved by benchmarking and setting energy-saving goals that motivate to improve their energy management performance. Achievements are rewarded in the form of badges, points, or other in-game rewards. Performance is measured with data coming from the Energy Community Monitoring Platform.
Business roles and Objectives	Energy efficiency, self-consumption and demand response programs: • Ob1) Enhancing customer engagement and encouraging them to take an active role in energy management.
Relation to other Use Cases	• BUC1: Energy management (intra community). Valorisation of energy management strategies at community level. • BUC3: Sizing and organisation of energy communities. Define business models to guarantee economic sustainability of the energy community and establish a reference framework in terms of energy managed and/or participants involved. • BUC4: Social awareness and participation in the value proposition of communities. Foster the social awareness of energy communities as a social and economic driver and exploit it as a true value proposal. Can impact: • HLUC1 - Energy management. • HLUC3- Automated participation of energy communities in energy markets. • HLUC8- Citizen engagement for community building at broad scale through gamification and rewarding.

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	• HLUC9- Interactive communication and collaborative participation oriented to foster joint initiatives and investments.
Pilots	ES, SE, GR, NE

Table 85 HLUC10: Narrative of Use Case

Short description	Benchmarking system that allows users to compare their energy performance to others in their community. Incorporating gamification elements, make this system fun and engaging for long periods of time. The gaming system is expected to access energy data from the energy community monitoring platform (ECMP).
Complete Description	This HLUC describes the logic of a serious game application (SGA) that interacts with real energy data generated by members of the community (M) in order to achieve certain objectives defined at community level. In the Serious Game Application (SGA) ecosystem, the primary objective is to enhance energy performance within a community, guided by specific energy goals. These goals are pre-defined, however, they can be chosen and tailored by the Energy Community Manager (ECM) according to the unique needs of their community. To help the community attain these energy goals, SGA provides various missions to its members (M), which, when accomplished, result in quantifiable energy performance improvements. Participation to these missions will be rewarded according to internal rules of the game based on a reinforcement schema (achievement points / leaderboards / similar gamification reinforcement strategies) together in addition to the achieved savings. The gamification framework works by collecting data on users' performance for a specific goal in the context of energy usage and propose specific missions (or tasks/levels) oriented to improve this performance. Interaction between the SGA and the energy community management system is described below: 1. The Energy Community Manager (ECM) selects specific energy goals from the SGA's predefined list. 2. Energy Community Member (M) undertakes missions provided by the SGA to improve their energy performance. 3. SGA retrieves energy data from the Energy Community Monitoring Platform (ECMP). 4. The SGA Optimizer evaluates energy data to: ○ Benchmark energy performance of every M. ○ Determine the potential of various missions. ○ Suggest specific missions to each M to optimize energy performance. 5. As members undertake missions and improve performance, the SGA Reward System provides incentives based on game rules and the energy savings achieved. 6. The cycle continues, with the SGA consistently providing new missions based on updated data and benchmarks, driving members towards better energy performance. Refs: [Fijnheer et al. 2019, 2020], [AlSkaif et al. 2018], [Lampropoulos et al. 2019], [Mashoff et al. 2016]

Associated KPIs in Annex 1

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Table 86 HLUC10: Use Case Conditions

Assumptions
• Access to the community energy data including historical data sets.

5.6.2 Actors and Use Case diagram

Table 87 HLUC10: Actors list

Actor name	Actor type	Description
Energy Community Manager (ECM)	Business	He also has an administrator role for the game application that selects and adjusts the energy goals for the community based on the predefined list in SGA.
Energy Community Monitoring Platform (ECMP)	System (software)	A software platform capable to collect energy data from devices, energy assets and systems of the Energy Community Members, through specific metering and/or control systems, store this data, compute basic energy indicators at individual and collective level and share the results through graphical user interfaces with community members and energy managers.
Serious Game Application (SGA)	System (software)	Application that implements the serious game logic and interacts with the energy data of the community, computes performance and rewards.
SGA Optimiser	System (software)	A sub-component of the SGA responsible for processing energy data, benchmarking members' performances, and suggesting missions.
Gaming Provider (GP)	Person	Responsible for providing awareness/engagement games to community members.
Energy Community Member (M)	Person	Individual community member whose energy data are collected and analysed, and whose energy habits can be modified according to the suggestions received or consent to controlling their flexible loads. The target audience (players) for the game.

Use Case Diagram

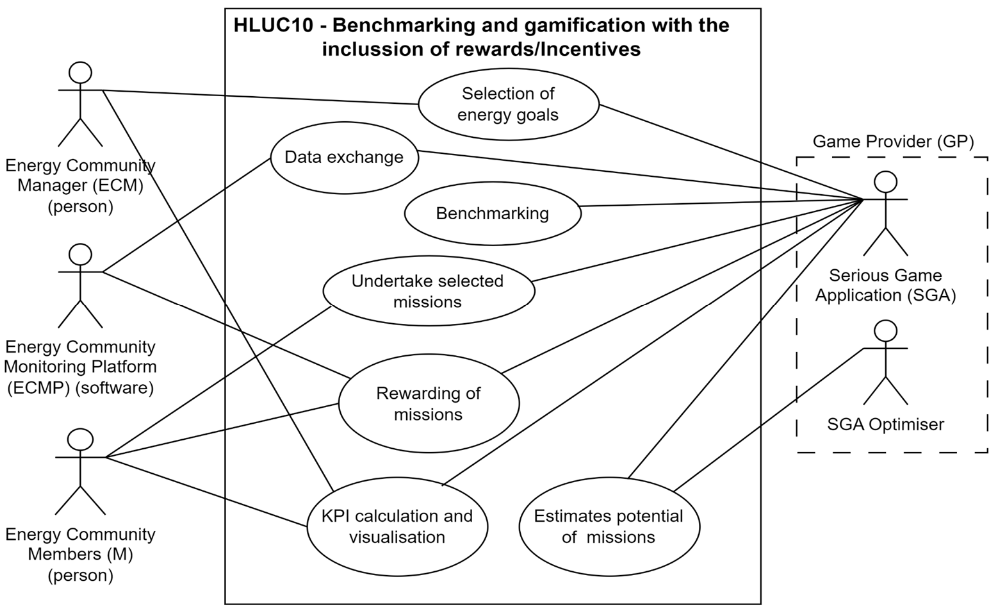

Figure 35 HLUC10: Benchmarking and gamification with the inclusion of rewards/incentives

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5.6.3 Step-by-step analysis

Benchmarking and gamification with the inclusion of rewards/incentives

Table 88 HLUC10: Scenarios

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Gamification of energy community goals	The day ahead real-time scheduling	GP / EMS	In-game behaviour analysis	System integrated. Availability of data from the field	

Table 89 HLUC10: Step-by-step

Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Gamification of energy community goals						
1	Request Gaming	SGA	Exposes energy goals for selection and request a selection	SGA	ECM	List of goals
2	Under request	SGA	Selects an energy goal	ECM	SGA	Selection
3	Periodically	SGA	Suggest missions	SGA	M	Missions
4	After3	M	Acknowledges and Undertakes mission	M	M	-
5	Periodically	SGA	Requests energy data	SGA	ECM	Id energy assets
6	Under request	SGA	Sends energy data	ECM	SGA	Energy Data
7	After 6	SGA	Request KPI computation	SGA	SGA optimiser	-
8	Under request	SGA optimiser	Computes benchmarking indicators	SGA optimiser	SGA optimiser	KPIs

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			Computes mission potential Computes performance KPIs			
9	After 8	SGA optimiser	Sends KPI values	SGA optimiser	SGA	KPIs
10	After 9	SGA	Computes rewards	SGA	SGA	Rewards
11	After 10	SGA	Informs about performance and rewards	SGA	ECM M	KPIs Rewards

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Activity Diagram

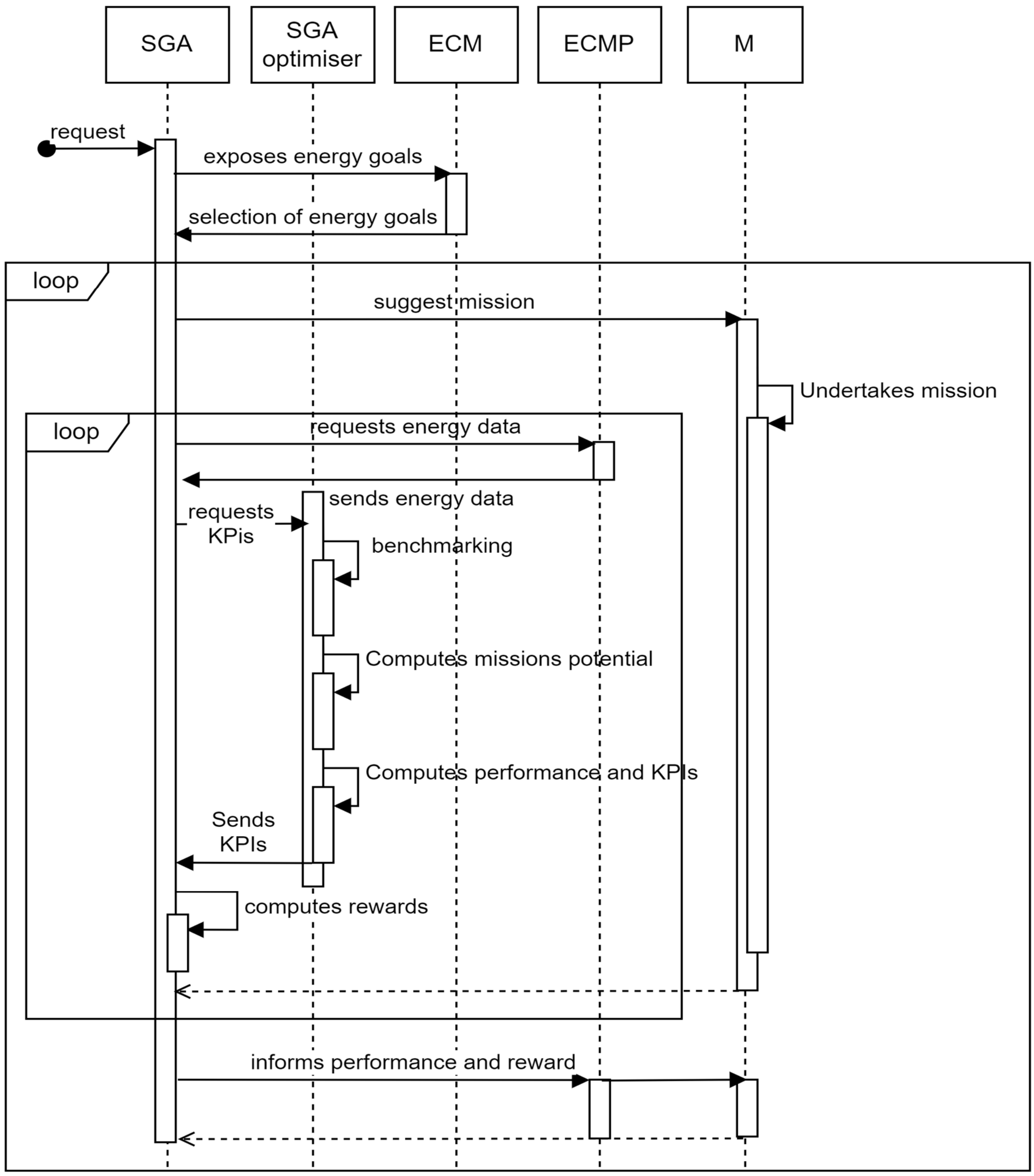

Figure 36 HLUC10: Sequence Diagram

5.6.4 Information exchanged

Table 90 HLUC10: Information exchanged.

Name	Description
Energy data	Generation and consumption data.
List of goals	List of possible missions
Missions	Description of action / activities to be performed to reach specific goals

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Id energy assets	Identifier of energy assets (e.g.: meters, devices, generators, loads, etc.) for which energy data is required.
KPIs	Performance indicators relative to the impact of the proposed activities, including benchmarking indicators.
Rewards	Quantification of rewards (points, badges, etc...)

5.7 HLUC11 - Adaptive communities: reacting to evolution of markets, regulations and contexts

5.7.1 Description of HLUC11

Table 91 HLUC11: General Information

Use Case Id	HLUC11
Title	Adaptive communities: reacting to evolution of markets, regulations and contexts
Authors	EREF
Version	V_2
Date	12/07/23

Table 92 HLUC11: Scope, Objectives and Boundaries of Use case

Scope and boundaries	The scope is defined by barriers and drivers of existing energy markets and regulatory frameworks, as well as anticipated changes that could be introduced in the near future. This refers to the transposition of relevant EU Directives as well as further ongoing reform processes at national levels in Greece, Spain, Sweden and the Netherlands that can impact future business and operational environments of energy communities.
Business roles and Objectives	Include the need for continuous change and adaptation as a design requirement from the beginning and assess it.
Relation to other Use Cases	• HLUC6 on Private-Public Collaboration
Pilots	ES, GR, NL, SE

Table 93 HLUC11: Narrative of Use Case

Short description	The use case describes elements regarding evolving energy markets and regulatory environments that energy communities should, in the early design and planning phase, take into account. This includes the establishment of new energy community projects as well as the extension of activities that are foreseen to be conducted by existing energy communities, helping to anticipate the impact of legal and policy reform on business and operational environments. Therefore this use case highlights the importance for energy community managers and project developers to follow and analyse the transposition progress of relevant EU Directives into Greek, Dutch, Spanish and Swedish law, in order to understand how national reform processes could allow for energy communities to adapt and undertake new activities, benefiting from e.g.: aggregation, demand response, the provision of flexibility services, the introduction of local energy markets, the use of smart energy management systems, storage, etc. HLUC11 is designed to issue guidance for the decision-making process among energy communities that promote adaptive

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	capacities (e.g.: for integrating new business models) and prevent lock-in-effects and risks to future economic viability. The use case further describes expected impact from the ongoing reform of the EU's electricity market design, which is likely to bear consequences also for energy communities acting on existing markets, on power purchase agreements and other regulatory evolution that can be beneficial to energy communities.
Complete Description	HLUC11 is relevant to project developers, public authorities, investors and energy community managers who need to, as early as in the planning and preparational stages, analyse risks - as well as opportunities - and therefore be knowledgeable of relevant regulation at national and EU level. Particular focus should be directed at potential regulatory changes that stem from ongoing or upcoming legal and policy reform processes and that can impact market and system interactions of energy communities, such as the provision of services to grid operators, aggregation, demand response and the conclusion of renewable power-purchase agreements. This will impact the use and implementation of efficient technologies (e.g.: IT systems for energy management), as well as securing economic viability and sustainable community development. To this end, professionals who are in charge of establishing and operating energy communities are well advised to acquire a solid understanding of relevant EU rules and their transposition into national laws within their competent jurisdiction. The legal reform adopted by EU decision-makers in 2018-2019, as part of the "Clean Energy Package" (CEP), established, for the first time in EU law, "renewable" as well as "citizen" energy communities as new actors in the energy sector. The CEP's recast Renewable Energy Directive (RED II) and the Internal Electricity Market Directive (IEMD) require Member States to introduce definitions and legislate on rights, duties, and potential market activities, establish enabling frameworks, and take energy communities into consideration when designing support schemes. The knowledge on the existence of such EU legal requirements helps understand that the effective implementation of energy communities in practice also depends on how Member States are transposing these into national laws – something which has been done in varying degrees and forms e.g.: in Greece, Spain, Sweden and the Netherlands. At the same time, it is useful to keep the bigger climate and energy policy picture in mind, with which are reflected through increased decarbonisation efforts, for instance in the form of higher EU target levels for renewables and energy efficiency, as well as sub-targets for heating, mobility and industry. This is likely to impact national policy design and the ambition to accelerate the transition to climate-neutral societies, incl. through support that is made available to energy community projects. In this context, it is important to bear in mind that regulation affecting the establishment of energy communities goes well beyond the previously mentioned "enabling frameworks" which EU rules require national law-makers to adopt. Areas of regulation – and in particular related reform processes that might impact these areas and in consequence the operation and economic viability of energy communities – touch upon as consumer protection, infrastructure rules, public procurement, as well as supplier and network charging arrangements. Certain aspects, such as ownership of simple generation assets or the provision of direct services to the local community (such as advice on energy efficiency or initiatives to mitigate energy poverty) are,

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	from a regulatory perspective, largely unproblematic. On the other hand, energy sharing within energy communities defies the classical supplier-customer relationship and requires defining clear frameworks (which is currently underway at EU level, in the form of an energy market design reform). Also, energy communities may, depending on which EU and national regulation applies, act as supplier or service provider (e.g.: of aggregation and balancing services) or, if allowed, as network operator. These activities fall under the competence of electricity market regulation and go beyond energy community frameworks (for instance, RECs operating distribution networks would have to comply with all regulatory requirements that apply to DSOs). In consequence, energy community operators should closely follow whether national regulatory authorities pay particular attention when introducing new legal provisions that imply increasing complexity for the consumer. The same diligence applies when reforming market designs and optimise roles and responsibilities for actors that are needed to deliver on the energy sector's requirement to decarbonise. This extends to market entrants such as aggregators and other energy service providers, to revised tariff structures, and to changing roles and obligations for transmission system operators (TSOs) and distribution system operators (DSOs) that are tasked to develop more flexible, smart and decarbonised infrastructures. It further encompasses rules related to data management and protection, and cyber-security, as well as a reinforced emissions trading scheme (with the recent agreement among EU institutions to include transport and buildings), accelerated and simplified permitting granting procedures for renewable energy projects, as well as the decarbonisation of gas markets and the uptake of green hydrogen. Each of such regulatory interventions can also impact energy community projects, and should be addressed in their development. Further impact from regulatory changes is likely to stem from the question how national authorities will treat the many existing cooperatives and other collective energy initiatives, when transposing EU Directives into national laws. While many of Europe's energy cooperatives comply to some extent with EU provisions on autonomy, membership and most importantly, the primary purpose to provide social, economic and environmental benefits (rather than financial profits), there are important features and activities that RECs and CECs should be entitled to carry out - but that many of today's cooperative models do not offer. For instance, this includes sharing renewable energy within an energy community, without brokerage of any third party, even when using the distribution network. As such, this regulatory treatment can have national authorities amend existing provisions, allowing for energy cooperatives and other existing initiatives to evolve and qualify as renewable or citizens energy community – which in return might offer new opportunities for project developers and energy community managers (or else put new risks if new regulation is poorly designed and e.g.: fosters the market dominance of energy industry incumbents, or limits activities that energy community are already conducting).

Associated KPIs in Annex 1

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5.7.2 Actors

Table 94 HLUC11: Actor list

Actor name	Actor type	Description
Energy Community Manager (ECM)	Business	Responsible for accessing and managing energy data from/to the prosumers and energy assets. Energy and flexibility management functionalities.
Project Developer (PD)	Business	Responsible for checking that the energy community project follows the existing legal and regulatory framework.
Public Body (PB)	Entity	Any public administration (municipality, local or regional government) or agency in charge of developing policies and master plans to manage energy transition in a specific area (e.g.: local, regional, national).

5.8 Socioeconomic and engagement Primary Use Cases

The Table 95 summarises actions required to implement socioeconomic and engagement use cases (HLUC06-HLUC11) conceived as primary use cases (PUCs).

Table 95 Socioeconomic and engagement PUCs

PUC	Description
Master plan for LECs	Elaboration of general strategy for the creation of local energy communities including objectives, timing, allocation of funds, participation conditions and calls.
Collective RES project	Project for a PV (or alternative RES) plant whose production is being shared among several partners under specific conditions defined in an agreement signed by all the participants.
Open call for funding collective RES installation	Access to funding by applying to public calls through a competitive schema.
Execution of the collective RES project	Installation of RES.
Creation of LEC	Contractual agreement between the members of the community (citizens, public administration, energy community manager).
Inform DSO	DSO is informed about the creation of a LEC at their premises.
Individual energy accounting	Energy accounting of each energy community member.
LEC monitoring, accounting and managing	Energy accounting and management of the LEC.
Design interventions	Production and adaptation of material to be used in schools.
Training of teaching staff	Preparation of teachers to carry out the designed activities.
Educational intervention	Execution of the activities in the school.
Post-intervention surveys	Design and fulfilment of surveys to gather feedback after the execution of the interventions in school.
Impact assessment and dissemination	Assessment of the impact of the activities carried out in the school.
Data collection	Gathering of data from an existing energy community to be used in the creation of a game.
Gaming structure and rules	Definition of the game to engage citizens to participate in an energy community.
Tracking progress	Assessment of the progress of the players through a game.

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Rewards / Incentives	A player receives a reward based on his performance in the game.
Interactive communication system	Communication between energy communities through a collaborative platform.
Energy metrics and trends	Energy metrics, trends and reports are generated for each energy community.
Data storage and management	Storage of variables and parameters retrieved from energy assets or systems.
Energy simulator	The performance of an energy community can be simulated by means of a digital twin.
Selection of energy goals	A predefined goal, which can be pursued by an energy community member through the execution of missions of a game, is selected based on its needs.
Benchmarking (game)	Assessment of the energy performance of an energy community member (baseline)
Estimates potential of missions	Calculation of what can be achieved by the energy community member executing different missions (game).
Undertake selected missions	Execution of missions (game) based on selected goals.
Rewarding of missions	Energy community members receive rewards based on their performance in the game.

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6 Conclusions

This document analyses and describes the use cases, both technical and socioeconomic/engagement, that will be implemented throughout the development of RESCHOOL project to reach its goals. The methodology followed to elaborate the use cases consists in splitting the goals of the project in different Business Use Cases (BUCs) and, starting from these BUCs, identifying the High Level Use Cases (HLUCs) that are needed to be implemented. The analysis of BUCs allows identifying the required business actors, their roles and the interactions between them to achieve specific goals. HLUCs are more technical descriptions where business actors interact with other relevant actors (systems, devices, software) required to execute specific activities. In the description of HLUCs, also information exchanged between actors and the sequence of interactions is included following a step-by-step analysis. IEC 62559-2:2015 standard has been considered to elaborate both the BUCs and HLUCs.

Use cases have been grouped, per convenience, in two non-hermetic categories (technical and socio-economic & engagement use cases) covering two business use cases each. BUCs in the technical group cover Energy management (BUC1) and Community as flexibility provider (Buc2). These focus on energy management challenges of communities including self-sufficiency, collective generation, participation in flexibility programmes including DSO interaction (e.g.: congestion avoidance), aggregated access to markets or energy communities composed by housing associations with multiple energy vectors. And the two BUCs covering the Socioeconomic and engagement group are BUC3 - Sizing and organisation of energy communities, and BUC4 - Social awareness and participation in the value proposition of communities. They embrace challenges related to creation of EC through public-private collaboration, awareness through the use of serious games and gamification as engagement and participative strategies, intergenerational knowledge transfer (training young generations to impact older generations) conceived as a long term strategy to increase awareness and participation in energy communities, collaborative approaches to reinforce participation, and the challenge of communities to adapt to changing contexts (regulations, energy uses, economic viability, etc.).

HLUCs falling in the category of technical Use Cases (HLUC0 to HLUC5) mainly support developments in work package WP3 whereas those falling in the socioeconomic and engagement category (HLUC6-HLUC11) are conceived to push developments in work package WP2. Although these two categories are not independent silos, there are some development aspects that can be managed separately. Thus, the backbone of HLUC01-HLUC05 is the energy data flow in a general sense. That is, gathering energy data from devices, integration and aggregation for accounting and assessing energy balances at individual and community level (HLUC0, HLUC1, HLUC2). Elaboration of energy data allows forecasting demand and estimation of flexibility as basic operations to leverage communities as flexibility providers, either implicit or explicit. Participation in flexibility programs implies another level of interaction with third parties demanding flexibility, either energy markets (HLUC3) or grid operators (HLUC4) to support its operation (e.g.: congestion avoidance). Another level of complexity is also envisioned when energy management considers other energy vectors (HLUC5). Energy data is also used to support incentive-based strategies and benchmarking behind some serious games (HLUC10). However, other engagement strategies considered in the project do not require access to energy community data. Specific communication and training activities to increase awareness and engagement include intergenerational knowledge transfer (HLUC7) and other approaches based on serious games at large scale (HLUC8). In another category, specific use cases address the challenge of creation of energy communities supported by public actions, the so-called Local Energy Communities (LECs), starting with collective self-consumption installed in public equipment (HLUC6), their development based on a collaborative approach for decision making (HLUC9) and their viability and adaptation to evolving context defined by new coming rules, energy uses and markets (HLUC11).

Actors and actions in these eleven HLUCs have been harmonised to identify a common set of actors that has relevant participation on them and those activities that implement HLUCs have been identified as primary use cases enabling the implementation of HLUCs.

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7 List of Acronyms

Table 96 Deliverable Acronyms

AEMS	Asset Energy Management System
AMA	Aggregator Market Agent
AMCS	Asset Metering and Control System
AP	Aggregator Platform
BBEN	Bamboo Energy Tech (Reschool Partner)
BEMS	Building Energy Management System
BMS	Battery Management System
BUC	Business Use Case
CEC	Citizen Energy Community
CERTH	Center for Research and Technology Hellas (Reschool Partner)
COEN	Cooperative Energy (Reschool Partner)
CSP	Collaborative Service Provider
DSO	Distribution System Operator
DdGi	Diputació de Girona (Reschool Partner)
EC	Energy Community
ECM	Energy Community Manager
ECMP	Energy Community Monitoring Platform
EDP	Energy Data Provider
EE	Educational Entity
EF	Energy Forecasting
ELEC	Electricity (Reschool Partner)
EOS	Energy Optimisation System
EMS	Energy Management System
EREF	European Renewable Energies Federation (Reschool Partner)
ES	Spain (Refers to the location of the RESCHOOL pilot)
FM	Facility Manager
GM	Gaming Provider
GR	Greece (Refers to the location of the RESCHOOL pilot)
IPM	Innovation and Participation Manager
KPI	Key Performance Indicator
HEMS	Home Energy Management System
HLUC	High Level use Case
HERM	Harmonised Electricity Role Model
HVAC	Heating Ventilation and Air Conditioning
IEC	International Electrotechnical Comission
KMo	Kmo Energy (Reschool Partner)
LCM	Local Council Manager
LEC	Local Energy Community
LFM	Local Flexibility Market
LSO	Local System Operator
LCLF	Local Life (Reschool Partner)
M	energy community Member
NE	The Nethrelands (Refers to the location of the RESCHOOL pilot)
OR	Open Remote (Reschool Partner)
PA	Public Administration
PEVCO	Public Electric Vehicle Charging Operator
PUC	Primary Use Case
PV	Photovoltaic Generation

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REC	Renewable Energy Community
RES	Renewable Energy Sources
RESF	Resourcefully Consulting (Reschool Partner)
ScM	School Manager
SE	Sweden (Refers to the location of the RESCHOOL pilot)
SEA	Social Engagement Agent
SaaS	Software as a Service
TSO	Transmission System Operator
UdG	Universitat de Girona (Reschool Partner)
UU	Utrecht University (Reschool Partner)
UML	Unified Modelling Language
WDP	Weather Data Provider
WP	Work Package
WS	Web Service

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Annex 1: Key Performance Indicators

Table 97reports the list of Key Performance Indicators (KPIs) and a short description. Column on the right links these KPIs with the High Level Use Cases proposed in this document as main scenario where the KPI should be accounted.

Table 97 KPIs and Pertinence to HLUCs

ID	Name	Description	HLUC pertinence
1	Transactions	Number of transactions flowing through the bus- [1000 transactions/sec]	Platform integration
2	Completion	% of processes where completion falls with +-5% of estimated completion [lower than 5%]	Platform integration
3	Interconnections	number modules/applications/services interconnected [100%]	Platform integration
4	Reuse	reusability [100% of the implemented process]	Platform integration
5	Latency	latency - throughput of transactions- [less than 1 sec]	Platform integration
6	Interoperability	information model and connected and interoperable modules [100%]	Platform integration
7	Standards complience	information model and standards compliance [100%]	Platform integration
8	Improvement of self-consumption	Percentage of increase of self-consumption with respect to BAU	HLUC1
9	Grid dependence	Percentage of imported energy with respect to total energy demand	HLUC1
10	Internal flexibility	Percentage of energy provided by storage system (internal) with respect to the total self-consumed	HLUC1
11	Behavioural change	Percentage of suggestions accepted by the users (notifications)	HLUC1
12	Average economic savings for community members	Cumulative savings of the Energy Community Members in a certain period	HLUC1
13	Flexibility savings	Savings or earnings of the Energy Community Members due to the implementation of measures suggested through notifications	HLUC1
14	Flexibility	Flexibility generated per hour [5-10% of installed power]	HLUC1
15	Response time DR	Response time to demand response (day-ahead scheduling)	HLUC1
16	Energy savings	Energy savings in %	HLUC1
17	Flexible power	Flexible power, in kW	HLUC1
18	Local renewable energy sources	% of iRES mix	HLUC1
19	Local self-consumption	Self consumption ratio	HLUC2
20	Improvement of Autarky	Percentage of increase of autarky (self-consumption, reduced energy import, share of year with self-sufficiency)	HLUC2
21	Forecasting accuracy	Accuracy of energy forecasting	HLUC2
22	Energy system efficiency	Number of energy vectors optimized	HLUC2
23	Flexibility outcomes	Economical and technical effects from flexibility to the energy community members and energy system.	HLUC3

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24	Aggregator effects	Economical benefits for the energy community and aggregators in the market, offering services to the energy system.	HLUC3
25	Participation	% of connections under a secondary substation (transformer) that participates	HLUC4
		Participation in flexibility services (tbd: e.g. individuals, #bids/activations in a time period)	HLUC4
26	Peak reduction	Peak reduction at secondary substation	HLUC4
27	Decreased energy costs	Variation of energy costs since implementation	HLUC5
28	Economic effects	Economic effects generated from collaboratively managing energy resources, supply and demand.	HLUC5
29	Congestion	Congestion avoidance [>95%]	HLUC4/HLUC5
30	Impact of intergenerational transfers for participation in energy communities	Assessment of training and engagement activities developed in schools, based on quantitative surveys and qualitative interviews.	HLUC7
31	Intergenerational transfers value on energy feedback	Assessment of training and engagement activities developed in schools, based on quantitative surveys and qualitative interviews.	HLUC7
32	School engagement	School engagement [2 per pilot] - (2 step comparative assessment)	HLUC7
33	Family engagement	Families enrolled [100-150 total]	HLUC7
34	Age diffusion	Age stratified indicator of engagement evolution	HLUC7
35	Energy knowledge	Perceived energy knowledge (survey)	HLUC7
36	Intergenerational/Cultural diffusion	Intergenerational/cultural diffusion (demographic statistics in players/users)	HLUC7
37	Socio-economic diffusion	Inclusion of lower socio-economic class	HLUC7
38	Learning outcomes	Impact of serious gaming in knowledge gain: Assessing of players' knowledge before and after playing the game and their ability to apply the knowledge gained from the game in real-world scenarios.	HLUC8
39	User's satisfaction with the game	Players feedback: likes, dislikes, as well as areas for improvement, to increase player retention and engagement.	HLUC8
40	Player engagement	The number of players who have signed up to play the game as well as their demographic characteristics. (ex. number of downloads of game kit).	HLUC8
		Prosumers engaged [target:800]	HLUC8
41	Community activities	Number of community activities leveraging the developed game and number of audience/participants.	HLUC8
42	General diffusion	Others "reached" [target: 20000]	All HLUCs
43	Energy communities	Number of energy communities (i.e.: housing associations, coops, municipalities) a) reached or b) involved (project target:42)	All HLUCs
44	Political communication	Marketing in political feeds (mentions in political communication)	All HLUCs

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45	Public media communication	Communication (social media, newspapers, etc)	All HLUCs
46	CO_2 footprint	Individual CO_2 footprint	All HLUCs
47	Well-being	Estimated well-being (survey)	All HLUCs
48	EC market growth	Potential market growth	All HLUCs
49	Local external investments	Increased local investments in businesses and other operations	All HLUCs
50	Local economy	Increase in local economy	All HLUCs
51	Participation in local meetings	Number of participants at meetings	All HLUCs
52	Local related events	Number of events in relation with energy community	All HLUCs
53	Members	Number of associations and number of members	All HLUCs
54	Safety	Perceived safety (survey)	All HLUCs
55	Private capital	Invested private capital in local energy resources	All HLUCs
56	Familiarity	Perceived familiarity in area and with neighbours (survey)	All HLUCs
57	Belonging	Perceived sense of belonging in the community (survey)	All HLUCs
58	Energy community interactions	The total number of posts, comments for each posts and the number of chats initiated between different BAs	HLUC9
59	Appeals	Decreased number of appeals	HLUC9
60	Collaborations	Collaborations (number of)	HLUC9
61	Investment decisions	Increased number of decisions for investments	HLUC9
62	Decision time	Shorter time for decisions	HLUC9
63	Collective investments	Number of collective investments	HLUC9
64	Working groups	Number of working groups in energy related dimensions	HLUC9
65	Player Engagement	The level of engagement of players with the game. It can be measured by tracking the number of logins, the time spent playing the game, the number of completed game objectives, and the frequency of returning players.	HLUC10
66	Attitude	User attitude over time	HLUC10
67	User time	Average user time	HLUC10
68	Inspiration	Inspiration to others (individual or group talks around intervention) (survey)	HLUC10
69	Visits	Number of visits at showroom/infocenters	HLUC10
70	Study visits	Number of study visits/visiting delegations	HLUC10

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Annex 2: Use Case Template

The following subsections describe the general structure proposed to describe Use Cases in RESCHOOL.

Description of Use Cases

- ### General Information

Use Case Id	
Title	
Authors	
Version	
Date	

- ### Scope, Objectives and Boundaries of Use case

Scope	
Business roles and Objectives	
Relation to other Use Cases	
Pilots	

- ### Narrative of Use Case

Short description	
Complete Description	

- ### Use Case Conditions

Assumptions
Preconditions

Actors and Use Case diagram

- ### Actor list

Actor name	Actor type	Description

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- **Use Case diagram**

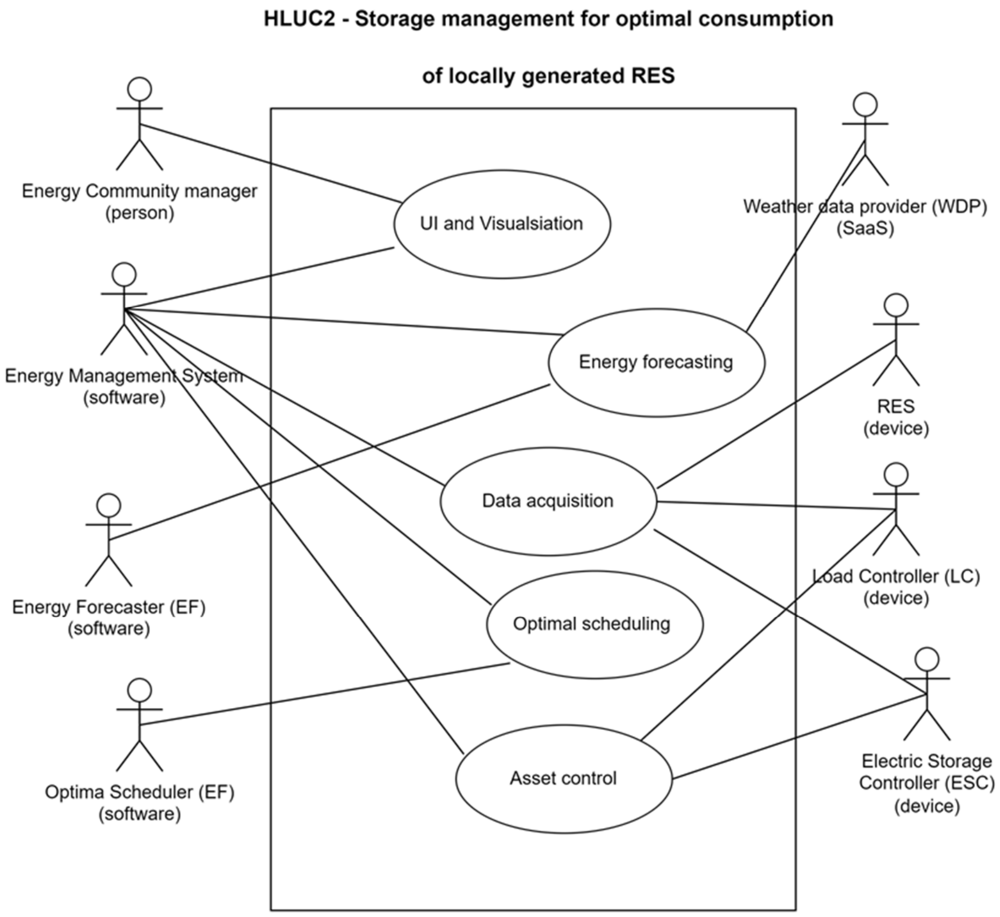

Figure 37 Example of Use Cases Diagram

Step-by-step analysis

- **Scenarios**

Name	Description	Primary actor	Triggering event	Pre-condition	Post-condition
Scenario 1					
Scenario 2					

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Step	Triggering event	Actor	Activity	Information Producer	Information Receiver	Information Exchanged
Scenario 1						
Scenario 2						

- **Sequence / activity diagrams**

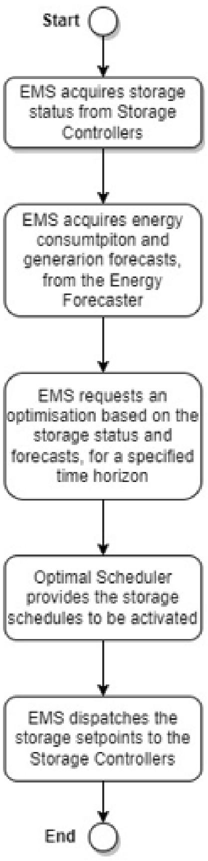

Figure 38 Example of activity diagram

Information exchanged

Name	Description

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