D1.2 - SYSTEM USE CASES FOR INTEROPERABLE DISTRIBUTED HYBRID STORAGE SYSTEMS

WP1 - Requirements, Use Cases, Specifications

T1.2 - Define Multiservice Storage Flexibility Use-Cases and KPIs

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ABBREVIATIONS AND ACRONYMS

EMS	Energy Management System
BMS	Battery Management System
CPO	Charging Point Operators
DEMS	Distributed Energy Management System
HEMS	Hybrid Energy Management System
HyDEMS	Hybrid Distributed Energy Management System
IPP	Independent Power Producers
DER	Distributed Energy Resources
DES	Distributed Energy System
DSO	Distribution System Operator
HESS	Hybrid Energy Storage System
BESS	Battery Energy Storage System
C&I	Commercial and Industrial sites
EV	Electrical Vehicle
REC	Renewable Energy Community
SoC	State of the Charge
SoF	State of the Function
SoH	State of the Health
TRL	Technology Readiness Level
TSO	Transmission System Operator
NILM	Non-Intrusive Load Monitoring
DERMS	Distributed Energy Resources Management System

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EXECUTIVE SUMMARY

The overall vision of InterSTORE is set on the awareness that the mass deployment of Distributed Energy Resources (DER) will massively increase in the near future. This will require the assurance of interoperability of those resources to work together in a seamless way. The goal of InterSTORE is to deploy and demonstrate a set of interoperable Open-Source tools to integrate Distributed Energy Storage (DES) and DER, to enable the hybridization, utilisation and monetisation of storage flexibility, within a real-life environment. To this end, the project will replicate the IEEE2030.5 standard [1] and adapt it for an asynchronous communication, using NATS [2] instead of Restful API communication. The project outcome will allow various DES, DER and several new generation Energy Management Systems (EMS) to be integrated by different stakeholders, while demonstrating the added value of asset's connection to common data spaces, promoted by the International Data Space Association (IDSA) [3], reducing uncertainty and hence increasing acceptance by technology takers and final users.

The IEEE Standard 2030.5 is designed to support many different application domains. The biggest area of application of interest, emerging in technology deployments using the IEEE standard 2030.5, is in the distributed energy resource area, specifically in distributed solar and wind systems using smart inverters, as well as storage systems, particularly hybrid systems, which is the focus of InterSTORE.

In addition, interactions between transmission level operations and distribution system operations have a great influence on how customer-oriented assets are engaged in the operation of the power grid. This effort recognizes the importance that aggregated distribution level resources has with the transmission level interactions. While the IEEE 2030.5 standard may also be applied to other services such as water and gas, the scope of InterSTORE focuses on electric system interactions only.

For achieving this vision, InterSTORE will develop the following:

- Provide 4 open-source software tools for assuring interoperability, flexibility and data standardization
- Upgrades in 4 existing Energy management Systems from partners
- Consider each relevant aspect of flexible use of HESS in different main application areas (EV, Industrial, Residential, Commercial)
- Demonstrate 7 high impact use cases in 4 real-life living labs
- Use beyond the state-of-the-art methods to enable hybridization, utilisation and monetisation of storage flexibility, while also ensuring data space standardization.

The overarching aim of InterSTORE is to deliver a set of interoperable Open-Source tools to integrate Distributed Energy Storage (DES) and Distributed Energy Resources (DER), to enable the hybridization, utilisation and monetisation of storage flexibility, within a real-life environment. To this end, a comprehensive consortium composed by an aggregator, manufacturers, research centres, standardization organization, Independent Power Producers (IPP) and charging point operators (CPO), and different technology takers (REC, commercial users and final users) came together to deliver the goals of this project. The InterSTORE is widely demonstrated in its several perspectives by 4 Pilots to incorporate the hybridization solutions within homes, buildings, EV communities; as a stand-alone and

power-grid–connected solution, including real-time data sharing and operation within a connected data space environment.

To this end, the 4 Demo sites (Portugal, Italy, Austria and Germany) will apply 7 use cases to address the objectives of the project from different angles, plus 2 use cases, being tested in a lab environment (Spain), resulting in 9 use cases dedicated to covering the following topics:

- Demonstrate higher performance of Hybrid Energy Storage Systems
- Monetisation
- Connected Data Spaces
- Flexibility/Consumer engagement
- Interoperable tools - IEEE implementation (converter or interoperable client/server)
- 2nd life battery use and integration
- Battery support for EVs

This deliverable hence describes the use cases drafted in InterSTORE proposal and further details regarding the business context (high level use case – HLUC) and functional (primary use case – PUC) levels of the Smart Grids Architecture Model (SGAM) framework. This structure enables getting into the definition of lower-level requirements that support the integration and coordination of different management and control methods. The use case methodology follows the IEC 62559, to ensure a complete compatibility with both normalisation and European Union work in a comprehensive manner. In this regard, InterSTORE participated in the IEC62559 Bridge online tool testing phase, reinforcing the need and alignment for the common approach for UC specification. Key Performance Indicators are identified for each use case and result from project's objectives and requirements.

1 Introduction

1.1 InterSTORE Vision and Objectives

As the European Union (EU) transitions from its traditional centralized energy system to a decentralized, digitalized, and decarbonized one, the utilization of Demand-Side Flexibility (DSF) becomes indispensable. DSF is a reliable and cost-effective resource with vast untapped potential. As the electrification of end-use sectors accelerates and renewable energy generation increases in parallel, the average system flexibility needs of Member States will rise by 133% between 2021 and 2030 according to the SmartEN report [4]. According to the same source, looking ahead to 2050 compared to 2030, an even more substantial increase of 250% will be required in the EU.

This heightened volatility necessitates a re-evaluation of how the energy system is managed, shifting towards rewarding and enabling consumers to use their Behind-the-Meter (BTM) Distributed Energy Resources (DERs) in adapting their energy management strategies based on various signals, be they implicit or explicit.

This transition is consumer-centric and aligned with both environmental sustainability and digital advancement. Central to this seamless interaction between consumers and their energy systems is the exchange of data. Activation of consumers' flexibility heavily relies on smooth data flows and communication among DERs, market players, system operators, and traders. Data sharing related to those same assets, under the context of the European connected data spaces, have the potential to be valorised in various levels, as it can improve generation forecast, operation, maintenance planning or investment decision support tool just to mention a few.

However, there arise several critical questions regarding the necessary data flows to activate consumers' flexibility. Some concerns relate to standards, protocols, and ontologies required for this data exchange and if they are already available and ready to support these objectives. If so, their performance must be known and under which context, for an effective application. Within the distributed energy resources and enhancing the pertinence of seamless coordination and operation of distributed assets, comes the increasing deployment of storage systems, which with specific application, can be improved with hybrid energy storage systems.

Hybrid energy storage systems are important for several reasons, as they offer unique advantages and address various challenges associated with renewable energy integration and grid stability. Here are some key reasons why hybrid energy storage systems are significant: i) Grid Stability and Reliability, ii) Smoothing Energy Output; iii) Enhanced Flexibility; iv) Energy Time Shifting; v) Cost Savings; vi) Backup Power; vii) Environmental Benefits, just to mention a few.

The InterSTORE project, hence, brings these dimensions all together, setting as the main research pillars for development and demonstration the following:

- Interoperability using IEEE.2030.5 over NATS (further explained in D1.3)
- Enhanced performance of Hybrid Energy Storage Systems (HESS)
- Development of existing EMS with new features (further explained in D1.4)
- Connected data spaces for valorisation of data.

In this regard, the IEEE2030.5 standard will be adapted in its communication, as it will replace the current REST API based communication by NATS communication [2]. This will increase the reliability of communication, as it will move from a synchronous to an asynchronous interaction, allowing differed message exchange requests, without the risk of loss of information. It is the intention of InterSTORE to involve manufacturers and certification entities in an advisory board, so that the developments can be followed and feedback from industry can be incorporated. This is being established to ensure that after the end of the project, the technology can be adopted by the market. It will also consider a protocol converter for legacy systems. The legacy converter receives messages from the MQTT and ModBus protocols and transforms them to IEEE2030.5. However, these are just to examples, future developments are welcome to integrate more protocols converters.

The second pillar will focus on demonstrating HESS performance compared to a single battery from different perspectives such as cost, environmental performance or degradation. It will do so, while leveraging on the application and demonstration of the IEEE2030.5 InterSTORE solution deployed on the demonstration sites.

The projects considered the use of several partner's energy management solutions. The existing solutions will move beyond their current state of the art, by incorporating HESS in their service portfolios such as hybridization configurations, operational features, dispatch, etc.

The fourth pillar of InterSTORE relies on the use of connected data spaces. Building upon other European projects such as OneNet [5] and Enershare [6], the data space connector will be further developed and deployed in the several demonstration sites, allowing sharing of data and valorisation cases by the project accounting for the IEEE2030.5 communication and Storage assets. This will enhance the pertinence of seamless and interoperable communication and coordination of distributed assets.

1.2 InterSTORE Business Domains

The InterSTORE project developments and use cases are framed by a wide range of business contexts or business Models (BM). Depending on the nature of the demonstration site (industrial, residential, REC, EV related), several business models can be found and are explored and unleashed under the context of the project. The main business models are here summarised.

- Explicit Demand response - The Explicit Demand Response (EDR) business model is a mechanism that allows electricity consumers to actively participate in demand response programs and respond to specific requests or signals from grid operators or energy aggregators. In an EDR model, grid operators or energy aggregators issue explicit requests to consumers, asking them to adjust their electricity usage during specific periods or in response to certain grid conditions. These requests can be triggered by factors such as high demand, grid instability, or the need to balance electricity supply and demand in real time. Participating consumers receive these requests through various means, such as email, text messages, mobile apps, or specialized demand response platforms. These requests can be sent directly to DER, triggering them automatically in a much faster way and in shorter periods, especially pertinent in balancing services. The requests typically include information about the duration, intensity, and desired actions to be taken, such as reducing electricity consumption by a certain percentage or shifting usage to a different time period. In return for their participation and contribution, consumers in an EDR program may receive financial incentives. From the perspective of grid operators or energy aggregators, the EDR model provides a more precise and controllable way to manage electricity demand. By explicitly coordinating with consumers, they can achieve specific load reduction targets, improve grid reliability, and optimize the utilization of available resources. This BM is mostly visible in UC1, 2 and 8

- Implicit demand response – The Implicit Demand Response (IDR) business model is a mechanism that incentivizes electricity consumers to adjust their electricity usage based on the real-time conditions of the grid. It is a demand-side management strategy that aims to balance electricity supply and demand by influencing consumer behaviour without explicit communication or direct control. In an IDR model, electricity consumers are provided with price signals or dynamic tariffs that reflect the current state of the electricity market. These price signals can vary based on factors such as peak demand periods, grid congestion, or the availability of renewable energy. The idea is to encourage consumers to modify their electricity consumption patterns to align with the needs of the grid and optimize their energy usage accordingly. By responding to the price signals and modifying their electricity consumption behaviour, consumers can collectively contribute to load management and grid stability. The IDR model helps in reducing peak demand, avoiding or mitigating the need for additional power generation capacity, and optimizing the utilization of existing infrastructure. Promoted by energy retailers, the implicit demand response business model relies on market-based incentives to achieve more efficient and flexible electricity consumption, resulting in cost savings, improved grid reliability, and environmental benefits. This BM can be found in UC 5 and 6.

- Inertia, frequency - Electric Energy Storage Systems (EESS) have the ability to provide fast frequency control and inertia services to the grid. As part of the system operator responsibility to maintain the grid balance, frequency regulation and inertia are important aspects of grid stability, and energy storage systems can help address these requirements. Frequency regulation involves maintaining the grid's electrical frequency within acceptable limits. EESS can respond rapidly to changes in grid frequency by either injecting or absorbing power as needed. When the frequency drops, indicating a shortage of power, energy storage systems can inject power into the grid to stabilize the frequency. Conversely, when the frequency increases, indicating an excess of power, they can absorb power to help balance the system. Inertia refers to the ability of a power system to withstand and recover from sudden changes in power demand or supply. Traditional power plants provide inertia to the grid due to the rotating masses in their generators. As the share of renewable energy sources increases, which generally lack inherent inertia capabilities, energy storage systems can step in to provide virtual inertia. By rapidly responding to changes in grid conditions, EESS can emulate the behaviour of traditional generators and contribute to grid stability. By utilizing advanced power electronics and control systems, energy storage systems can actively monitor grid conditions and respond within milliseconds to frequency deviations or changes in power demand. They can inject or absorb power almost instantaneously, helping to stabilize the grid and maintain system reliability. The services can be market-based offerings of eligible assets and are cleared by the market operator. This BM is being considered in the HESS tests in Use cases 4 and 7.

- Arbitrage – The Energy Arbitrage business model involves taking advantage of price differences in electricity markets to generate revenue by buying energy when prices are low and selling it when prices are high. It typically relies on the use of energy storage systems, such as batteries, to store excess energy during periods of low demand or low prices and discharge it during periods of high demand or high prices. Hybrid electric storage systems have the particularity of being able to assign a battery to charge while being possible to set the other battery to charge. Even if at the end of the day the cost may be optimized the same way as a single battery, it does provide a malleable tool for operation during the day, depending on user needs. This BM can be found in Use case 5.

- Aggregation of flexibility – This business model involves the pooling together of various distributed energy resources (DERs) and flexible loads to create a virtual power plant or aggregated portfolio of resources. Flexibility is the practice of adjusting load (or energy usage) to match the supply of electricity, or grid operation needs. This model aims to leverage the combined flexibility of these resources to provide valuable grid services, optimize energy consumption, and participate in energy markets. In this business model, a third-party entity, often referred to as an aggregator or energy service company (ESCO), acts as an intermediary between the grid operator or energy market and the individual DER owners or flexible load operators. The aggregator typically enters into contracts or agreements with the DER owners or flexible load operators, specifying the terms of participation, revenue sharing, and control mechanisms. The Aggregator aggregates the available flexibility from multiple sources, such as residential or commercial buildings, industrial processes, electric vehicle charging stations and energy storage systems. The aggregated flexibility can then be used to provide a range of services to the grid or energy market, such as: Demand Response; Ancillary Services, Energy Arbitrage or Market Participation. This BM is visible in Use cases 1, 2 and 9

- Behind the meter Load optimization – In this operational mode, the user or an ESCO aims at optimizing the energy assets to achieve a given goal. Optimization can have different targets. It can for example target the maximization of revenue/reduction of cost by having in mind the energy/environmental costs, it can target minimize energy dependency of the grid or even increase auto-consumption – Use case 3, 5 and 6.

- Battery system for Electric Vehicles (EV) support – business motivation is the increase simultaneity of charging sessions which lead to increased revenues in the case of the Portuguese (PT) demo. In the case of the Italian demo the virtualisation of distributed storage units has the potential of being explored as aggregated flexibility as well as battery support for EV charging. Use case 6 and 9.

- Connected data spaces. Even though the data market aspect is not covered in this project, it facilitates several businesses, namely:

- Integration of Renewable Energy Sources: facilitates the coordination of renewable energy generation, storage and consumption;
- Demand Response and Energy Efficiency: enables energy providers to collect and analyse information about energy consumption patterns, demand fluctuations and customer behaviours;
- Grid Management and Operation: Data exchange plays a pivotal role in grid management and operation. Real-time data on power generation, transmission, and distribution is shared among various stakeholders;
- Market Operation: data exchange is essential for efficient market operation and trading. Market participants need access to accurate and timely data on energy prices, demand forecasts and market conditions
- Asset Management: stakeholders can collaboratively plan and optimize the operation, expansion, investment, upgrade and maintenance of energy assets.

The valorisation aspect of the connected data space will be further developed in T4.3 with a special focus on asset management, leveraging the perspective of operation and investments from a common data sharing. This valorisation inside the asset category can be financial analysis for decision making, preventive maintenance planning or others. The Connected data spaces will be tackled in UC 1, 2, 3, 5, 6, 8 and 9

- The project as a whole will also promote and enable the wide adoption of the IEEE2030.5. Since the IEEE2030.5 converter will be adapted using NATS, and see its own legacy protocol converter developed using MQTT and ModBus conversion. The new protocol will be subjected to a certification process which, will also promote an exploitation of the project as a business. For this, the project has set up a call for interest for organizations who would like to follow the project and be part of the InterSTORE advisory board. This would allow the interested organizations to follow the developments, provide suggestions and get aware of the testing procedures as the basis for the future business model implementation. The IEEE2030.5 implementation will be visible in Use cases 1, 2, 3, 5, 6, 8 and 9

1.3 InterSTORE Demonstration Locations

The InterSTORE project has from its very inception, the vision to test a wide range of use cases, to demonstrate the IEEE2030.5, HESS solutions and Data Space deployment. A variety of geographic locations would by itself leverage this, but it was also achieved by including these features in distinct environments; Residential, Commercial, Industrial and EV charging cluster. Figure 1 depicts the location of each environment.

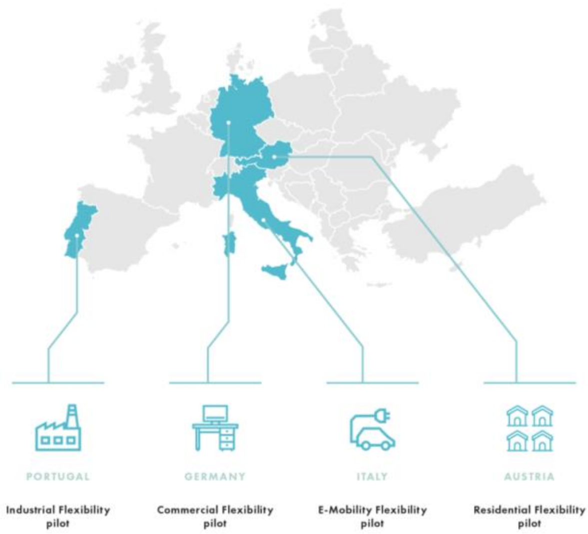

Figure 1 - Distribution of InterSTORE Demo Location

1.3.1 Industrial Flexibility Pilot Portugal

The Portuguese pilot project will take place at Sonae Campus, in Maia. The Campus is composed of many companies that share the same electrical network fully managed by Capwatt in the command and control centre 24/7. This electrical network currently has PV production systems, several charging points for electric vehicles (AC of 22kW and one DC of 160kW) that feed the fleet of the companies located in the industrial park, and an electric energy storage system of 320kW/798kWh, a 7.4 MWe CHP, among other technologies. In this way, the pilot intends to install a small ESS next to the hub of the electric vehicle chargers and manage the distributed storage, controlling and operating, the ESS already installed, the system to be installed and two more systems (a HESS and an ESS of 2nd life batteries) that are already planned and expected to be installed in the next few years. Figure 2 and Figure 3 show details about the equipment to be used in the demo site.

Figure 2 - EV charger detail and parking lot part of Use Case 6 (left and center), and Vanadium Battery from Visblue manufacturer and Lithium batteries, part of Use Case 5 (right)

The pilot foresees the use of the ESS next to the EV chargers, to increase the capacity of the electric grid nodes, without the need to change or upgrade the currently installed infrastructures. The battery will be charged when the power supply is lower than what the grid is capable of and discharged when the chargers need more power than the grid can give.

Figure 3 - PV installation example (left) part of Use Case 5 building and EV charger (right) from Use Case 6

Objectives

- Demonstration of the integration of distributed resources in an industrial context
- Increase acceptance and improve end-user perception for the provision of services foreseen in the UCs for the industrial hub network
- Demonstrate integration with connected data spaces and the consequent valorisation of data
- Demonstrate capacity services and itinerant flexibility, promoting the renewable energy penetration

1.3.2 Commercial Flexibility pilot Germany

Forschungszentrum Jülich (FZJ, "Jülich Research Centre") is a German national research institution that pursues interdisciplinary research in the fields of energy, information, and bioeconomy. In particular, at the Institute of Energy and Climate Research - Energy Systems Engineering (IEK - 10) it develops models and algorithms for the simulation, optimization, and control of energy systems, with a focus on multi-physical energy grids, industrial energy systems, and buildings and districts.

The Living Lab Energy Campus (LLEC) at FZJ constitutes a testbed where both innovative hardware and software solutions for district energy systems are tested under close to real conditions, in a scientifically monitored environment incorporating real users. The basis for LLEC is formed by the already existing infrastructure of the FZJ, which is one of the largest interdisciplinary research centres in Europe. The research centre forms a self-contained district with few infrastructural connections to the surrounding area. The main part of the research centre in Jülich covers an area of about 1.7 square kilometres with approximately 150 buildings, multiple large test facilities, and supercomputers. The infrastructure consists of an electricity grid at various voltage levels, a meshed heating grid, various cooling grids, and a gas grid. Within LLEC, different energy demonstrators for both generating and storing energy are integrated into the existing infrastructure in such a way, that the resulting infrastructure forms an ideal testbed for future multi-modal district energy systems with a high share of intermittent renewables energies. In the commercial flexibility pilot located at FZJ, by making use of the Living Lab Energy Campus (LLEC) infrastructure, the following assets will be integrated:

- High energy battery system, Tesla Megapack (500 kW/2.6 MWh)
- High power battery system, Riello (1.5 MW/500 kWh)
- Large photovoltaic system (1.1 MWp)
- Heat-pump, Viessmann Vitocal 350-HT Pro

In use case 3 (UC3), the interoperable protocol converter developed in InterSTORE will be used to interface two large battery storage solutions with the energy management system of FZJ, that runs in the local FIWARE-based ICT-platform. In use case 8 (UC8), the same battery systems, a heat pump, and a large PV system will be interfaced with multiple Home Management Systems (HMSs) from Eaton, to enable flexibility optimization of a multi-physics-based system of an energy community. The batteries can be seen in Figure 4.

Figure 4 - Overview of assets integrated at Julich Living Lab Energy Campus. From the top-left corner: Riello battery system, Tesla battery system, photovoltaic installation, heat-pump.

The commercial flexibility pilot will contribute to achieve the following objectives:

- Develop and deploy harmonization software protocol to integrate different distributed storage applications ensuring interoperability (Interoperable DES).
- Integrate and explore synergies of a HESS to enable its operation as a conventional BESS, with enhanced performance.
- Enable data valorization and data-driven service digitalization.

1.3.3 E-Mobility Flexibility Pilot Italy

Enel X is the Enel Group company that supplies innovative products and services for energy transformation at home, city and industrial level, with a view to sustainable development. By applying the solutions offered by digital transformation to the energy sector, Enel X is active in the field of electric public transport, smart homes and smart cities, intelligent public lighting and services for the integration of renewables, energy efficiency for businesses and public administrations. Enel X is working with a rich set of partners in order to provide integrated solutions to the final customers. The innovation has a crucial role and different alternative are exploited, innovation by vendor is a frequent option. The living labs are recognized as an efficient option to quickly develop integrated solutions built from different internal/external products at any Technology Readiness Level (TRL). Particularly the living lab is considered a multidisciplinary phenomenon and it encompasses various research domains despite typically being discussed under open and user innovation paradigms. What is more, the existing literature views living labs simultaneously as landscapes, real-life environments, and methodologies, and it suggests that they include heterogeneous stakeholders and apply various business models, methods, tools and approaches. Finally, living labs face some challenges, such as temporality, governance, efficiency, user recruitment, sustainability, scalability and unpredictable outcomes. In contrast, the benefits include tangible and intangible innovation and a broader diversity of innovation [1]. Starting from these assumptions Enel X decided to develop the two X Lab described in this document. Figure 5 shows an overview of the laboratory facilities.

Figure 5 - XLab Rome example of equipment and facilities (Itech inverters, Control room and Li battery container)

XLAB ROME Enel X Lab Rome was completed in 2022 and is located in Via Flaminia 871, Rome, Italy, inside a facility that also hosts 2 Labs for testing e-mobility charging solutions (operated by Enel X Way, one of Enel's companies) and the wider public high-power charging (HPC) stations of Italy (operated by Ewiva). Inside X Lab Rome 5 labs are present: – X Lab 1, X Lab 3 and X Lab 5. X Lab 2 and X Lab 4 are the overmentioned e-mobility Labs. X Lab is the test field for middle scale solutions (e. g. middle residential, small commercial and industrial) and it is made by 2 interconnected microgrids (MG). XLab3 is the test field for small scale solutions (e. g. small residential, very small commercial and industrial). Below the list of equipment that can be found in each of the labs involved in the demonstration:

LAB 1			
PV1 Inverter AC/DC	XW Pro Hybrid Solar Inverter	Schneider Electric	CONEXT XW PRO 6.8 KW 120-240V INVERTER 48V CHARGER
PV1	bifacial Enel 3SUN panels that can reach 14.5 kWp in bifacial way	3SUN	12 kWp
Inverter PV2	XW Pro Hybrid Solar Inverter	Schneider Electric	CONEXT XW PRO 6.8 KW 120-240V INVERTER 48V CHARGER
PV2	bifacial Enel 3SUN panels that can reach 14.5 kWp in bifacial way	3SUN	12 kWp
Inverter EV Recharge	XW Pro Hybrid Solar Inverter	Schneider Electric	CONEXT XW PRO 6.8 KW 120-240V INVERTER 48V CHARGER
DC Storage	Four modules battery LI-ION	Pylontec	4X2,4kWh
AC/DC Storage Inverter	Storage inverter		
Simulators	2	ITEC	
LAB 3			
DC PV3 Plant	Bifacial	3SUN	3,7kWp to 4,5kWp
DC Electrical Storage	Supercapacitor Energy Intensive	Greentech	5,5kWh
DC PV4 Plant	Bifacial	3SUN	3,7kWp to 4,5kWp
DC Electrical Storage	LI-ION	Pylontec	4x2,4kWh
LAB 5			
Containerized Battery storage	Li-Ion electrical energy storage system (EESS)	LG	132 kVA – 274 kWh
AC PV5 Plant	Bifacial	3SUN	102 kWp up to 125kWp
Multiple AC V2G Charging Station			

Figure 6 illustrates the systems and assets involved in Use case 9 to be used by EnelX.

A summary of the XLab Rome capabilities:

– Two separated point of deliveries (PODs) with very high connection power (1.8 MVA for each one) allow the possibility to test system and devices up to the industrial sizes.

– Several switches are enabled to be used for the on/off grid transition.

– The specific DC architecture allows to change the nominal voltage from 48V to 750 V simply acting on the X Lab control and to the poles connection inside switches and breakers.

– The adoption of DC and AC regenerative grid simulators allow the maximum degree of power flow management, while simulating from any kind of appliance and generators to entire grids.

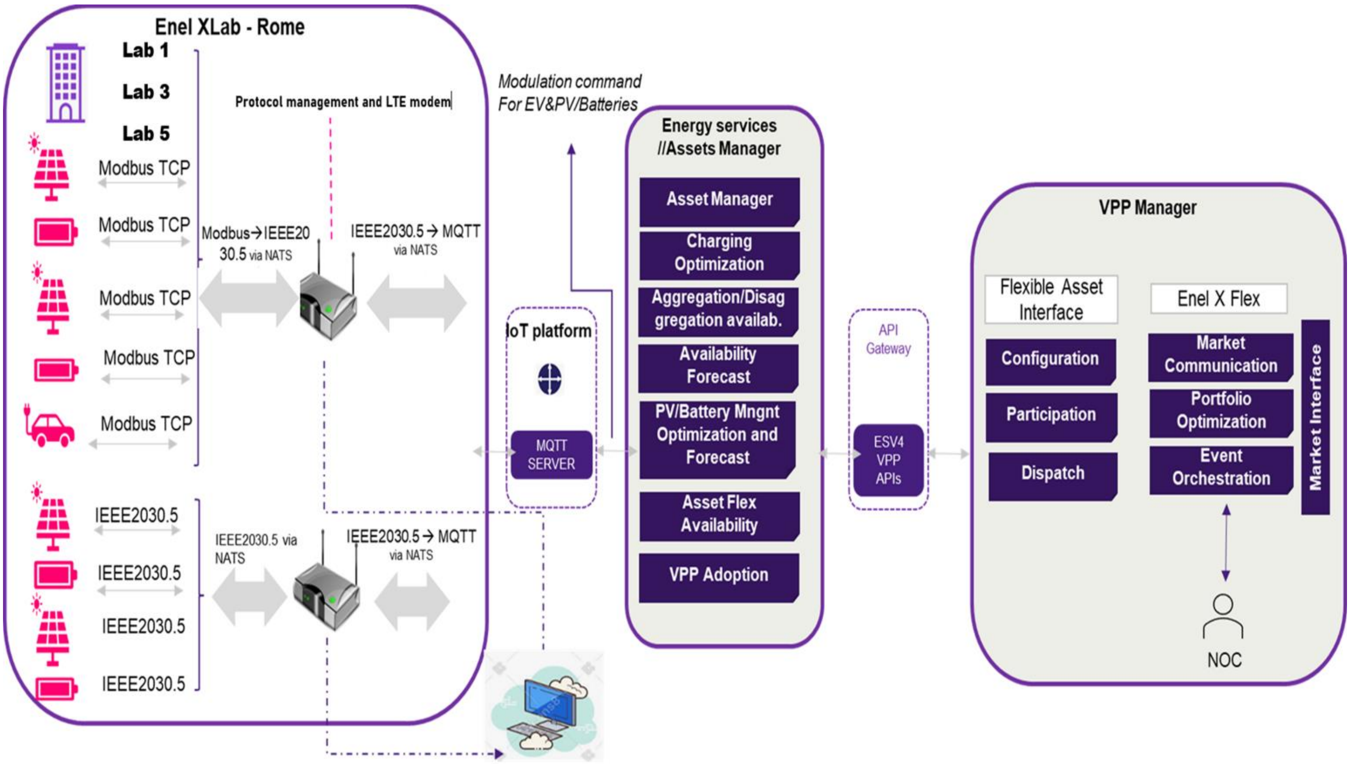

Figure 6 – Xlabs Rome: Systems and assets involved in Use case 9.

– Three levels of monitoring, all the devices, breakers and switches are smart (sensors inside) creating the first levels, the second level is made by the sensors inside the cubicles, finally the third level is made from power quality instruments (PQIs).

– Non-destructive inspection systems, like the Advanced Thermal Imaging system with digitalized data management, automatic diagnosis, object identification, instant data synchronization, and one-click report generation.

1.3.4 Residential Flexibility Pilot Austria

The Austrian pilot is located in the areas of operation for EVN in the region of Lower Austria and within the residential sector depicted in Figure 7. EVN is one of Austria's largest DSO, energy supplier and energy services providers and is coordinating the EU Innovation Fund project Green The Flex (GtF). Other GtF's project partners, apart from EVN and CyberGrid, are TIKO (heat pumps aggregation) and Fronius (inverters manufacturer). EVN is also the parent company to CyberGrid, who is leading the InterSTORE Residential Flexibility pilot. This pilot area was chosen to achieve synergies between this project and the GtF project which plans to aggregate more than 2500 decentralised units until 2025 and use them for ancillary services, making more than 6 MW of power and more than 5 GWh/a short term load shift potential accessible to our energy system as flexibility. Out of this large aggregation pool, created for the needs of GtF project, CyberGrid will pick approximately 20-30 most suitable DERs and use them as a pilot site for the InterSTORE project by forming two energy communities out of this smaller pool. The two created Energy communities will be used to demonstrate the developed interoperability toolkit and new generation of Energy Management System functionalities (e.g. enhanced Flexibility Management Platform cyberNoc) through two use cases (UC1, UC2).

Figure 7 - Location and overview of Austrian Renewable Energy Communities sites

The two energy communities will also be used to compare different operational modes, like market optimization and self-sufficiency, in addition to showcasing newly developed features of CyberNoc including ex-post accounting and HESS integration. Furthermore, in the integration and testing project phase, CyberGrid will leverage its Smart Grids Laboratory Infrastructure for hosting flexibility management platform and a laboratory setting of smart meters and several RTU/IED devices for simulating, testing and evaluating various demand response, distributed generation and storage configurations, TSO/DSO market bidding and activations, wholesale electricity markets and various use cases. These objectives will be achieved by aiming to address the following topics within the call text:

- semantic interoperability;
- common protocol and solutions between different stakeholder groups, i.e. brands and sectors;
- privacy, liability, security;
- framework for use of data, accounting for GDPR;
- real-time data sharing and operation; and
- energy community business model development.

One of the Energy communities' sites used in the project is the Renewable Energy Community of Dietach, "Erneuerbare Energiegemeinschaft Dietach". The community is in full operation since 01.03.2023. It has 63 participants and can be seen in Figure 8.

Figure 8 - Dietach Renewable Energy Community

The community counts with 103 metering points, 38 PV systems totalling around 700kWp, 24 heat pumps and 13 EV charging stations.

The second Energy Community is the Renewable Energy Community of Heiligenkreuz "Erneuerbare Energiegemeinschaft Heiligenkreuz", with 75 members and active from 01/02/2023. It counts with 87 metering points, 17 PV systems with approximately 250 kWp, 19 heat pumps and 19 EV chargers.

1.3.5 Spanish laboratory demonstration

The laboratory, located in Valencia (Spain), has 1.5 MW of connected power systems, as well as AC and DC current buses, and a capacity to recirculate up to 500 kW of power. It also integrates a hybrid storage system, integrating 200 kW/200 kWh lithium batteries and 250kW/60 sec ultracapacitors. The general control unit of the laboratory is based on the InMS™ platform, HESStec's energy management system, a fundamental piece for the development of storage at all levels. Implementing services such as Grid forming or Black start. The ability to emulate renewable sources also allows to validate a wide portfolio of network services, thus verifying the potential of hybrid plants, in order to maximize their functional and economic profitability. This infrastructure gives HESStec the opportunity to respond to the need to validate storage solutions before being implemented in real scenarios validating their functionality, and generating confidence in the potential and benefits that this technology offers to the different actors in the value chain of the energy market.

The Advanced Grid Lab in Valencia has the possibility to emulate the behaviour of different renewable generation-based unit next to the developed HESS system. The objective of our laboratory is to provide a testbench for the implementation of different use cases as in pilot side needs. HESStec's laboratory offers the capability of generating frequency deviations and the power electronics along with the control systems. Moreover, it has the capability of transitioning from a grid-following mode to a grid-forming mode. Thus, the laboratory is the perfect environment for implementing selected uses cases, supporting the validation of hybrid energy storage systems and energy management platform as enabling technologies of the energy transition. The main cabinets can be seen in Figure 9.

Figure 9 - Connection cabinets and power conversion system at HESS

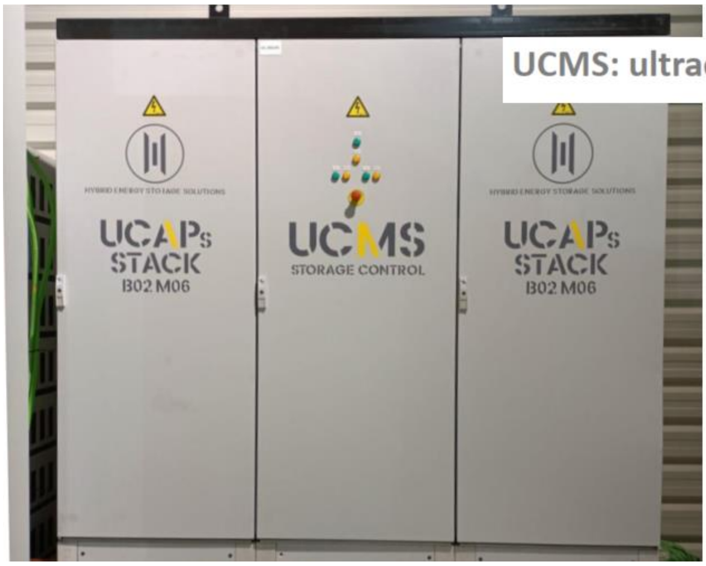

Figure 10 - Ultra capacitors energy storage devices

Figure 11 - High Density Energy Storage Lithium batteries

The ulta-capacitors equipment can be seen in Figure 10. While lithium energy density storage is in Figure 11. The ultimate goal of HESStec's laboratory is to facilitate the development of advanced energy management systems and hybrid energy storage solutions that respond to the current and future challenges of the electrical system, as well as accelerating its validation and certification, while increasing the confidence of end users in this type of solutions.

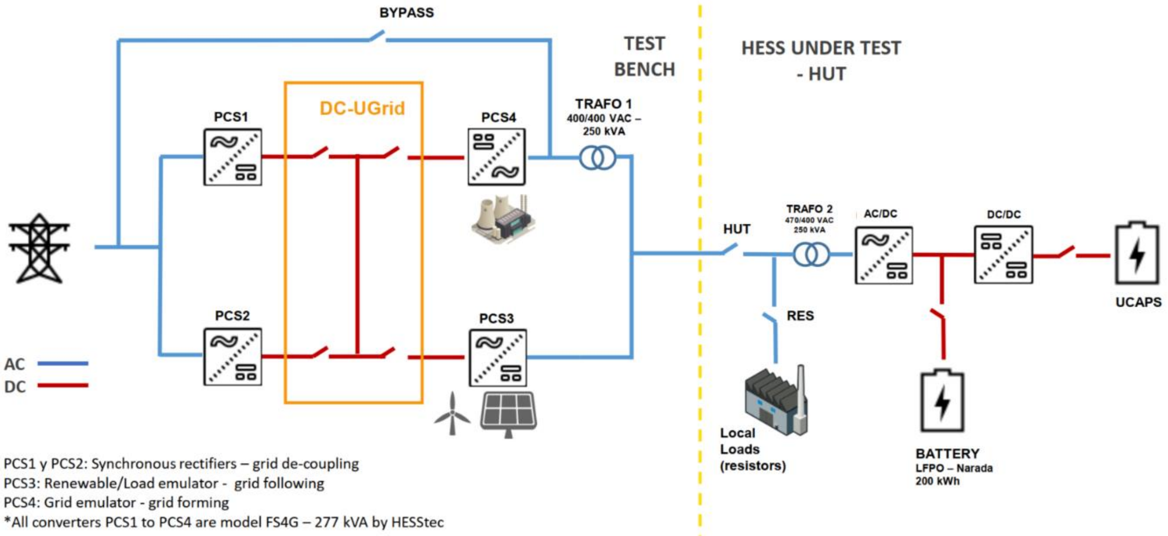

Figure 12 - General diagram of the testing laboratory for large scale hybrid energy storage integration.

The general diagram of the lab can be seen Figure 12. Besides the capabilities of a HESS to provide inertial responses and grid forming features (UC4), another innovative element for the project is the interoperability between the node management system (NMS) and the distributed energy management system (DEMS), testing and validating the State of Function (SoF) parameter, as the cornerstone of HESStec in terms of interoperability (UC7).

1.4 Document Objectives and Structure

The purpose of this deliverable is to provide an overview of the objectives and demonstrations setting the stage for WP5 responsible for the pilot run. It outlines the use cases for InterSTORE, centered around Hybrid Energy Storage Systems, Interoperability, and connected data spaces. The deliverable was thought to offer a clear understanding of the practical implications of the project, scope and structure. Stakeholder Engagement, monetisation, battery usage for EV support and use of 2nd life batteries are elements identified in the proposal and in this deliverable, becomes clear where they are tackled.

Chapter 1 - Presenting InterSTORE: This document introduces the InterSTORE's objectives and highlights its significance in the field of Hybrid Energy Storage Systems. It provides a comprehensive understanding of the project's goals, technologies involved, and potential benefits. It does so while framing the business models under which the project operates.

In chapter 2 – Presents the requirements explaining the writing and maturing process of the use case specification. The work methodology is explained and KPIs, initially defined and revised as well as the targets established as a project. The expanded list of KPIs coming out of the specification activity is also presented in this chapter.

In chapter 3 - Use Case Identification: This chapter identifies and describes the several key use cases that demonstrate the practical applications of InterSTORE. These use cases will highlight the project's capabilities and showcase its potential in addressing real-world challenges related to energy storage and management. A short narrative is presented, actors are identified and communication needs are clarified. This section invites the reader to further explore the details of each use case in the Annex 2 section, where sequence diagrams are identified and also messages to be exchanged. Even though it does not go into the detail of message content, units, time step etc…it already identifies the needs and the nature of that communication.

Chapter 4 - Conclusion and discussion focusing on HESS, Interoperability and Connected Data Spaces. Provides insights to partners responsible for developing the task related to interoperability and connected data spaces. The document will emphasize the importance of interoperability and connected data spaces within the context of Hybrid Energy Storage Systems. It will explore the role of InterSTORE in enabling seamless integration of diverse energy storage technologies, facilitating data exchange, and promoting efficient system operation. This chapter will conclude with the identified requirements under a business context, but also for the data spaces activity and demonstrations. It also makes an initial assessment of the risk identified in this stage of use case specification.

The complete Use Case description, all the nine cases will be placed under the annex section for the reader’s convenience.

2 InterSTORE Use Case Methodology

2.1 Definitions

The following nomenclature and definitions are used across all use cases, as well as in this report.

Domain is an area of knowledge or activity characterized by a set of concepts and terminology understood by the practitioners in that area. EXAMPLE Taken from Smart Grid/energy system area: Generation, transmission, distribution, customer.

Actor is an entity that communicates and interacts. A Role is played by an actor in interaction with the system under discussion. EXAMPLES: A legally defined market participant (e.g. grid operator, customer), a generic role which represents a bundle of possible roles (e.g. flexibility operator) or an artificially defined body needed for generic process and use case descriptions. It is important to emphasize that an actor can have different roles and different actors can play the same role.

Use case describes functions of a system in a technology-neutral way. It identifies participating actors that can for instance be other systems or human actors that are playing a role within a use case. Use cases can be specified on different levels of granularity and are according to their level of technological abstraction and granularity described either as High-Level Use Case (HLUC) or Primary Use Case (PUC).

Interoperability – In this project interoperability is being tacked at two levels. Firstly, behind the meter between inverters of DER and EMS/BMS using the IEEE2030.5 standard and improvements. Secondly, by the connected data space. InterSTORE makes use of the OneNet project version of the data connector, with upgraded features ensuring interoperability by using common dictionary of terms (Ontologies) within the context of Storage and hybrid systems for data exchange and corresponding service provision

HESS – Hybrid Storage System. Sister Projects FLEXCHESS and PARMENIDES have used broader/tolerant definitions of hybrid system, including flexible assets, which could reduce/increase their operational setpoint.

Functional requirements capture the intended behaviour of the system. This behaviour may be expressed as services, tasks and functions, which the system is required to perform. Use cases are a valuable tool to capture the functional requirements of a system.

Non-functional requirements capture general restrictions the system is subject to, such as:

- Pre-existing architectural constraints.
- Architectural qualities (extensibility, flexibility…).
- Performances, reliability, fault tolerance, frequency.

- Maintainability.
- Security.
- Priority.

Finally, it is important to underline that use cases must capture all of the functional requirements of a given system (business process or function), and part of its non-functional requirements (performance, security, or interoperability for instance), not based on specific technologies, products, or solutions.

2.2 Use Cases Identification and Writing Process

The Use case general concept was developed in the InterSTORE proposal stage. It then evolved to a more mature idea with the beginning of the project with the Use Case specification. With the use cases identification, InterSTORE started with a Workshop organized in the beginning of January 2023 (kick-off meeting) and kept its efforts in promoting meetings every two weeks, to check the progress of each partner in the task. The IEC62559 standard was followed to be aligned with the European project trend in specifying use cases. Moreover, the template provides a guide and a common language, promoting a common stage for fruitful discussion. As part of the use case specifications, the task T1.2 aimed at providing clarity for the connected data spaces framework in, InterSTORE by identifying message exchange between actors on one hand, and what equipment and systems would be able to share data on the other. Furthermore, the use case template clearly requests the objectives and ways to measure its achievements by KPI definition, helping the pilot responsible to maintain focus and effectiveness in the demonstrations, by aligning with the project's objectives. All mandatory sections of the template were followed, and the optional section 6 was incorporated since it defines the requirements of systems, platforms, and communications.

The initial list of KPIs of the proposal were maintained and expanded, aligning with the objectives defined for each of the Use Cases. The writing process was a collective effort and continuous alignment of demo responsible and the task leader. A cluster initiative was promoted with the other two projects awarded with funding for the same call, referred to as "Sister Projects", FLEXCHESS and PARMENIDES running at the same time as InterSTORE. During the specification of the Use cases a first workshop was held to share use cases, definition, and goals. There was a common understanding regarding the following topics:

- Opportunities to improve existing ontologies to incorporate hybrid storage related terms in Energy.
- A shared valued vision regarding data sharing for the valorisation and data driven services.
- The need to tackle interoperability between DER and EMS, considering the foreseen mass deployment of DER (shared with FLEXCHESS and InterSTORE).
- Explore the performance of connected hybrid storage systems.

Another workshop will be promoted closer to the demonstrations to share lessons learned and challenges.

The KPI identification was fruit of bilateral meetings, in which each partner was challenged to identify how they would be able to measure the achievement of the objectives set out in the Use Case. The data and Demos results template, as well as the baseline and methodologies for the calculation following the FAIR data approach was discussed with the

T1.2 (Use case definition) task leader and WP5 demo leader. A matrix of objectives was defined, aligning the call requests and projects objectives, to ensure all elements were being covered by the demos and provide an overview of common areas among use cases. Table 1 provides the mapping of the contributions by use case to the classes of objectives.

Table 1: Use Case Matrix with contributions to main objectives

Use Case name	HESS performance	Monetisation	Connected Data Spaces	Flexibility/ Consumer engagement	IEEE 2030.5	2nd Life Batteries	EV Battery support
DES Flexibility Market Monetisation	x	x	x	x	x		
Energy community DES utilisation	x	x	x	x	x		
Grid supporting BESS	x		x		x		
Innovative Frequency services	x			x			
Hybrid storage for higher performance and flexibility provision	x		x	x	x	x	
Management of battery systems for Node capacity increase				x			x
Adaptive BESS management for autonomous grid operation	x			x	x		
Multiphysics flexibility optimization for Home Management Systems and their global integration	x			x			
Management of EV charging clusters as HESS			x		x		x

The methodology followed the European adopted standard IEC62559 and Bridge promoted standard. In this context, following the Q1 Bridge GA, InterSTORE participated in the online testing tool of the IEC62559 template, identifying improvements and sharing the user experience (UX), by submitting a set of use cases. The tool holds a repository with UC and is part of the EIRI platform and is being hosted by the JRC.

2.3 Identification of requirements

The use case is a powerful tool to document existing functional requirements and find non-functional requirements (e.g., technology requirements, data variation, interface requirements, execution time). The methodology was also used to identify the impact of the changes and opportunities brought by smart grid implementation, electricity market development and new regulations. The template of the IEC62559 provides 8 sections, being the first 5 mandatory and the last three optional. Given that one of the intentions of following the UC template was to provide some initial insights of requirements, the section 6 even though optional, was kept. These were identified as part of the following categories: configurations, data exchange and security requirements.

The functional requirements correspond to each sentence of the step-by-step description of the use case ("Complete Description" – see Annex II), i.e. what its associated actors must do. When the use case is complete, we can assume that the main functional requirements were documented, even if in a first attempt. Non-functional requirements are identified in a specific section of the use case. The partners were encouraged to use the categories and list of non-functional requirements defined in IEC 62559. The list of non-functional requirements was provided to the use cases' writers in order to provide guidelines on possible values that could be given to each type. However, other values not included in the list could be used if necessary. The tentative list of requirements was defined in tables 5 and 6 of the UC template for each use case. Three categories were highlighted during the UC specification:

Message exchange: During the IEEE2030.5 integration discussion and message exchange requirements, when the NATS improvement (beyond REST API) was discussed, some services were brought into light, especially the ones related to inertia and frequency response to be tested by HESSTec). The main function of HESS hybridization system is based on Power based and Energy based for frequency regulation but specifically for inertia services, where communication under 50ms is required. This became a target to be investigated once NATS communication was implemented with a native installation of the IEEE2030.5. Regarding the legacy protocol converter, the requirements regarding protocol conversion were found to be MQTT and ModBus. For the remaining UC, A common definition of data exchange was identified, specifying only at this stage the message nature in each of the scenarios of the use cases.

Configurations – This element was widely discussed in a need for the deployment of the IEEE2030.5 and the data connector. The task responsible partners for these two developments were in charge of promoting internal workshops to instruct what configuration need to be done by the demo responsible. As examples i) the need to configure a static IP address for the connector communication; ii) the need to specify all local existing protocols in the demo sites that the IEEE2030.5 must integrate. iii) need to configure optimization algorithms with the input values from the demo resources.

Securities – Given that most of the use cases will be sharing operational data of their resources via connected data spaces, security measures and concerns were shared. Issues such as data ownership, access control, and the connector deployment were addressed. Moreover, third party communication, which exist in some use cases such as UC1,2 5 and 6 need to implement security measures to ensure the third party is authenticated and allowed to exchange information (ex: CapWatt Cloud data monitoring system and InescTec HEMS). Other security measures identified are firewall, password implementation and token usage in API communication.

Finally, it is important to underline that both HLUC and PUC do not capture all non-functional requirements. First, they do not intend to describe algorithms or aspects related to the design of a system's user interface. Including these elements in the description only adds complexity and length to the use case, which should ideally be as simple and as concise as possible. Besides, use cases, to be considered as generic, should not be based on specific technologies or products.

2.4. Identification of KPIs

The InterSTORE proposal set itself ambitious targets to an initial set of performance indicators described in Table 2, which were expanded during the Use case specification task, to capture individual specificities.

Table 2: Initial set of KPIs defined in the proposal and targets.

KPI Nbr	Description of initial KPI
KPI 1	Number of aggregated DES: ≥20
KPI 2	Number of energy communities: ≥2
KPI 3	DES time to market: ≤5 working days
KPI 4	DES multi-service support: · local primary operation, · ≥1 grid supporting service (DR, voltage, reactive etc.), · ≥1 balancing market (e.g. aFRR, mFRR).
KPI 5	DER integration savings for end customers
KPI 6	No. of different DER devices and EMS systems successfully tested and demonstrated
KPI 7	Integrated capacity of the HESS within the pilot site exchanging data KPI–Nbr. of beyond storage digitized assets integrated in the common data space exchanging data
KPI 8	Demand side flexibility potential increase due to hybridisation implementation
KPI 9	Nbr. of digitized storage systems integrated in the common data space
KPI 10	Energy volume Exchange kWh between different assets within ENX test bench
KPI 11	Coverage of Interoperability scenarios between different assets - Minimum 2 assets (e.g. batteries + chargers, chargers and PV only, pv+chargers+batteries, chargers+building etc…)
KPI 12	Number of grid peak avoidance in interoperability scenarios in Rome Lab site
KPI 13	Data volume related to 6 months experimentation duration
KPI 14	Number of APIs for monitoring and control Economic analysis provided to engage EV user group and Demand Response programme to promote 3rd party engagement in interoperability scenario
KPI 15	Cost avoided with installation improvements due to the installation of hybrid systems (measured in €)
KPI 16	Improved acceptance and perception by end users (surveys at start and end of demo)

KPI 17	Number of cases developed with data valorisation (assess longevity, maintenance, pay-back, ROI,...)
KPI 18	Amount of flexibility provided (measured in kW)
KPI 19	Amount of capacity provided (measured in kWh)

From the initial list of KPIs presented in the proposal, there was the need to further incorporate performance indicators, given the variety of resources available and objectives. The proposed targets will be evaluated as collective goals at the end of the Demonstrations and complemented with the new performance indicators presented in Table 3. These will be used to assess the achievement of the objectives and provide metrics for analysis and recommendations.

Table 3: Extended list of KPIs developed during the Use case specification.

KPI Nbr.	KPI Name	KPI description	Apply to UC
1	Forecasting accuracy	Used to evaluate the accuracy of the forecasting algorithm (load/generation). This is a measure for the reliability of the applied forecasting method as a function of the considered forecast horizons. This provides an error measure for the variance of the considered load/generation prediction horizons in the field. Divided between MV and LV	1
2	DES multi-service support	Number of grid supporting service (DR, voltage, reactive etc.), provided by a specific DES.	1
3	DES multi-service market participation	Number of possible balancing and power exchange markets (e.g. aFRR, mFRR, intra-day) on which specific DES can participate.	1
4	Battery capacity	Amount of Flexibility provision in the demos from HESS (Target: >220 kW)	All
5	Diversity of DER	Number of different DER devices successfully tested and demonstrated	All
6	Asset management monitored by EMS	Number of assets monitored by the InterSTORE EMS solutions (Target: 50)	All
7	No. of assets aggregated	Number of assets integrated with the Aggregation platform presenting hybrid market bids (Target: 60)	2
8	N° of end users involved in HESS	N° of end users (workers, EV users, consumers) engaged in the demonstration of interoperable HESS	3,4,5,6,7,8,9
9	Demand Response cost	This KPI evaluates the electricity cost per kWh which is to check the optimization of the energy plan of flexible demands.	2
10	Time savings	Time saved for end customers integrating DER (end customer target: 80% of time savings)	3

11	Nbr. of DER assets tested with IEEE2030.5	Number of different DER devices and EMS successfully tested with the IEEE2030.5 and demonstrated in real-life pilots (project target: 16)	All
12	Data space digitized assets	Amount of digitized storage systems/platforms/hubs assets integrated in the common data space exchanging data (project Target: 50% of the assets)	1,2,3,5,8,9
13	Time savings	Demand side Flexibility potential increase due to hybridization implementation (Target: >20%)	4, 7
14	Monitoring	N° of assets monitored in GridLab for the project	4, 7
15	Time response	is considered as the overall HESS system time response which will be needed for providing the service complying TSO grid codes.	4, 7
16	System NADIR	indicator that corresponds to the lower frequency value during frequency regulation services	4, 7
17	System ROCOF	Indicator which results during the first instants after the time of occurrence of an event during fast services	4, 7
18	Data Valorisation cases	Number of cases developed with data valorisation (assess longevity, maintenance, pay-back, ROI)	All
19	HESS performance	Improvement of cost reduction and lifetime extension VS energy supply due to HESS when compared to a single battery	5
20	Data Spaces	Nbr. Of shared services/files subscribed and published	5
21	User Engagement	Improved acceptance and perception by end users (surveys at start and end of demo)	6
22	Demand Response	Amount of flexibility provided (measured in kWh). Amount of kWh resulting from shift from baseline (forecast consumption)	6
23	Node power increase time	Time (in minutes) in which the power demand was higher than the upstream capacity, by using the battery support for that increase.	6
24	Node power increase percentage	Maximum percentage of Power surpassing the installation's capacity due to the use of the battery to charge the EVs	6
25	User participation	Percentage of users (being monitored) actively following the DR inventive. Actively meaning that they follow the incentive (deviate from past behaviour) on the majority of days during the demonstration	6
26	Integrated capacity	Integrated capacity of the HESS within the project demos (Target: 1 MW)	All
27	Increase of flexibility	Demand side flexibility potential increase due to hybridization implementation (Target: >20%)	All
30	Energy Volume exchanged	Energy volume Exchange kWh between different assets within Enel X test plant	9

31	Different hybridization configuration	Hybridization scenarios with 2 or more different assets	9
32	Grid peak avoidance	% of reduction of grid peak power due to flexibility activation	9

The following Targets were set in the beginning of the project as for the end of the project. Both T1.2 as well as T5.1 will align and make sure the coordination between demonstrations will collectively fulfil the targets. Each KPI and corresponding target is shown in Table 4

Table 4: Project KPI and targets set during proposal

KPIs per Topic Outcome	Targets (OYPE)
Topic Outcome 1: New generation of energy management systems implemented to provide the capability of a hybrid energy storage systems (HESS) to work as a conventional battery energy storage system	
KPI4 - Integrated capacity of the HESS within the project demos	1MW
KPI7 - Amount of Flexibility provision in the demos from HESS	>220kW
KPI8 - N° of monetized events in the demos of flexibility from HESS	60
KPI9 - N° of assets integrated with the Aggregation platform presenting hybrid market bids	60
KPI5 – Improvement of balancing performance of HESS	>20%
KPI6 – Demand side Flexibility potential increase due to hybridization implementation	>20%
Topic Outcome 2: Agreeing in wide scope of stakeholders including EV community and other sources of storage (e.g. flexible heat pumps) on a common protocol.	
KPI11 - N° of users (companies, CPOs, REC) engaged in the demonstration of interoperable HESS solutions	16
KPI12 - N° of end users (workers, EV users, consumers) engaged in the demonstration of interoperable HESS solutions	500
KPI3 - N° of assets monitored by the InterSTORE EMS	50
KPI21 - N° of SMEs and other stakeholders engaged in the tech transfer ecosystems	100
KPI1 - Protocol implementation savings for DER (e.g. inverter) and EMS manufacturers due to open-source software toolkit and testing procedures	60%
KPI2 - DER integration savings for end customers	80%
Topic Outcome 3: Validation of user acceptance, and demonstrating concepts that ensure privacy, liability, security and trust in connected DS	
KPI19 – N° of communication through project events and web portals	100
KPI22 - N° of stakeholders reached by the tech transfer initiatives	>250
KPI23 – N° of stakeholders willing to integrate the interoperable Open-source tools	>250

KPI20 – N° of standards and regulatory bodies approached and influenced by the project	3
KPI15 - Data space – Amount of beyond storage digitized assets/platforms/hubs integrated in the common DS exchanging data	50%
KPI24 - Increase in customer energy awareness and acceptance towards hybrid enabling services	60%
Topic Outcome 4: To encourage European citizens and businesses, especially SMEs to deploy storage, the ease of use and consequently interoperability are a must	
KPI17 - N° Of recommendations for the replication of the InterSTORE use case solutions across demos, based on replicability models and best practices introduced and validated in the scope of the project	>30
KPI18 - N° of Digital Innovation Hubs (DIHs) reached as potential adopters/disseminators. Including through workshop organization and collaboration with 2Zero, Bridge and others.	10
KPI19 – N° of communication through project events and web portals	>100
KPI11 - N° of users (companies, CPOs, REC) engaged in the demonstration of interoperable HESS solutions	>200
KPI10 - N° of use cases where new EMS will be demonstrated	9
KPI25 - N° of end users (workers, EV users, consumers) reached by various dissemination channels	>1000

2.5 Benefits of the methodology for InterSTORE

We chose to describe the HLUCs followed by the primary use cases in the same context, to help the reader follow the rationale and make the document readable and effective for consultation. Furthermore, the use case report is a milestone of the project since it unlocked several details needed for other project tasks.

The use cases consist of a coherent and structured description of business processes and functions, which allows to analyse key issues according to different levels or perspectives, while ensuring a global consistency. In fact, the use case methodology allows to represent the characteristics of a complex system according to a structuring and at the same time iterative method.

Moreover, the methodology is a collective bargaining process that is based on a pragmatic approach. It is designed to involve and actively engage different partners (countries, organizations, domains, etc.) from the project, both during the writing and the review process. This contributes to provide an exhaustive and accurate list of requirements for the system under study and ensures no topic or point of view has been left aside. In the InterSTORE project this has revealed particularly important since some of the industrial partners had never gone through such a process, hence the required discussions for the IEC62559 standard specification, helped mature ideas to concrete implementation descriptions.

The Use case methodology is particularly appropriate for describing services, business processes, and functions evolving with smart grid technologies, such as storage systems and smart metering systems, as it allows domain experts to brainstorm new requirements. On this basis, its use is relevant to identify the impact of the changes and opportunities brought by smart grid technologies, markets development, or regulations.

In InterSTORE, it allowed partners to identify a set of new processes and functions across the four domains and to establish the foundations for the follow-up activities in other WP. The simple picture of the HLUC and PUC divided by domains and their title, provides the stakeholders a summary image of the project's scope, goals, and activities.

Figure 13 summarizes the interrelations between the use cases work in Task 1.2 (WP1) and the other WPs and tasks of the project. The use case work in WP1, in combination with the work described in the Description of Activities, defines a set of functional requirements setting the ground for different tasks. To start with, it allowed defining the protocols and communications details from the several resources of the Demos in order to contribute to T1.3, where the specifications for the IEEE2030.5 was done. This task (T1.3) is by itself interrelated with T2.1 where the developments started to occur. With the Use Case specification, the messages exchanged between actors were identification, which helped clear the way for the role of the connected data spaces, need for ontology update and frame what services will be tackled.

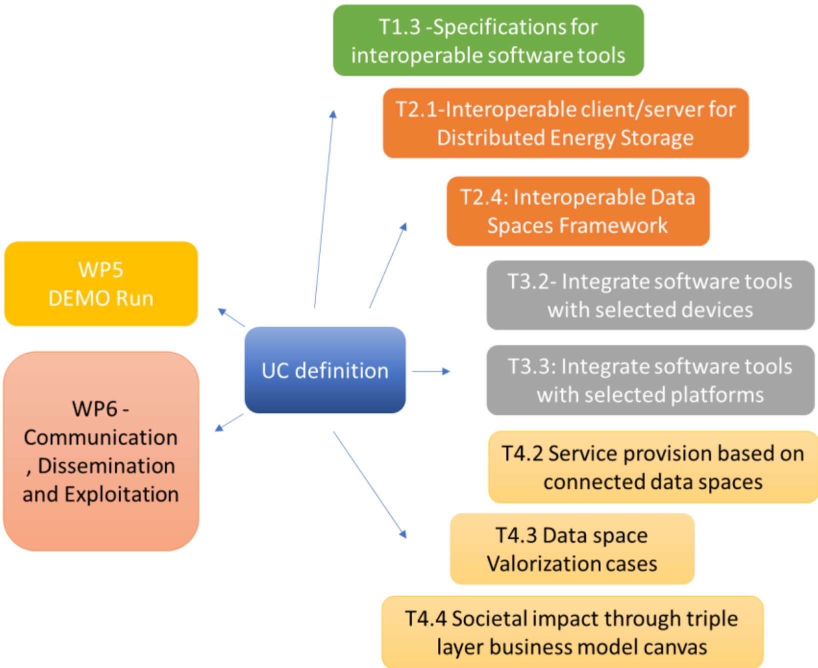

Figure 13 - Use case definition impact on other tasks and work packages

The use case definition contribution to WP3 is also evident. It was based on the device and platform identification that partners evaluated where the native implementation of the IEEE2030.5 in the inverters themselves would be possible and where the converters would be applied instead. For WP4 all tasks benefited from the statement of the different use case actors, relation, message exchange and sequence diagrams. This provides enough information for the connected data spaces related tasks and sets the scene for the Societal impact analysis task. On the left side of the Figure, WP5 which is the DEMOs themselves, to which the KPIs where handover to plan for the data gathering, processing and storage for future replicability and for the project KPI calculation. WP6 has naturally been in contact with this task, disseminating the use cases and goals of the project in diverse communication channels, but especially coordinating with BRIDGE on the use case methodology online tool testing and the interaction with the "sister projects" from the same call PARMENIDES and FLEXCHESS, in which the use cases discussion provided a common ground for alignment.

3 Overview of Use case and context

3.1 InterSTORE Architecture

As shown in the Figure 1, on one hand the project plans to cover the classical use cases for flexibility and distributed energy management systems while highlighting and focusing on data-driven implications on potential new services, but on the other hand plans to go beyond this view by integrating the InterSTORE concept focusing on decentralized energy storage within the broader view of Data Space and Energy Data Space more in general. The architecture used as basis for InterSTORE is shown in Figure 14.

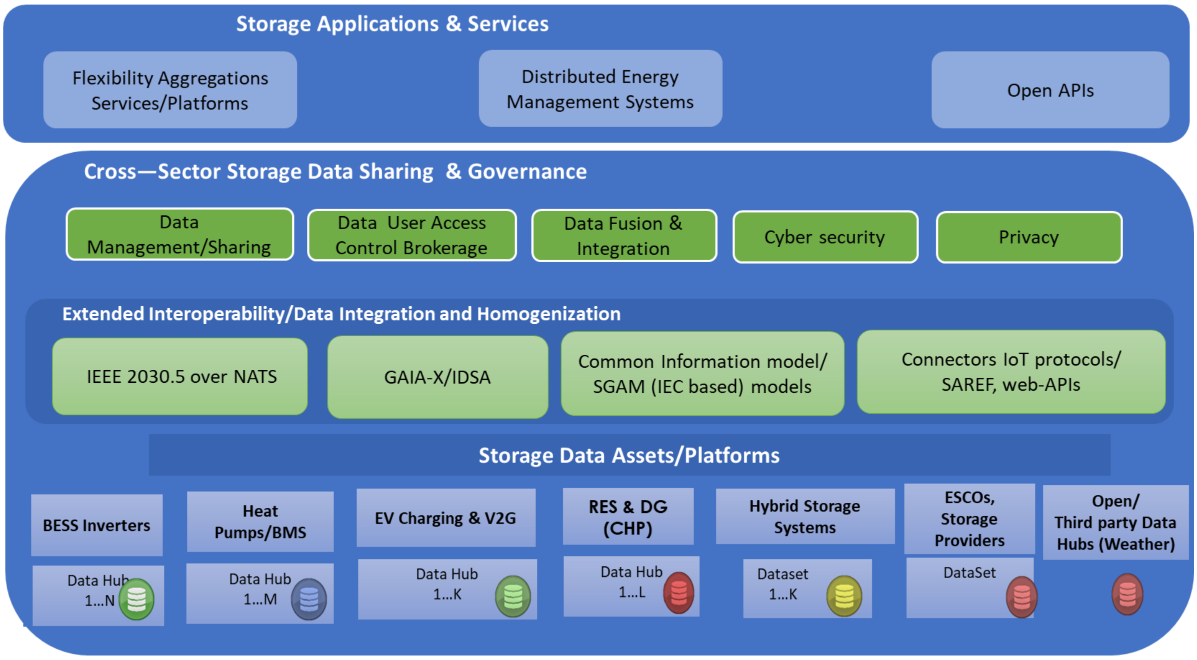

Figure 14 - InterSTORE architecture and actor layer positioning

To undertake this further development, InterSTORE is leveraging on H2020 OpenDEI [7] (ENG, RWTH common partners) which has provided a Reference Architecture for cross-sector energy data space, and on the H2020 BD4NRG (ENG; RWTH, ENEL-X common partners) and has developed a number of IDSA/GAIA-X [3] compliant technology building blocks, aka "connectors", enabling seamless extended interoperability management, trusted multi-stakeholders digital sovereignty of data and data-enhanced digital services for storage valorization. In addition to the above, InterSTORE is coordinating with the projects which EC has retained for funding in the EU Common Energy Data Space call. The InterSTORE solutions will be enriched with the data connectors developed within H2020 BD4NRG and tested in several demonstration sites to get more experience about the role data-driven perspective and dataspaces can play in future innovative business cases, for DES management.

InterSTORE proposal for storage-oriented connected data space spans over a two-layered conceptual architecture:

Cross—Stakeholder Storage Data Sharing Governance layer aimed to enable data access and sharing of a large variety of data sets and/or data hubs, including data from storage operators, storage service providers, utilities, RES plant operators, flexibility platforms/solution managers), alternative mobility infrastructure operators, heat pumps manufacturers, market operators (aggregators, multi-sector Virtual Power Plants/flexibility service providers, ESCOs), third party open or legacy energy data hubs, third party non-energy data hubs, such as weather and Earth-based Observation data hubs/services , synthetic data from research labs). Data integration and homogenization will be managed via open standards such as FIWARE Context Broker ETSI standard and/or via interoperability with SGAM-based IEC (or extended versions), and SAREF at semantic level. Data access and sharing will be made available by suitable adaptation of IDSA/GAIA-X conceptual architectures and technological connectors for Access Usage Control. All in all, data will be kept at the generation point and will be accessed and shared while fully guaranteeing sovereignty over the generated data. In this layer the support for semantic enrichment and for data-driven modelling and confidentiality-preserving federated learning will be made available. In particular, techniques such as algorithms-to-data, will be deployed, with a view to minimize data transfer among different actors.

3.2 UC Objective matrix and tools

Figure 15, presents how demonstrations sites and use cases match with the InterSTORE data tools, Energy management systems to be used by the different partners.

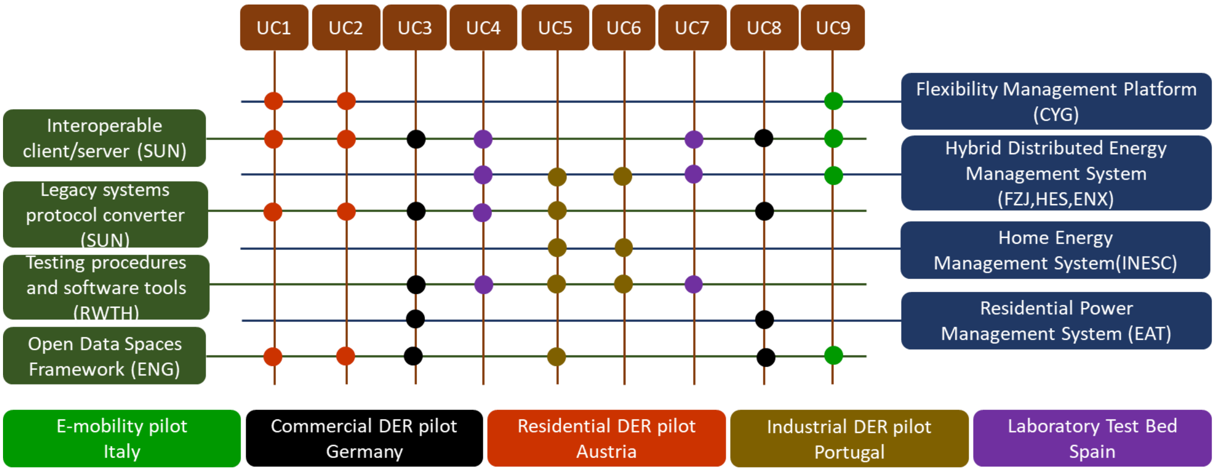

Figure 15 - InterSTORE EMS and tools applied to each use case by Demos Site category.

LIST OF MAIN TOOLS DEVELOPED IN INTERSTORE

The several HESS addressed in the several use cases of InterSTORE will entail new tools integrating the upgrades of all Energy Management Systems brought to the project. The main tools are the following:

- HESS Optimization of cost and degradation for tariffs or environmental signals,
- Optimization of HESS for environmental/cost minimization (DR signal),
- HESS sizing methodology and tool,
- Model for Aggregation of distributed resources,
- Model for frequency service provision, damping and inertia,
- Model for virtual storage integration from EnelX,
- Tool for testing the IEEE2030.5 integration
- IEEE 2030.5 native installation toolkit,
- Legacy protocol converter (Villasnode framework from EriGrid2.0),,
- EMS upgrades incorporating HESS features,

- Data Space connector update from OneNet Connector.

With regards to the new features being implemented in the several EMS and shown in the Use Cases, their descriptions are further explained in D1.4 and developed in T4.1.

3.3 Use Case Overview

3.3.1 UC01 - DES Flexibility Market Monetisation

Scope

As society we need to accelerate green energy transition so that in the future all energy generated, stored, and consumed could be renewable and flexible. This is why it is important to unlock and manage distributed power flexibility and make it useful for variety of power system use-cases.

Each individual flexibility resource, like consumer loads, distributed generation (RES and DG) and storage, does not hold much market value unless aggregated in larger pool with capacity and characteristics that fulfil balancing services and markets' requirements. Each type of flexibility asset comes with different characteristics, like capacity, time constraints, response and ramp times, etc. thus, emphasising the importance and value of intelligent flexibility hybridization at portfolio level. The next step is finding the best possible market for its monetization.

Objectives

Enable monetisation of Distributed Energy Resources (DER) flexibility at various markets.

Short description

A user, an Aggregator, would like to offer its customers a possibility to generate flexibility revenues, thus decreasing their overall electricity cost.

To technically achieve this, the Aggregator deploys and operates a Flexibility Management Platform – an ICT system which aggregates and manages flexibility from diverse Dis-tributed Energy Storage (DES) sources, like BESS, HESS, heat pumps and EV. The real-time data collected will comprise electricity consumption and generation measurements, BESS State of Charge, EV charging status, EV charging power, and if available by local EMS also baseline and flexibility forecasts. The real time data sent to these DES sources will mostly comprise power curtailment setpoint. Its innovative optimization algorithms hybridize them with other flexibilities (loads, RES, DG, etc.) into marketable products. It will autonomously bid the hybrid flexibility products to the most appropriate markets (balancing, TSO and DSO balancing services, intra-day, etc.) and executes the provision of the flexibility.

KPIs

1 Forecasting accuracy
2 DES multi-service support
3 DES multi-service market participation
4 Battery capacity
5 Diversity of DER
6 Asset management monitored by EMS

12 Nbr. of DER assets tested with IEEE2030.5
13 Data space digitized assets
19 Data Valorisation cases
28 Integrated capacity
29 Increase of flexibility

The main Innovations and tools applied to/used in this Use case are: i) CyberGrid aggregation tool, ii) Tool for testing the IEEE2030.5 integration, iii) IEEE 2030.5 native installation toolkit, iv) IEEE2030.5 protocol converter, v) Data Space connector update from OneNet Connector.

3.3.2 UC02 - Energy community DES utilisation

Scope

The participation of citizens and communities as partners in renewable and storage energy projects are transforming the energy system. Community energy initiatives are offering new opportunities for citizens to get actively involved in energy matters and to promote their self-sufficiency and sustainability.

Energy communities could generate flows of real time data from electricity meters placed at renewable electricity sources (e.g., solar, wind, CHP), consumption sites (households, schools, commercial buildings, farms, etc.), battery energy storage systems, electric vehicle charging stations, heat pumps, etc. Most of these could provide some electric flexibility which can be utilized either locally, within the community supporting self-sufficiency mode or at different electricity markets, like helping balance the transmission grid, improving voltage levels at distribution grid or taping into price opportunities of intraday markets.

Objectives

Enhance community self-sufficiency mode

Short description

A user, a Community Manager, would like to digitalize the community energy assets and their energy flows to manage and optimize energy community's operation. To technically achieve this, the Community Manager deploys and operates a Flexibility Management Platform – an ICT system which aggregates and manages flexibility from diverse Distributed Energy Resources (DER) including a set of novel Energy Community data management functionalities. It will receive real time DES assets' data via novel interoperable software tools, implement the latest regulatory and business/community rules (energy accounting, static and dynamic distribution key specification and utilisation, reporting etc.), calculate baselines and forecasts, aggregate energy assets data using advanced algorithms, optimize pooling of available flexibility resources for various events (self-sufficient community, grid balancing, wholesale, etc.), de-aggregate, and dispatch them in a timely manner

KPIs

4 Battery capacity
5 Diversity of DER
6 Asset management monitored by EMS
7 No. of assets aggregated
10 Demand Response cost
12 Nbr of DER assets tested with IEEE2030.5

13 Data space digitized assets
19 Data Valorisation cases
28 Integrated capacity
29 Increase of flexibility

The main Innovations and tools applied to/used in this Use case are: - CyberGrid EMS features for maximizing self sufficiency

3.3.3 UC03 - Grid supporting BESS

Scope

A hybrid energy storage system will be integrated, for operation, in an internal Network (grid). In this use case, the time using the ICT deployment tool (connection with the EMS), i.e. using the IEEE2030.5 approach will be compared to a traditional deployment. The subsequent HESS operation will then verify the successful deployment of the system.

Objectives

- To demonstrate that the required DER IEEE2030.5 standard deployment is more seamless when compared to a traditional approach (even with just one battery)
- Verify the IEEE2030.5 interoperability tool, with different inverters (same and different manufacturer)
- Share operation data of the HESS through the connected data spaces tool

Short description

This use case investigates the integration of hybrid energy storage systems (HESSs) in the already-existing ICT platform of FZJ (FIWARE-based). The aim is to verify that the integration of the HESS using the InterSTORE solution (IEEE2030.5 based) is seamless when compared to the integration using the current solution (FIWARE-based). The Use case will then verify the correct deployment by operating the HESS connected to the grid, providing setpoints and receiving operational data.

KPIs

4 Battery capacity
5 Diversity of DER
6 Asset management monitored by EMS
8 N° of end users involved in HESS
11 Time savings
12 Nbr. of DER assets tested with IEEE2030.5
13 Data space digitized assets
19 Data Valorisation cases
28 Integrated capacity
29 Increase of flexibility

The main Innovations and tools applied to/used in this Use case are: i) Tool for testing the IEEE2030.5 integration, ii) IEEE2030.5 protocol converter, iii) Data Space connector update from OneNet Connector.

3.3.4 UC04 - Innovative Frequency services

Scope

The main focus of this HLUC can be broke-down as follows:

This Use Case identifies and analyses how the system can be used for providing different innovative grid services with grid forming capabilities in low inertia networks. Tests and validates the possibility of HESS conversion system in island mode and reconnection, after synchronization activation, with the main grid with proper communication. It also offer additional services in grid connected mode such as frequency regulation with the goal of improving the dynamic response of the system consisting of different type of storages (High power UCAPS + High energy Batteries). Moreover it focuses in fast advanced control solution for virtual inertia emulation with sufficient damping.

Objectives

- Enabling a grid forming capability with flexibility to work in both island and grid connected modes with hybrid storage conversion system
- Enabling and validation of the HESS conversion unit for providing different grid services such as frequency regulation.
- Enabling fast functionalities such as virtual inertia control and oscillation damping.

Short description

This use-case presents a procedure to test and validate the performance of the HESS unit for providing fast grid services to coupe with future challenges of low inertia systems. To do so, first the grid forming capability of the HESS conversions system will be tested in island mode and then provision of providing fast services such as virtual inertia, frequency regulation and oscillation damping will be evaluated in grid connected mode.

KPIs

4 Battery capacity
5 Diversity of DER
6 Asset management monitored by EMS
8 N° of end users involved in HESS
12 Nbr. of DER assets tested with IEEE2030.5
14 Time savings
15 Monitoring
16 Time response
17 System NADIR
18 System ROCOF
19 Data Valorisation cases
28 Integrated capacity
29 Increase of flexibility

The main Innovations and tools applied to/used in this Use case are: HyDems, Model for frequency service provision, damping and inertia by HESSTec

3.3.5 UC05 - Hybrid storage for higher performance and flexibility provision

Scope

In this use case (UC), the objective is to demonstrate how it can optimize the cost of supplying electric energy to a generic load (which is the associated building, which has a HESS (hybrid energy storage system), while increasing the lifetime of the Storage Systems, compared to a base case of a single battery.

Currently, the electric energy of the building is supplied by the grid, by the onsite PV, by the storage system or by all, with different values of "cost/carbon intensity" of energy. In this UC it is also an objective to test the interoperability of distributed resources by installing the IEEE2030.5 standard to the already installed equipment, between the inverter and BMS (battery management system), according to the data of the HESS in operation.

Operational data is exported to a database of InescTec (HEMS backend) and made available to the connected dataspace.

Objectives

- Implementation of the IEEE 2030.5 in the HESS and test its implementation in the inverter of the 2nd life battery of the HESS and BMS of the HESS.
- Compare the performance in an optimization exercise with a hybrid energy storage system vs base case of a single battery.
- Demonstrate the reporting of operational data from the hybrid Storage system to the InterSTORE connected data space.

Short description

A HESS is installed in a building basement. The HESS is composed by two batteries: One is a vanadium redox flow, with 10kW and 40kWh and the other is a set of second life lithium batteries with 100kW and 92 kWh. Those batteries are connected to their inverters and are operated according to an EMS installed in a local PC. The HESS is connected to the building, 'behind the meter'. The building also has a PV system of 100kW installed on the top.

In the present UC, it is expected to demonstrate strategies for the HESS operation, that aim to optimize a cost function (minimize the system degradation), comparing Hybrid systems to single battery systems. The UC will also integrate the IEEE2030.5 in the 2nd life battery inverter/BMS, to showcase the interoperable solution of InterSTORE, applied to distributed resources. It will also share data with the connected data spaces developed in T2.4.

KPIs

4	Battery capacity
5	Diversity of DER
6	Asset management monitored by EMS
8	N° of end users involved in HESS
12	Nbr of DER assets tested with IEEE2030.5
13	Data space digitized assets
19	Data Valorisation cases
20	HESS performance
22	Data Spaces (nbr. Of services published/subscribes)
28	Integrated capacity
29	Increase of flexibility

The main Innovations and tools applied to/used in this Use case are: i) HEMS features from InescTec; ii) HESS sizing methodology and tool (validation); iii) IEEE2030.5 protocol converter; iv) Tool for testing the IEEE2030.5 integration; v) HESS Optimization of cost and degradation for tariffs or environmental signals; vi) Data Space connector update from OneNet Connector.

3.3.6 UC06 - Management of battery systems for Node capacity increase

Scope

The use case aims to demonstrate the increase in Node power of the internal electric network of a parking lot, next to a hub of electrical vehicles charging station (due to upstream infrastructure limitation), by installing an energy storage system on that grid node. If a charging simultaneity that exceeds the present power limits occurs, the battery will ensure the additional capacity. It will also consider the consumer engagement element requested in the call, shown by implicit DR incentives, for example, where users receive an environmental signal in CO2/kWh to deviate from their baseline (forecast part of InescTec backend). The deviation assessment (flexibility) and the verification of the baseline deviation will also be calculated in the backend by InescTec EMS.

Objectives

- Increase local electric node capacity by using power supply from a local ESS
- To demonstrate implicit DR for a virtual capacity of EVs batteries by ecological signal.
- Evaluate user acceptance and engagement, by reaction to the incentive.

Short description

At a parking lot in the Sonae Campus site, there is a set of EV chargers whose total power exceeds the upstream board and cable power capacity, or in some cases with a high simultaneity factor. Installing and using a local ESS, expected to be around 40-50kW, it will enable the simultaneous operation of the chargers and even install others surpassing, as a whole, the upstream installed power at the moment.

Included in this Use Case, is also defining a set of EV users that typically charge in that parking lot and share with them an incentive schedule for implicit demand response, based on an environmental signal.

KPIs

4 Battery capacity
5 Diversity of DER
6 Asset management monitored by EMS
8 N° of end users involved in HESS
12 Nbr of DER assets tested with IEEE2030.5
19 Data Valorisation cases
23 User Engagement
24 Demand Response
25 Node power increase time
26 Node power increase percentage
27 User participation
28 Integrated capacity
29 Increase of flexibility

Main Innovations and tools – i) HEMS features from InescTec, ii) Optimization of HESS for environmental/cost minimization (DR signal) and iii) HyDems for battery management.

3.3.7 UC07 - Adaptive BESS management for autonomous grid operation

Scope

The main focus of this HLUC can be broken-down as follows:

This use case will identify and analyse how the hybridization algorithm can be incorporated and tested for HyDEMS application with aggregator on top and multiple DER in laboratory scenario. It will test and incorporate the use of SoF for an interoperable distributed energy storage (DES) operation for one selected grid service. Moreover, it will test and validate the developed energy management system on incorporation and coordination of different DERs with different mode of operation: Grid Forming (GFM) and Grid Following (GFL) in laboratory scenario.

Objectives

- Assess the operation of both grid forming (GFM) and grid following (GFL) DERs on providing one selected grid service.
- Analysis and assessment of hybrid solution with different DER assignment roles in distributed storage system for improved flexible and autonomous (micro-grid) operation considering SoF as DER figure of merit.

Short description

This use-case presents a procedure to test and validate the hybridization approach considering SoF, as interoperable tool, for providing gird services under different operational mode of DERs. In this UC, the actual and former grid condition/service needs from the aggregator, real time data such as SoC, SoF from the DERs will be collected to identify the appropriate operational mode of the DERs for autonomous grid operation.

KPIs

4 Battery capacity
5 Diversity of DER
6 Asset management monitored by EMS
12 Nbr. of DER assets tested with IEEE2030.5
14 Time savings
15 Monitoring
16 Time response
17 System NADIR
18 System ROCOF
19 Data Valorisation cases
28 Integrated capacity
29 Increase of flexibility

The main Innovations and tools applied to/used in this Use case are: HyDems, Model for frequency service provision, damping and inertia by HESSTec

3.3.8 UC08 - Multiphysics flexibility optimization for Home Management Systems and their global integration

Scope

A hybrid energy storage system will be integrated, for operation, in an internal Network (grid). In this use case, thermal storage systems (heat pumps) will be integrated into a home management system (HMS), to enable flexibility optimization. Battery storage systems and photovoltaic systems will be also integrated into the home management system. The operation of the subsequent hybrid energy storage system (HESS) on the building level, and the coordination among multiple HMSs, will then verify the successful deployment of the system.

Objectives

- To demonstrate that the inclusion of heat pumps in the HMS can increase the flexibility optimization
- Verify the IEEE2030.5 interoperability tool, with different inverters (for different demonstrators)
- Demonstrate multi-scale flexibility optimization (different time-scales involved)
- Demonstrate the integration of the HMSs in an energy community environment, with each HMS being a node
- Share operation data of the HESS through the connected data spaces tool

Short description

This use case investigates the integration of hybrid energy storage systems (HESSs) on an already-existing home management system (HMS). The aim is to verify that the integration of the HESS using the InterSTORE solution (IEEE2030.5 based) is effective and enables the flexibility optimization of a multi-physics-based system on a local (building) level, and on a community (multiple buildings) level. The Use case will then verify the correct deployment by operating the HMS connected to the buildings, providing setpoints and receiving operational data.

KPIs

4 Battery capacity
5 Diversity of DER
6 Asset management monitored by EMS
12 Nbr. of DER assets tested with IEEE2030.5
13 Data space digitized assets
19 Data Valorisation cases
28 Integrated capacity
29 Increase of flexibility

The main Innovations and tools applied to/used in this Use case are: i) EMS flexibility features and optimization; ii) IEEE2030.5 protocol converter; iii) Tool for testing the IEEE2030.5 integration; iv) Data Space connector update from OneNet Connector.

3.3.9 UC09 - Management of EV charging clusters as HESS

Scope

The main scope of this HLUC can be broken-down as follows:

One aspect of the scope is to use the Flexibility platform to allow a set of assets to participate as a portfolio in flexibility market services. This shall leverage the available resources to provide grid services. To enable the energy transition to clean generation, it is important to manage distributed power flexibility and use the flexibility to provide grid services.

This Use Case identifies and analyses how different type of storage technologies (Industrial, Residential, EVs) can contribute in a unique cluster to providing Flexibility grid services. Each individual flexibility resource does not hold adequate market value unless aggregated in larger pool with capacity and characteristics that fulfil balancing services and markets' requirements. In this way, each resource can contribute to grid service markets as part of a virtual power plant (VPP), despite having different power profiles and capabilities (capacity, time constraints, response and ramp times),

This UC will be implemented, tested and validated in Rome XLAB. The assets in the XLAB will ultimately respond to a test signal, to simulate grid responsiveness. Ultimately, this project tests necessary know-how that will enable using HESS (Hybrid Energy Service Systems) to execute a balancing order, but due to the regulations and market requirements, it is not in scope to have this set of assets participate in a live market program.

Objectives

- Hybridization: we develop a unique environment where different kind of assets are integrated;
- Energy monitoring assets consumption/production making use of IEEE 2030.5, or the protocol appropriate for the asset control reporting to connected dataspace;
- Exchange several messages between different distributed assets and the VPP through the Asset Manager;
- Identify the minimum set of information needed to be exchanged between assets and asset Manager and the VPP for flexibility provision.

Short description

The use case aims to demonstrate how the Flexibility platform (VPP) that aggregates many different DERs into a single operating agent can participate in energy system to provide flexibility services to the network (TSO); customers can take advantage from the services in order to reduce their energy bill or to receive incentives from the BSP (Balancing Service Provider). The UC will be implemented in the test XLab in the Rome to test the possibility of managing a cluster of heterogeneous storage resources E2E so that their capacity can be used seamlessly and without constraints for the services of the flexibility market.

KPIs

4 Battery capacity
5 Diversity of DER
6 Asset management monitored by EMS
8 N° of end users involved in HESS
12 Nbr of DER assets tested with IEEE2030.5
13 Data space digitized assets
19 Data Valorisation cases
28 Integrated capacity
29 Increase of flexibility
30 Energy Volume exchanged
31 Different hybridization configuration
32 Grid peak avoidance

The main Innovations and tools applied to/used in this Use case are: i) Model for virtual storage integration from EnelX; ii) Tool for testing the IEEE2030.5 integration ; iii) IEEE 2030.5 native installation toolkit; iv) IEEE2030.5 protocol converter; v) EMS upgrades incorporating HESS features; vi) Data Space connector update from OneNet Connector

4 Conclusions

4.1 Project outcomes and results

The InterSTORE vision was very ambitious right from the start, as it set itself to integrate several distinct perspectives. In fact, aligning the different demands from the call is what bridged the different needs and, in the end, enabled the 3 pillars of the project: Interoperability, Hybrid energy storage systems and Connected data spaces. The following results were proposed for InterSTORE:

- Development of 4 Open-source interoperability toolkit and implementation of 5EMS and flexibility products in 4 real pilots. This are: Interoperable client/server for Distributed Energy Storage, Legacy System protocol converter, Testing procedures and software tools, EMS for HESS across different applications
- Increase number of stakeholders interested in data space, promoting data valorization through public API of DES/DER SoF
- Development and testing of new business model for energy community, allowed by Flexibility Aggregation Platform
- Creation of synergies a among different interoperability standards (IEEE 2030,5, and similar) and facilitation of its implementation

Achieving these results will enable the following outcomes:

- Demonstrate use cases in which Hybridization can be applied to, allowed for one of the project's outcomes which is the 5 EMS products update, incorporating hybrid storage features, such as hybrid dispatch, degradation optimization and aggregation of different resource configurations. Furthermore, higher performance of hybrid systems will be shown in at least extending the joint lifetime of the batteries by minimizing the joint degradation. It will also show as a project outcome the successful multiple deployment of a data space connector (based on the OneNet connector), on one hand, to share data from different sites and enable the exploration of valorization cases by federated learning. On the other hand, it will enable the data sharing on a data sovereignty context, where the data owner (different from the service providers), can decide what exactly wants to share, authorize who does it share with and for how long. It also keeps track of what data has been use and to what end. Still in the context of data spaces, the connector also ensures interoperability between actor and systems in the energy domain with a security layer assured, since potential sensitive data is shared.

- Another level of interoperability achieved in the project and results as an outcome is at the level of the inverters/distributed resources, in this case applied to battery systems. This is one of the Key project outcomes in fact. The IEEE2030.5 replication to Europe, aligns members states with the United States of America and Australia, where the standard is already being applied. This is achieved by developing an adapted toolkit for inverter native installations and also a IEEE2030.5 protocol converter for legacy systems. The compliance of such installations of client and server components will be ensured by a set of testing procedures. The certification of such procedures will be provided openly to the market so that it can be subject to different business models, similarly to what happens in the USA. Within InterSTORE, an advisory board is being put together with major stakeholders, to monitor and advise on the progress of the developments. One of the expected results of having the advisory board is that a first certification entity may arise right from the very inception, making the IEEE2030.5 standard ready for the European market.

4.2 Business impacts

The ultimate goal of the project is to have an impact on the market, and let businesses integrate the developments, findings and improvements of InterSTORE. The implications on scalability of distributed resources integration, flexibility, market design, are huge. InterSTORE addresses several business models and naturally many requirements became evident during development or implementation, which are worth sharing the reflection.

4.2.1 IEEE2030.5 and HESS

Power and Energy Services (Inertia, frequency, arbitrage)

Considering the trends on energy transition in Europe and the replacement of conventional sources with power electronic based units, the role of energy storage systems and particularly hybrid energy storage systems will be critical. In such scenario, a mix of different technologies is required to provide essential services across different time-scales. For example, pairing a ultracapacitor with different types of batteries enables milli-second, second to hours for providing wide range of services such as inertial response, frequency control and energy arbitrage services, with several technologies operating within their intended performance envelope. In such a scenario, the role of proper and fast communication protocol with good infrastructure will be important. It would be necessary to transmit a huge amount of data in a very fast time window. Within the InterSTORE project, the use of IEEE2030.5 next to other fast communication systems will be crucial. Standards are particularly relevant to leveraging the full value stack of Distributed Energy Resources (DER). IEEE2030.5 as one of the main interoperability standards are well established and supported by nearly all off-the-shelf inverters which can enable communication between various components of the electric grid, including smart meters, grid management systems, and distributed energy resources (DERs) like PV and energy storage systems.

Considering the increasing need of data exchange for having flexibility with respect to the dynamic behaviour of the network and to have a corresponding inertia, IEEE2030.5 can provide useful data exchange for smart grid management and proper hybridization. It will provide data on state of the different storage devices enabling a smooth hybridization for providing different services. IEEE2030.5 has the potential to bring about significant impacts on businesses related to providing services such as virtual inertia and frequency control in hybrid energy systems. Here are some potential business impacts:

1- Expansion of power and energy services: Companies offering virtual inertia and frequency control services in hybrid energy systems can leverage IEEE2030.5 to expand their offerings. The standard enables seamless communication between utilities and distributed energy resources (DERs), allowing for more efficient and accurate control over these systems. This expanded service portfolio can attract new customers and revenue streams.

2- Enhanced Integration: IEEE2030.5 facilitates better integration of DERs into the grid. Businesses that specialize in integrating renewable energy sources with conventional grids can benefit from this standard. They can offer high power service and hybrid energy storage energy solutions that improve grid stability, reduce energy waste, and optimize the use of renewable resources.

3- Grid Services Market: With the standard facilitating seamless communication between utilities and DERs, businesses can participate in future grid services markets more effectively. They can offer services like fast frequency regulation, energy arbitrage, demand response, grid balancing, and voltage regulation, capitalizing on the flexibility and responsiveness of distributed energy resources. In the future of modern power systems, it is expected to have more dynamic market on providing power services such as virtual inertia and fast frequency regulation. Companies offering virtual inertia services can participate in grid services markets more effectively. They can bid their services to grid operators and earn revenue by contributing to grid stability and reliability.

4- Precise Response: Businesses can use the IEEE2030.5 protocol to enable DERs to respond quickly to grid frequency deviations. When the grid frequency deviates from its nominal value, these DERs can autonomously inject or absorb power to stabilize the grid, mimicking the behaviour of traditional generators.

5- Energy arbitrage: IEEE2030.5 can indeed have positive impacts on providing long-term services like energy arbitrage. Energy arbitrage involves buying electricity at low prices and storing it for later use or selling it when prices are high. The protocol's impact on this service lies in its ability to facilitate efficient communication and control between energy storage systems, huge amount of historical data and the grid/aggregator. IEEE2030.5 ensures that these operations are precisely timed for maximum financial benefit.

6- Data-Driven Insights: The standard promotes remote monitoring and control, which means businesses can access real-time data about energy usage and generation. Companies can offer data analytics services to utilities and consumers, providing valuable insights for energy optimization. This data-driven approach can create new revenue opportunities.

Aggregation

Flexibility aggregation is the process of aggregating DERs to provide grid services such as frequency regulation and peak shaving. This can help to improve the efficiency and reliability of the grid, and it can also provide new revenue opportunities for DER owners. The pertinence of the IEEE2030.5 is to coordinate the activation of mass deployed distributed resources in real-time, using the new developments of NATS integration as asynchronous communication. This will improve reliability, scale and speed in the communication. Regarding HESS application, the fact that combined technologies are working together, this can provide Aggregators with the possibility of value stacking, taking advantage of the specific characteristics of each battery system.

IEEE 2030.5 over NATS is expected to be a fast, decentralized, and secure way of communication. This is especially important for aggregators and VPP operators which need a fast communication with different assets in their pool. For instance, aggregators that would like to engage in the FCR market (Frequency Containment Reserves) need to be able to reach given setpoint in no more than 1 minute since receiving command by TSO. For this to work, it is required a responsive asset and a fast and reliable communication. The benefits are obvious: lowered market barrier, shortening return-on-investment of additional DER, expansion of available resources which can be connected and more.

Energy communities and Demand Response

Energy communities are groups of consumers who collectively manage their energy resources with the objective to improve self-sufficiency. This can include shared solar PV systems, battery storage, and demand response programs. Energy communities can help to reduce energy costs and improve energy security for their members.

Demand response is the ability to reduce or shift electricity consumption in response to changes in supply or demand. This can help to balance the grid and avoid blackouts. DERs can play a major role in demand response, and the IEEE2030.5 standard can help to facilitate this.

Energy communities are an example of win-win situation for energy system in general. For the energy market operators, like TSOs and DSOs, the communities present a decrease in stress for the system as they manage (a portion of) their load by themselves by distributing generated energy among themselves. In times of sunny weather and low consumption different storage systems embedded in the community can also help to shave peaks, created by community PVs. This would not be achieved so efficiently if assets would be connected to the grid separately. IEEE2030.5 over NATS is an upgrade for all energy communities due to its ability to allow M:N communication. This means that several messages can be sent at the same time from many devices and received by many devices at once and in an orderly fashion. Such a feature is a must have for a communication between assets in any energy community. Such communication alleviates the pressure on a community operator and decreases number of interventions needed. Decentralisation of the new protocol also increases the efficiency and eliminates the worry regarding the central broker which could be the case if other protocols would be used.

Electric vehicles, BESS for EV support and behind the meter load optimization

Electric vehicles are a major source of DERs. They can provide grid services such as peak shaving and frequency regulation, and they can also help to reduce emissions. The IEEE2030.5 standard can help to integrate EVs into the grid and make them a more valuable resource. Battery energy storage systems (BESS) can store energy from DERs and make it available when needed. This can help to smooth out fluctuations in renewable energy generation and improve the reliability of the grid. The IEEE2030.5 standard can help to integrate BESS into the grid and make them a more efficient and cost-effective way to store energy. Potential business impacts include:

- Multi-vendor integration: Thanks to the standard IEEE2030.5, BESSs from different manufacturers can be easily integrated into the grid and interfaced with the already available energy management system (EMS) without requiring dedicated adapters and interfaces.
- Improved Grid Services: Thanks to the possibility of storing energy from DER, and the facilitated communication via IEEE2030.5, BESSs can be used to promptly compensate for the aleatory nature of renewable resources and to provide services such as voltage regulation and peak shaving. System operators can make use of these services to ensure a proper supply to the users. At the same time, users and energy communities can make use of the same services to maximize the self-consumption.
- Effective data handling: The implementation of the standard IEEE2030.5 ensures a unique structure of data and metadata. Companies can benefit from this well-defined structure by simplifying and reducing the amount of data exchanged/stored for monitoring and control applications. This would result in a smoother and more effective communication chain, as well as a reduction of space needed for data storage.

The IEEE2030.5 standard InterSTORE implementation considers communication over NATS. This has the potential to have a significant impact on the energy industry. And promoting larger market traction. NATS offers better security, asynchronous data exchange, real-time, n:m connectivity, distributed architecture. The main cons are IEEE2030.5 EU lagging behind other parts of the world, NATS being fairly new messaging technology.

When compared to REST or MQTT, NATS performs better. This is because REST is based on synchronous data exchange, 1:1 and not suitable for real-time data exchange (not suitable for automatic Frequency Restoration Reserve (aFRR) service delivery). On the other hand, MQTT requires a centralized broker while NATS doesn't. It can help to improve the efficiency and reliability of the grid, reduce emissions, and create new revenue opportunities for DER owners. The standard is still maturing, but it is already being used by a number of countries such as the USA and Australia. As the standard matures, it is expected to play an increasingly important role in the future of energy. Expected specific business implications of the IEEE2030.5 standard are:

New market opportunities: The standard will create new market opportunities for DER owners, aggregators, and service providers. For example, DER owners can sell their flexibility services to the grid, and aggregators can offer demand response programs to consumers. The coordination between assets and fast data exchange is enabled by the NATS communication instead of REST APIs.

Reduced costs: The standard can help to reduce costs for companies and consumers. For example, companies can use the standard to reduce their reliance on traditional power plants, and consumers can use the standard to save money on their energy bills.

Improved reliability: The standard can help to improve the reliability of the grid by making it more resilient to disruptions. For example, the standard can be used to coordinate the deployment of DERs to help mitigate the effects of power outages.

Increased sustainability: The standard can help to increase the sustainability of the energy system by promoting the use of renewable energy and energy efficiency. For example, the standard can be used to integrate EVs into the grid and help to reduce emissions.

The IEEE2030.5 standard is a significant development in the energy industry. It has the potential to have a major impact on the way that energy is produced, distributed, and consumed. The standard is still under development, but it is already being used by a number of utilities and DER aggregators. As the standard matures, it is expected to play an increasingly important role in the future of energy.

4.2.2 Data Spaces and IEEE2030.5

Data Spaces

The connected data spaces in energy are expected to promote several valorisation cases, which will be explored in InterSTORE under task 4.3. The sharing of trusted data will enable federated learning for model development, leading to: i) improved accuracy in forecasting models ii) predictive maintenance services iii) resource optimization from iv) facilitate the aggregation of flexibility and offerings, just to mention a few. For the Business examples, in InterSTORE, the following deserve special mention:

Retailers can use connected data spaces to collect data from DERs such as solar PV systems, wind turbines, and electric vehicles. This data can be used to identify and optimize the use of DERs to provide grid services such as frequency regulation and peak shaving.

An energy community can use a connected data space to share data on energy use and production among its members. This data can be used to improve the efficiency of energy use and reduce costs for community members.

Demand response aggregators will be able to use connected data spaces to communicate with consumers about demand response programs. This data can be used to inform consumers about the programs and to incentivize them to participate.

A power grid operator can use a connected data space to collect data from DERs and other grid assets. This data can be used to optimize the operation of the grid and improve the performance of DERs.

Connected data spaces have also the potential to significantly improve the efficiency and reliability of the energy system. They can help to facilitate flexibility aggregation, energy communities, demand response and various power/energy services, and they can help to reduce emissions and improve the sustainability of the energy system. Nevertheless, some challenges need to be addressed in order to realize the full potential of connected data spaces for energy, these are:

Data security and privacy: Connected data spaces will need to be secure and protect the privacy of data.

Interoperability: Connected data spaces will need to be interoperable so that they can be used by different stakeholders.

Standardization: There is a need for standards for connected data spaces to ensure that they are interoperable and secure.

Cost: The cost of developing and deploying connected data spaces can be a barrier to adoption.

Despite these challenges, the potential benefits of connected data spaces for energy are significant. As the technology matures and the cost of deployment decreases, it is expected that connected data spaces will play an increasingly important role in the future of energy.

Data Spaces and the IEEE2030.5

In order to support and integrate the IEEE2030.5 standard, the InterSTORE Data Space connector should act as an intermediary between the IEEE2030.5 standard and the data space, ensuring that data from IEEE2030.5-compliant devices and systems can be seamlessly integrated into the data space. In this way, we are able to maintain the integrity of the standard while integrating its data and functionality into the data space in a seamless way. In order to make this, some aspects must be considered:

The connector should be capable of understanding IEEE2030.5 communication and data formats. The connector should be capable to translate data received in IEEE2030.5 format into a format compatible with the data space.

The connector should implement APIs that allow other components of the data space to interact with the translated data. These APIs should provide access to the data in a way that aligns with the expectations of the data space participants and applications. The connector should ensure security and privacy measures required by IEEE2030.5

The implementation and adaption of an existing connector for interfacing with the IEEE 2030.5 standard or any other external standard can present various challenges. One primary challenge is the complexity of the standard itself, such as IEEE2030.5, which encompasses a range of features and protocols, making it a comprehensive standard that requires a deep understanding for correct implementation. Moreover, understanding the applications and scenarios requirements (coming from use cases) will be crucial for determining what types of data need to be collected, from which sources, and for what purposes is necessary to guide the connector's adaptation.

Another significant challenge lies in the mapping and integration of data. Integrating data from the IEEE2030.5 standard format to match a more generic data space's structure can be difficult, particularly when dealing with differences in data structures, semantics, or units of measurement. In addition to this, the scalability can be a concern, particularly as the number of devices and data sources in your data space grows. It will be important to ensure that the connector remains reliable and performs well under increasing data loads. The connector could also adopt principles from IEEE2030.5 for insights into building scalable systems.

Finally, ensuring data quality during the integration from external sources is fundamental, as data inconsistencies or errors can affect the reliability of the data space.

4.3 System requirements

The incorporation of IEEE2030.5 imply certain requirements for deployments. Virtual inertia and fast frequency regulation are among the services that entail the rapid injection or absorption of power to stabilize grid frequency in response to sudden changes in load or generation. In the future of modern power systems, the role of fast communication is crucial. Given that the primary system indicator for verifying a proper inertial response is the Rate of Change of Frequency (RoCoF), which should be calculated within a short time window, typically no more than 0.5 seconds, this underscores the paramount importance of fast communication. In this context, NATS offers several advantages:

1. Low Latency: NATS' low-latency messaging ensures that signals for adjusting power generation or consumption can be disseminated with minimal delay. This is essential for swiftly countering frequency deviations and preventing grid instability.
2. Real-time Coordination: Virtual inertia services often require seamless coordination between various grid components, including renewable energy sources, energy storage systems under the umbrella of hybridization strategy. NATS facilitates real-time communication among these components, allowing them to respond rapidly and collaboratively to grid frequency fluctuations.
3. Scalability: As the grid evolves with the integration of more renewable resources and distributed energy assets, scalability becomes crucial. NATS' ability to scale horizontally by adding more servers to the cluster supports the growing demand for virtual inertia services as the grid expands.
4. Reliability and Security: Virtual inertia or fast frequency regulation services involve critical grid operations, making security paramount. NATS provides authentication and encryption features to safeguard communication and protect against unauthorized access with reliable communication even in the presence of sever failure or network issues.

Regarding data space connectors, in InterSTORE an updated version from the OneNet connector incorporating the IEEE2030.5 is being replicated and deployed. At the time of writing in terms of pre-requisites for the deployment should foresee:

The hardware and operating system prerequisites are:

- A 2-core processor
- 4GB RAM Memory
- 50GB of disk space or more.

The software prerequisites include:

- Centos 7 or Windows Server Operative System (OS)
- docker and docker-compose.

The connector used in InterSTORE (OneNet replication) software and its components are delivered utilizing the Docker containers functionalities. Firstly, the Docker platform must be downloaded and installed according to the OS of the server to host the deployment, as described in the following paragraphs.

The deployment is time consuming and requires the setting of static public addresses which in some organizations may be difficult to request for internal cyber-security policies. However, once the deployment is done, the interaction with the available API is standard, only requiring a few lines of code in python referring to the endpoints made available by the user interface platform according to the services published/subscribed. The OneNet deployment guideline can be followed in the following Github page:

GitHub - european-dynamics-rnd/OneNet

4.4 Mapping challenges, risks and mitigation actions

In the intricate landscape of project management, the ability to anticipate, assess, and address challenges and risks is paramount to ensuring the successful execution of any endeavour. It is in this vein that we delve into the subchapter focused on "Mapping Challenges, Risks, and Mitigation Actions" following a meticulous analysis of various project use cases. The table presented in this chapter will present a list of risks, taking into account the feedback from the use case specifications and explore viable mitigation actions and strategies that can be employed to mitigate these challenges and risks effectively. This comprehensive approach will serve as a valuable resource for the management WP and for WP5 dealing with the implementation, providing them with actionable insights to navigate the complexities of project execution and increase the likelihood of delivering successful outcomes.

Table 5: Table with identified risks from the use cases

Risk description	Likelihood	Potential Risk impact	Mitigation actions
Inverter Manufacturer unwilling to install firmware updates may impact IEEE2030.5 native demonstration	High	High	Secure at least one manufacturer
Disruption in Operations of Demo partners	High	High	Propose parallel deployments with current installations
Demo partners uncapable of implementing redundant /parallel test of the IEEE2030.5 with the system in operation.	Medium	High	Investigate the possibility of deploying switches or other technical solutions to enable parallel communication

Third party imposition of limitations for scheduling of HESS (DSO, internal systems)	High	Medium	If a specific dispatch is not able to be scheduled, at least comparable results should be provided
Unavailability of HESS systems to show higher performance or comparable results	Medium	Medium	The results of the project should not be biased. If no higher performance is observed, it should be explicitly stated in the proper reports and KPIs
Unwilling participants for DR demo	Low	Medium	The recruitment of the participants will be based on well explained rules, motivations. Only willing participants, but without disclosing the variable under study, should be recruited
Unmatching operational data for valorisation cases	Medium	Medium	Anticipating the knowledge of needed assets, resources and data may allow a better planning in ensuring the availability
Insufficient testing procedures of IEEE2030.5 for certification of open-source tool	Medium	Medium	Evaluate and coordinate with WP3 leader and partners
Insufficient requirements of NATS and IEEE2030.5 converter for specific service provision (e.g. inertia)	Medium	Medium	Only known in testing phase but explicitly noted for future test.

The results of this analysis will be shared with WP5 and the project management for action taking. A follow up activity and monitoring of each of the risk, category and mitigation actions will be shared with each Demo responsible.

5 REFERENCES

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6 APPENDIXES

7 LIST OF TABLES

8 LIST OF FIGURES

Annex 1 – Use Case Template

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	
Objective(s)	
Related business case(s)	

1.4 Narrative of use case

Narrative of Use Case
Short description

1.5 Key performance indicators (KPI)

ID(*)	Name	Description	Reference to mentioned use case objectives

(*) The ID number is based on the project KPI reference list –

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition

4.2 Steps – Scenarios

Scenario								
Scenario name:		*No. 1 and 2*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information*	*Requirement, R-IDs*
							Exchanged (IDs)	

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
Requirement R-ID	Requirement name	Requirement description

7 Common Terms and Definitions

Common Terms and Definitions	
Term	Definition

Annex 2 – InterSTORE Use Cases IEC62559 description

HLUC01 - DES Flexibility Market Monetization

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
HLUC01	Markets / Residential	Distributed Energy Storage (DES) Flexibility Market Monetisation

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	15.03.2023	Peter Nemček, Nikolaj Candellari, CYG	Initial definition of the use-case characteristics

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	As society we need to accelerate green energy transition so that in the future all energy generated, stored, and consumed could be renewable and flexible. This is why it is important to unlock and manage distributed power flexibility and make it useful for variety of power system use-cases. Each individual flexibility resource, like consumer loads, distributed generation (RES and DG) and storage, does not hold much market value unless aggregated in larger pool with capacity and characteristics that fulfil balancing services and markets' requirements. Each type of flexibility asset comes with different characteristics, like capacity, time constraints, response and ramp times, etc. thus, emphasising the importance and value of intelligent flexibility hybridization at portfolio level. The next step is finding the best possible market for its monetization.
Objective(s)	Enable monetisation of Distributed Energy Resources (DER) flexibility at various markets.
Related business case(s)	HLUC 2: Energy community Distributed Energy Storage (DES) utilisation

1.4 Narrative of use case

HLUC01 – DES Flexibility Market Monetisation

Narrative of Use Case
Short description
A user, an Aggregator, would like to offer its customers a possibility to generate flexibility revenues, thus decreasing their overall electricity cost. To technically achieve this, Aggregator deploys and operates a Flexibility Management Platform – an ICT system which aggregates and manages flexibility from diverse Distributed Energy Storage (DES) sources, like BESS, HESS, heat pumps and EV. The real-time data collected will comprise electricity consumption and generation measurements, BESS State of Charge, EV charging status, EV charging power, and if available by local EMS also baseline and flexibility forecasts. The real time data sent to these DES sources will mostly comprise power curtailment set-point. Its innovative optimization algorithms hybridize them with other flexibilities (loads, RES, DG, etc.) into marketable products. It will autonomously bid the hybrid flexibility products to the most appropriate markets (balancing, TSO and DSO balancing services, intra-day, etc.) and executes the provision of the flexibility.
Complete description
Introduction Transmission system operators (TSO) need balancing services to maintain the balance between generation and consumption in real time and to guarantee reliable grid operation. Balancing services are divided into frequency containment reserve (FCR), automatic frequency restoration reserve (aFRR), manual frequency restoration reserve (mFRR) and replacement reserve (RR) according to the full activation time and the duration of activation. For an aggregator this is an opportunity. By aggregating distributed flexibility resources, the aggregator can participate in balancing service market and profit of it. In the past only conventional generators could offer their flexibilities to the balancing service market. But nowadays this kind of service can also be delivered by aggregators (flexibility operators) operating a Flexibility Management Platform or Virtual Power Plant (VPP, also considered as EMS). Furthermore, the aggregator can also offer the flexibility as DSO flexibility service (voltage or congestion Management ancillary service) or to the power exchange intra-day market, in order to maximise its own profit. In order to be able to participate in the balancing service market and provide mFRR and aFRR services, VPP or flexibility operator must fulfil pre-qualifications tests, at which TSO checks if VPP system fulfils all required technical characteristics. These are: - limits of minimum and maximum power of offered flexibility. - TSO-specific bidding intervals from several hours to an entire year - 5 minute full activation time from call of TSO to provision of full capacity of the unit - maximum duration of activation can be limited - full (100%) delivery already the first minute of activation, otherwise penalization might be applied - capacity must stay within narrow limits during the whole duration of activation otherwise penalization applies - measurement and forecast (baseline) must be provided in 2 second resolution - all distributed generators or loads have to be connected to distribution grid and not to transmission grid. Only a flexibility operator which fulfils all these requirements could offer aFRR and mFRR balancing service to the TSO. A company active in the non-regulated sector, e.g. a retailer or a power trader normally plays the role of flexibility VPP operator. Based on various business models the VPP operator is purchasing flexibility from different distributed flexibility sources. The business model depends on type of DER (battery storage, industrial, commercial, diesel generator set, CHP, renewables, demand response etc.). Flexibility operator has a special contract for buying flexibility from DER, which can be independent from the energy supply contract. Step-by-step description of the use case The required steps can be differentiated between ex-ante procedures (balancing service market or power exchange intra-day market bidding), real-time procedures (aFRR or mFRR) and ex-post procedures (Reporting and invoicing).

Market bidding procedure:

1. The VPP gets information about expected market prices for a set of balancing service markets and power exchange intra-day market.

Tools or functions included in this step
Flexibility Management Platform (VPP)
OPTIONAL: Price forecasting system (market player operated)

2. The VPP gets information about available flexible capacities inside the pool. If no information is received from external systems, the VPP performs an internal calculation.
The VPP has an internal forecasting algorithm which can predict DER's behaviour based on behaviour of the past 10 weeks, if more precise information should not be available.

Tools or functions included in this step
Interoperability toolkit
Flexibility Management Platform (VPP)
OPTIONAL: Flexibility estimation
OPTIONAL: Renewable generation forecasting system
OPTIONAL: Load forecasting system (market player-operated)

3. The VPP calculates available capacity and optimal price of bids on all available markets via its Market arbitrage tool, considering further rules for internal backup.

The bids submitted by the VPP must fit to the auction schedule (start-time, end-time, minimum capacity) and reflect the variable costs of balancing service provision by DER as minimum price limit. Considering all the incoming and internally calculated information, the VPP assesses the available capacity of the pool in the mid-term (next upcoming trading period) and based on related costs derived from contracts with DERs, the VPP calculates possible bids for the markets. In this phase, internal backup rules (e.g. n2, -30%, etc.) are taken into account in order to assure, that the capacity of submitted bids can be provided with a very high reliability during the whole delivery period.

Tools or functions included in this step
Market arbitrage module
Flexibility Management Platform (VPP)

4. The VPP submits bids to the balancing service trading platform and/or power exchange market platform.

5. The balancing service trading platform and/or power exchange market platform informs the VPP about acceptance or non-acceptance of submitted bids.

6. The VPP internally assigns flexibilities (incl. backup) to accepted bids and reserves the capacities (of DER) to avoid double trading of flexibilities.

Thus, already reserved capacities cannot be used for bidding on other markets.

7. VPP also calculates the remaining available ancillary services (voltage and/or congestion management) which could be offered to the DSOs. The offers are then dispatched through Open Data Space service to "subscribed" DSO(s) which can accept or ignore them.

Tools or functions included in this step

Open data spaces tool Flexibility Management Platform (VPP)

8. *Optional:* The VPP informs the DER about reservation of flexibilities, if this was agreed between the parties.

Tools or functions included in this step
Interoperability toolkit Flexibility Management Platform (VPP)

Activation:

1. The VPP periodically receives measurement of each DER via the Legacy Protocol Converter (RTU) with Interoperability toolkit.

   If a customer wants to participate in a VPP, the minimum requirement is collecting reliable measurements, from the DSO's meter or any other certified measurements device installed at the customer site. In the Austrian case, the TSO demands measurements from the main-billing meter, however it also allows measurements from sub-meters of flexible units (loads, steam turbines, generators, etc.). All smart meters provide a 15-minute load profile which is used for billing purpose (energy consumption and maximum demand in a month). For efficient operation, a VPP needs real-time measurement data with at least 2 seconds readings. Ideally, the DSO would replace the billing meter with a new one which has ability to measure and store double load profile (15 min and 2 sec readings) and has two independent communication channels. Double communication channels are needed, because simultaneous requests from a metering center may collide and hinder the data transfer. One communication channel is for billing purpose, so DSO can, usually once per day, read billing registers and 15 minute load profile of the previous day. The second communication channels are for collecting 2 sec active power profiles in real time for VPP purpose. Both communications with the meter are established from DSO's Meter Data Management (MDM) system. The VPP requests measurement data via a Web service from the MDM system. MDM validates each request and if the VPP has approved licence for measurement data, then it receives the data, otherwise not.

   An alternative way for collecting 2 seconds data without changing main meter is to install a RTU (Legacy Protocol Converter) which is connected to a pulse output of the main meter. The RTU then counts pulses from the meter and calculates power/energy in 2 seconds resolution and sends measurements to the VPP.

Tools or functions included in this step
Legacy Protocol Converter Interoperability toolkit Flexibility Management Platform (VPP)

2. The VPP periodically calculates the aggregated values of the pool (e.g. baseline, measurements, available capacities) and sends the information to the balancing service platform and optionally to power exchange market platform. This is done only if a bid was accepted and is currently active, otherwise 0 MW will be sent. These requirements may be specific to TSO or power exchange markets.

   Based on the prediction of baseline of individual DER the VPP periodically sends aggregated prediction (baseline) to the TSO for the entire pool.

   In ex-ante forecasting and bid optimization the positive and negative value of flexibility of the DERs is the relevant value. In the real-time processes and activation control there is also a need to calculate a baseline, which is the reference point of active power (which the DER would generate or consume in normal operation without balancing service provision). The provided balancing *service is calculated in real-time as the difference between the baseline and the real measurement of active power. The VPP (and the TSO) must know the delivered amount of aFRR, mFRR or flexibility in each time interval.*

The baseline definition is market and TSO-dependent, a frequently used baseline can be e.g. the day-ahead trading schedule of the DER (only available for large units), a 15 min average of the same quarter-hour of the past 5 days, or the last measurement before reception of a switching command, etc.

The VPP System aggregates flexible units (DER) by collecting measurement data and current availability and based on their characteristics modulates and predicts the available flexibility.

The VPP calculates current available flexibility of each DER based on different input variable. For example, if it is known, that a certain customer cannot curtail (lower their consumption) below a given threshold value then an algorithm inside the VPP takes the current consumption into account for calculating availability. DER operators have access to a graphical interface which allows to insert information of their partly or total unavailability in the future (in case of scheduled maintenance or refit). The algorithm can even take into account on-line information if DER provides their availability via RTU.

The pool values (of measurements, baselines, flexibility), which must be sent to the TSO or optionally to power exchange intra-day market, are the sum of the values of each DER in the pool, and are calculated as soon as the calculation for each individual DER is finished.

Tools or functions included in this step
Interoperability toolkit Flexibility Management Platform (VPP)

3. In case of an enduring frequency deviation the balancing service market platform initiates the activation of DER by sending an activation request to the VPP. If the bid was accepted in power exchange intra-day market, then the activation is triggered automatically when the product/bid delivery is due.

   The activation request is transmitted electronically from TSO's balancing service market platform to the VPP. In this way activation commands and pool values are being adjusted in real time. The activation commands received via ICT interface will directly be used by the VPP to trigger the activation automatically.

   For the power exchange intra-day market there is no additional activation trigger because the activation timeframe is defined with accepted bid.

4. The VPP calculates the optimized dispatch of DER.

   A VPP internal function (Real time control of DER) then dispatches and activates DER based on costs and other parameters (availability, capacity, time delay settings, full activation time, maximum duration of activation, number of activations per period, etc.).

Tools or functions included in this step
Flexibility Management Platform

5. The VPP sends activation commands to the DER(s) and monitors the performance of the activation.

   The way of activating DERs is through direct switching DER (loads or generators) via RTU or comparable direct ICT connections with DER.

   By means of real-time measurements (e.g. 2 seconds interval) and the pre-calculated baseline, a closed loop control algorithm checks continuously if the activation is successful (power provision within tolerance band) or not. In case of deviation from the expected behaviour, individual DER's setpoints are corrected or additional DERs are activated or deactivated.

Tools or functions included in this step

Interoperability toolkit
Legacy Protocol Converter
Battery Energy Storage System tool
Flexibility Management Platform (VPP)

6. If needed, the balancing service market platform can change the activation schedule (capacity, end time or both) by sending a new command to the VPP.

7. If an activation change was received (step 6) the VPP repeats the steps 4) and 5) to adjust provision of balancing service to the new schedule.

8. The TSO's balancing service market platform sends the "activation stop" message to the VPP.

   The activation stop is transmitted electronically from TSO's balancing service market platform to the VPP. In this way activation commands and pool values are being adjusted in real time. The activation commands received via ICT interface will directly be used by the VPP to end the activation automatically.

   For the power exchange intra-day market there is no additional activation stop needed because the activation timeframe is defined with accepted bid.

9. The VPP sends deactivation commands to the DER(s) and continues monitoring the behaviour of the DER(s).

Tools or functions included in this step
Interoperability toolkit
Legacy Protocol Converter
Battery Energy Storage System tool
Flexibility Management Platform (VPP)

Reporting and invoicing:

Tools or functions included in this step
Flexibility Management Platform (VPP)

1. After the end of a delivery period (bidding and activation period) or on the following day the VPP sends a report about activation performance to the balancing service market platform and power exchange market platform.

   This report is specific to each TSO or power exchange market, and may for instance contain detailed measurements and baselines of activated DER in 2 seconds intervals etc.
2. The balancing service and power exchange intra-day market platforms check the report and send an approval message to the VPP.

3. The VPP submits an activation invoice to the balancing service and power exchange market platforms.

4. The VPP sends an activation performance report to the DER.

   The VPP sends activation reports to DER if that is foreseen in the contracts and handles invoices for activations.

5. The DER submits an activation invoice to the VPP.

1.5 Key performance indicators (KPI)

ID(*)	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI1	DES multi-service grid support	Number of grid supporting services (frequency, voltage, congestion etc.), provided by a specific DES.	Setting up system which can follow many goals is an added value and gives its user a competitive edge on the market.
KPI2	DES multi-service market participation	Number of possible balancing and power exchange markets (e.g. aFRR, mFRR, intra-day, day-ahead) on which specific DES can participate.	Maximising profit of sold produced electrical energy is greater with bigger number of available markets.
KPI3	Battery capacity	Amount of Flexibility provision in the demos from BESS	Added batteries help demonstrate their usefulness and grid balancing services possibilities.
KPI4	Diversity of resources	Number of different DER devices successfully tested and demonstrated	Greater diversity of assets makes it easier to showcase interoperable nature of interoperable toolkit.
KPI5	Asset management	Number of flexibility assets monitored by the InterSTORE EMS solutions	Testing monitoring capabilities of new generation EMS.
KPI7	N° of end users involved in HESS	N° of end users (workers, EV users, consumers) engaged in the demonstration of interoperable HESS	Hybridization
KPI10	Nbr of DER assets tested with IEEE2030.5	Number of different DER devices and EMS successfully tested with the IEEE2030.5 and demonstrated in real-life pilots	Interoperability
KPI11	Data space digitized assets	Amount of digitized storage systems/platforms/hubs assets integrated in the common data space exchanging data	Data Spaces
KPI25	Integrated capacity	Integrated power of the HESS within the project demos	Integrated power of HESS
KPI26	Increase of flexibility	Demand side flexibility potential increase due to hybridization implementation	Flexibility

(*) The ID number is based on the project KPI reference list

1.6 Use case conditions

Use case conditions
Assumptions
• Aggregation of flexibility is cost competitive with conventional sources of aFRR, mFRR or intra-day bids (e.g. gas/coal thermal power plant, big hydro power plant etc.). • DERs have an interest and ability to curtail/increase their consumption or generation (flexibility) when requested. • Two-way communication between the TSO system and VPP system, grid and VPP system.
Prerequisites

• Regulatory conditions allow aggregation of flexibility resources. • TSO balancing service market is accepting flexibility offers from aggregators. • Optionally: power exchange organized intraday market is accepting flexibility offers from aggregators. • Optionally: DSO is accepting flexibility offers from aggregators. • Distributed flexibility resources are aggregated and VPP system is qualified for balancing service delivery.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other HLUCs:
HLUC 2: Energy community Distributed Energy Storage (DES) utilisation
Level of depth
Use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution.
Prioritisation
This UC will be demonstrated at Austrian demo side once the interoperability toolkit and new-generation software will be deployed and flexibility assets connected.
Generic, regional or national relation
Generic in most aspects, national specifications (concerning market organisation and ICT requirements) of the TSO as operator of the aFFR and mFRR systems must be considered.
Nature of the use case
Technical/system use case.
Further keywords for classification
Flexibility aggregation, VPP, DR, balancing services, TSO, DSO, flexibility operator, smart grid, electricity metering, battery storage, interoperability

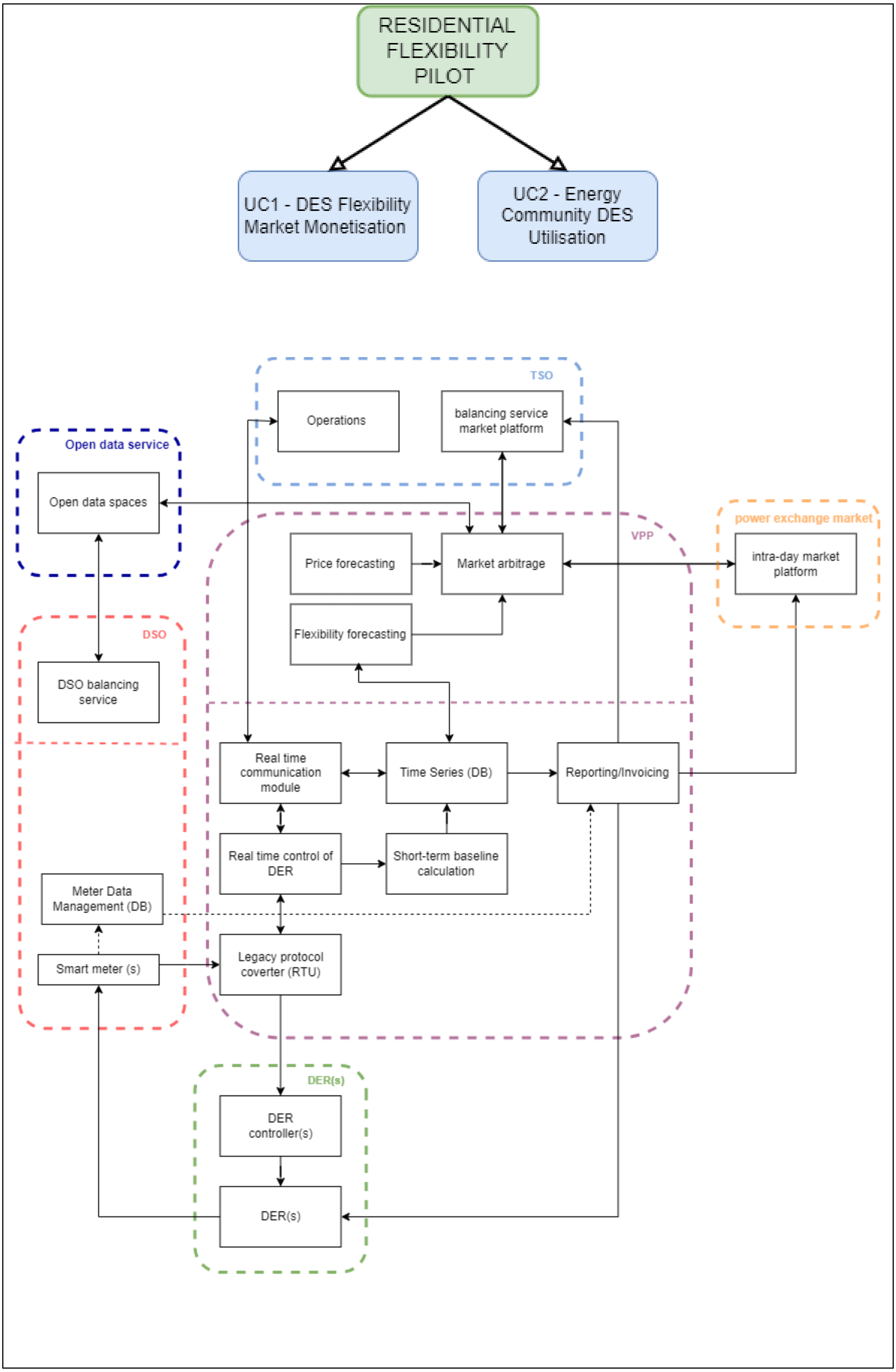
1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case
HLUC-PUC Relation Diagram

HLUC01 – DES Flexibility Market Monetisation



HLUC Sequence Diagrams:

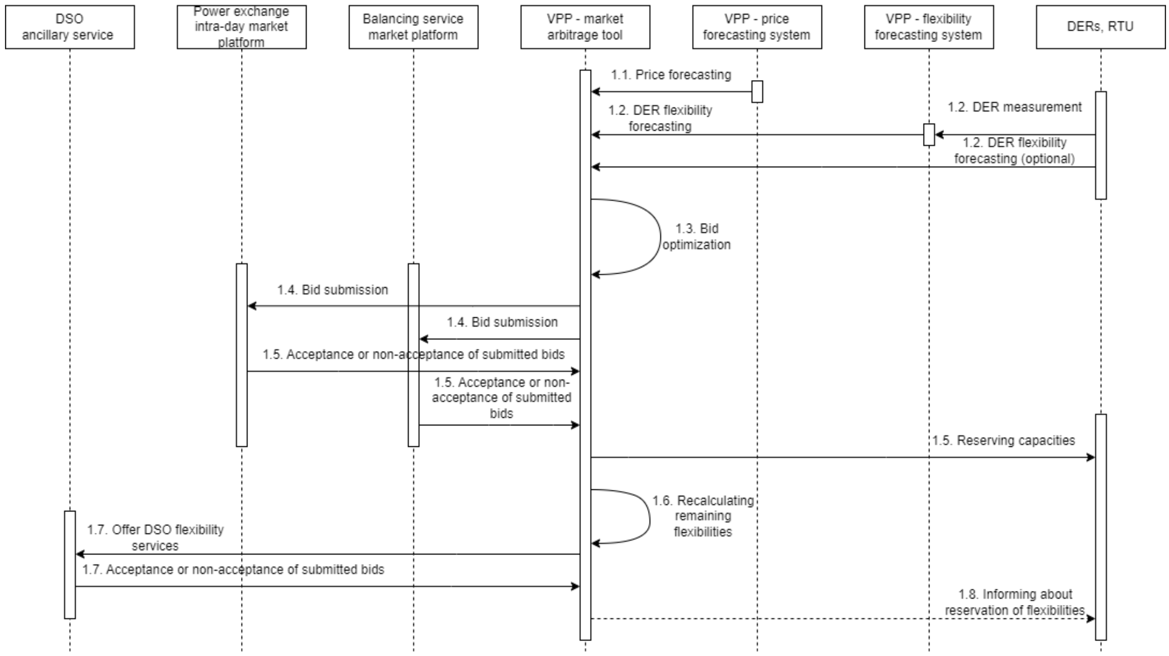


Figure 16 Bidding procedure

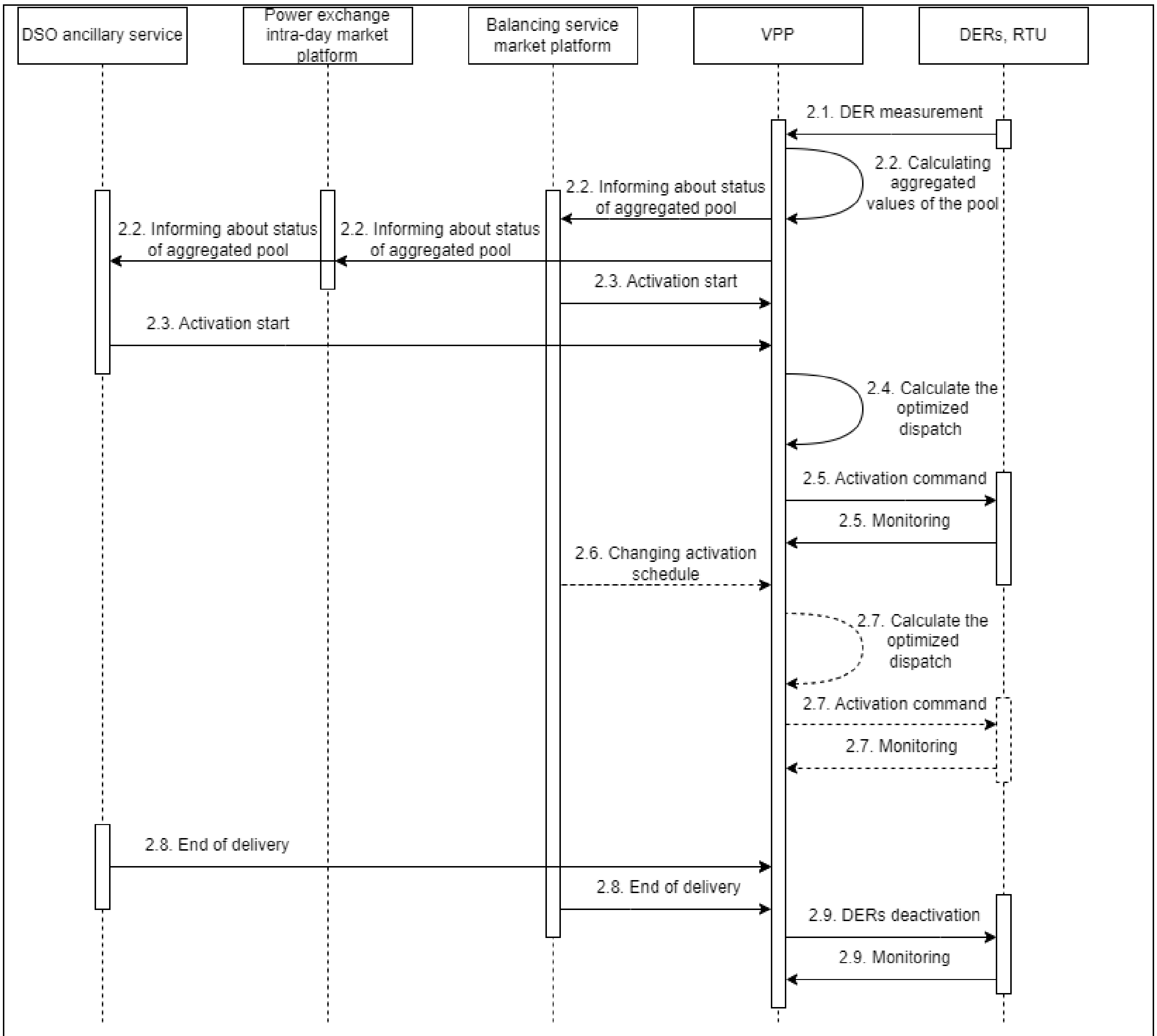


Figure 17 *Activation procedure*

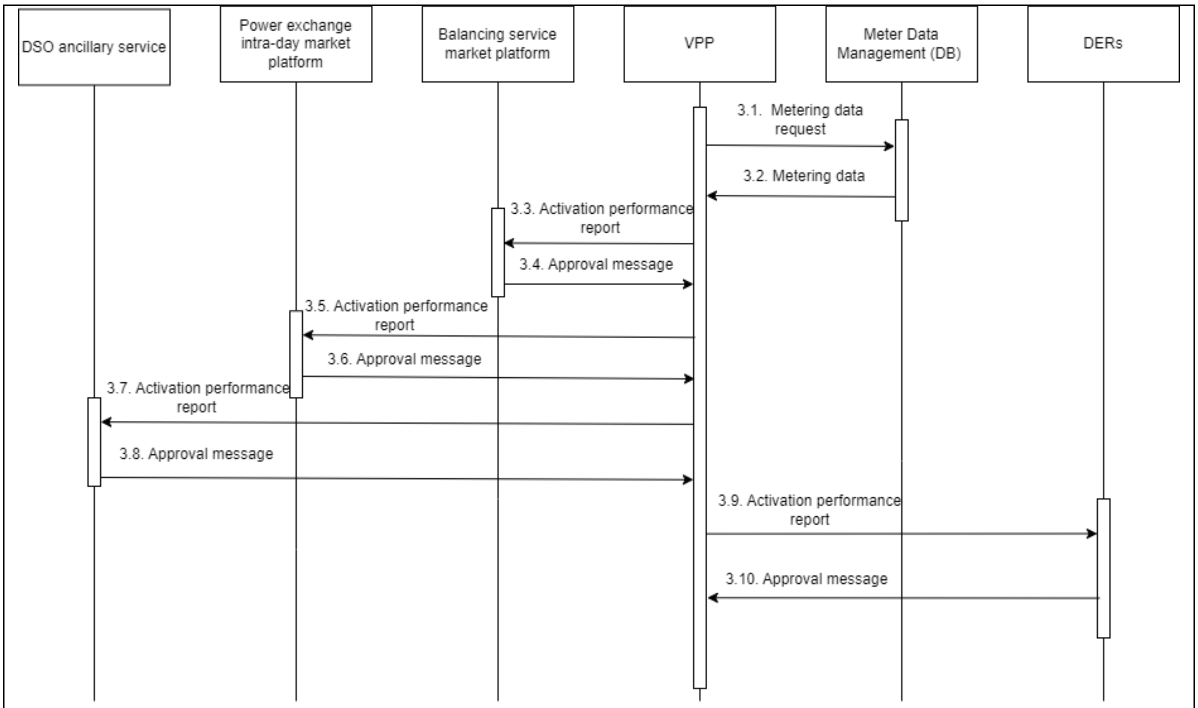


Figure 18 Reporting procedure

3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Distribution System Operator (DSO)	Actor	According to the Article 2.6 of the Directive: "a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity". Moreover, the DSO is responsible for regional grid access and grid stability, integration of renewables at the distribution level and regional load balancing.
Transmission System Operator (TSO)	Actor	According to the Article 2.4 of the Electricity Directive 2009/72/EC (Directive): "a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity". Moreover, the TSO is responsible for connection of all grid users at the transmission level and connection of the DSOs within the TSO control area.
Retailer	Role	Entity selling electrical energy to consumers - could also be a grid user who has a grid connection and access contract with the TSO or DSO. In addition, multiple combinations of different grid user groups (e.g. those grid users that do both consume and produce electricity) exist. In the remainder of this document, the terms customer/consumer and grid user are used interchangeably where appropriate.
DER	Role	A Distributed Energy Resource (DER) can be a generator, renewable generator, demand response unit or storage unit.
Flexibility operator	Role	Offers services to aggregate energy production from DER (generators, renewables or storage) and acts towards the grid as one entity, including local aggregation of demand (Demand Response management) and supply (generation management). In cases where the flexibility operator is not a supplier, it maintains a contract with the supplier.
Consumer (User)	Role	Citizen who is end-user of electricity, gas, water or heat.
Prosumer	Role	Consumer that can also generate energy using a Distributed Energy Resource
Electric Vehicle (EV)	System	A vehicle with an electric drive (as only drive or in combination with a fuel engine) and a battery which can be charged at a charging station.
Service Provider	Role	Entity providing energy services to consumers - could be a retailer or a DSO. In the remainder of this document, the terms customer/consumer and grid user are used interchangeably where appropriate.
Smart appliance	Device	An example of a smart device is a smart white goods appliance which is an appliance that has the capability to act in response to a signal and thereby optimize its behaviour towards the energy supply network. The signal can be

		received from a utility or a third-party energy service provider directly or via a home energy management system. The signal can be information like the cost of energy or the amount of available renewable energy, or it can be a Demand Respond signal (delay load signal or other related information) that the appliance must receive, interpret and react upon based on pre-set or active consumer input. The smart appliance is not guaranteed to respond but will do so based on its status and user settings in order to ensure the expected performance. The consumer has the ultimate control of the appliance and can override any specific mode (e.g., override a delay to allow immediate operation, limit delays to no more than a certain number of hours, or maintain a set room temperature). Any appliance operation settings or modes shall be easy for an average, non-technical consumer to activate or implement.
Sensor	Device	Part of a measuring instrument, or measuring chain, which is directly affected by the measurand, and which generates a signal related to the value of the measurand
Smart Meter	Device	The Smart Meter is a combination of the following meter-related functions from the Smart Metering reference architecture: Metrology functions including the conventional meter display (register or index) that are under legal metrological control. When under metrological control, these functions shall meet the essential requirements of the MID; One or more additional functions not covered by the MID. These may also make use of the display, Meter communication functions. The SM can have the tariffs in memory
VPP (EMS)	System	A Flexibility Management Platform or Virtual Power Plant (VPP) is a cloud-based Energy Management System (EMS) that aggregates the flexibility of different DERs for the purposes of trading on the various electricity markets, supporting grid or wholesale supply.
Electricity Balancing market	System	A special kind of market that specialises in trading of balancing services to help the TSO keep the transmission grid stable and secure. There are many types of balancing markets are there are many balancing services (FCR, aFRR, mFRR) that are sought by TSOs.
Ancillary service market	System	A special kind of market that specialises in trading of ancillary services to help DSO keep the distribution grid stable and secure. There are many types of ancillary services (e.g. voltage control, congestion management, etc.) services that are sought by DSOs.

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Standard	IEC 62559-2 Use Case Methodology	Published	Definition of the presented template	International Electrotechnical Commission	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Utilization and monetisation of Distributed Energy Resources (DER) flexibility at various markets.	VPP gathers up to date information from various DERs and can aggregate their flexibility. Furthermore, it connects to targeted flexibility markets where it bids accordingly to its primary objective: maximisation of asset owner's revenue.	VPP (EMS)	Delivery of accepted market bid.	DERs and markets are properly connected to VPP and can exchange required information.	Revenues generated.
2	Monetisation of DERs is disabled due to DER data not reaching VPP	VPP cannot gather information about DER statuses.	VPP (EMS)	No data in EMS system	DERs data is not shared with VPP.	Potential revenues lost.
3	Monetisation of DERs is disabled due to VPP not being able to participate on flexibility markets	VPP don't have access to different flexibility markets information.	VPP (EMS)	No trading	Flexibility market data is not shared with VPP.	Potential revenues lost.

4.2 Steps – Scenarios

Scenario No. 1								
Scenario name:		**Utilization and monetisation of Distributed Energy Resources (DER) flexibility at various markets**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
1.1	Price forecasting	Price forecasting	The VPP - price forecasting system makes predictions about market prices and sends the predicted values to VPP - market arbitrage tool.	REPORT	VPP - price forecasting system	VPP - market arbitrage tool	Markets price forecast (I-10)	
1.2.1	DER measurement	DER measurement	DERs send directly or via RTUs real-time consumption and/or generation measurements to VPP – flexibility forecasting system	REPORT	DERs, RTU	VPP – flexibility forecasting system	Metering data (I-1)	R-1.1, R-1.2, R-2.2
1.2.2	DER flexibility forecasting	DER flexibility forecasting	Based on received DERs' consumption and/or generation measurements, the VPP – flexibility forecasting calculates and predicts available flexibility for the future and sends the info to VPP - market arbitrage tool	REPORT	VPP - flexibility forecasting system	VPP - market arbitrage tool	DER flexibility forecast (I-11)	
1.2.3	DER flexibility forecasting (optional)	DER flexibility forecasting (optional)	DERs send directly or via RTU real-time or scheduled flexibility forecast to VPP – market arbitrage tool	REPORT	DERs, RTU	VPP - market arbitrage tool	DER flexibility forecast (I-11)	
1.3	Bid optimization	Bid optimization	The VPP - market arbitrage tool calculates optimal bidding strategy for flexibility monetization and generates bids accordingly.	CREATE	VPP - market arbitrage tool	VPP - market arbitrage tool	List of available bids (I-13)	

1.4.1	Bid submission	Bid submission	The VPP - market arbitrage tool sends bids to power exchange intra-day market platform.	REPORT	VPP - market arbitrage tool	Power exchange intra-day market platform	List of available bids (I-13)	
1.4.2	Bid submission	Bid submission	The VPP - market arbitrage tool sends bids to balancing service market platform.	REPORT	VPP - market arbitrage tool	Balancing service market platform	List of available bids (I-13)	
1.5.1	Bid acceptance	Bid acceptance	The power exchange intra-day market platform informs VPP - market arbitrage tool whether the specific bids were accepted or not.	REPORT	power exchange intra-day market platform	VPP - market arbitrage tool	List of accepted bids (I-15)	
1.5.2	Bid acceptance	Bid acceptance	The balancing service market platform informs VPP - market arbitrage tool whether the specific bids were accepted or not.	REPORT	balancing service market platform	VPP - market arbitrage tool	List of accepted bids (I-15)	
1.5.3	Reserving capacities	Reserving capacities	VPP - market arbitrage tool reserves DERs' flexibility to be delivered in accordance with accepted bids.	CREATE	VPP - market arbitrage tool	DERs, RTU	List of reserved capacity per grid area (I-16)	
1.6	Recalculating remaining flexibilities	Recalculating remaining flexibilities	VPP - market arbitrage tool recalculates available flexibilities after the reservation of the accepted bids.	CHANGE	VPP - market arbitrage tool	VPP - market arbitrage tool		R-2.5
1.7.1	Offer DSO flexibility services	Offer DSO flexibility services	The VPP - market arbitrage tool sends bids to DSO ancillary service platform.	REPORT	VPP - market arbitrage tool	DSO ancillary service	List of available bids (I-13)	
1.7.2	Acceptance or non-acceptance of submitted bids	Acceptance or non-acceptance of submitted bids	DSO ancillary service informs VPP - market arbitrage tool whether the specific bids were accepted or not.	REPORT	DSO ancillary service	VPP - market arbitrage tool	List of accepted bids (I-15)	

1.8	Informing about reservation of flexibilities	Informing about reservation of flexibilities	VPP - market arbitrage tool reserves DERs' flexibility to be delivered in accordance with accepted bids.	CHANGE	VPP - market arbitrage tool	DERs, RTU	List of reserved capacity per grid area (I-16a)	
2.1	DER measure ment	DER measure ment	DERs send directly or via RTUs real-time consumption and/or generation measurements to VPP	REPORT	DERs, RTU	VPP	Metering data (I-1)	R-1.1, R-1.2, R-2.2
2.2.1	Calculating aggregated values of the pool	Calculating aggregated values of the pool	Based on received information from DERs, VPP calculates the current status of the portfolio (e.g. baseline, flexibility etc.)	CREATE	VPP	VPP		
2.2.2	Informing about status of aggregated pool	Informing about status of aggregated pool	The VPP sends report of portfolio's current status to balancing service market platform.	REPORT	VPP	Balancing service market platform	Aggregated baseline of DER (I-4)	R-2.5
2.2.3	Informing about status of aggregated pool	Informing about status of aggregated pool	The VPP sends report of the portfolio's current status to power exchange intra-day market platform.	REPORT	VPP	Power exchange intra-day market platform	Aggregated baseline of DER (I-4)	R-2.5
2.2.4	Informing about status of aggregated pool	Informing about status of aggregated pool	The VPP sends report of the portfolio's current status to DSO ancillary service.	REPORT	VPP	DSO ancillary service	Aggregated baseline of DER (I-4)	R-2.5
2.3.1	Activation start	Activation start	In accordance with accepted bids the trigger is sent to VPP for activation.	EXECUTE	Balancing service market platform	VPP	Flexibility Perimeter Declaration (I-5)	R-5.1

2.3.2	Activation start	Activation start	In accordance with accepted bids the trigger is send to VPP for activation.	EXECUTE	DSO ancillary service	VPP	Flexibility Perimeter Declaration (I-5)	R-5.1
2.4	Calculate the optimized dispatch	Calculate the optimized dispatch	The VPP internally calculates optimal dispatchment of DERs' flexibility	CREATE	VPP	VPP		R-2.5
2.5.1	Activation command	activation command	The VPP sends dispatchment commands to DERs with activation information.	EXECUTE	VPP	DERs, RTU	Flexibility Perimeter Declaration (I-5a)	R-2.5
2.5.2	Monitoring	Monitoring	The DERssend information about their status on each predetermined interval	REPEAT	DERs, RTU	VPP	Analysis report (I-7)	R-2.5
2.6	Changing activation schedule	Changing activation schedule	Due to deviations on electrical grid corrections are required from VPP by balancing service market platform	CHANGE	Balancing service market platform	VPP	Flexibility Perimeter Declaration (I-5)	R-5.1
2.7.1	Activation command	Activation command	The VPP sends correction about dispatchment of DERs' flexibility.	EXECUTE	VPP	DERs, RTU	Flexibility Perimeter Declaration (I-5a)	R-2.5
2.7.2	Monitoring	Monitoring	The DERs send information about their status on each predetermined interval	REPEAT	DERs, RTU	VPP	Analysis report (I-7)	R-2.5
2.8.1	End of delivery	end of delivery	Ending of the balancing service delivery time.	EXECUTE	Balancing service market platform	VPP	Flexibility Perimeter Declaration (I-5)	R-5.1

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2.8.3	End of delivery	End of delivery	Ending of the DSO ancillary service delivery time.	EXECUTE	DSO ancillary service	VPP	Flexibility Perimeter Declaration (I-5)	R-5.1
2.9.1	DERs deactivation	DERs deactivation	Due to finished delivery of the services to the various markets VPP deactivates DERs' flexibility.	EXECUTE	VPP	DERs, RTU	Flexibility Perimeter Declaration (I-5a)	R-2.5
2.9.2	Monitoring	Monitoring	The DERs send information about their status on each predetermined interval	REPEAT	DERs, RTU	VPP	Analysis report (I-7)	R-2.5
3.1	Metering data request	Metering data request	The VPP sends DERs' metering data request to Meter Data Management (DB).	GET	VPP	Meter Data Management (DB)	Metering data (I-1)	R-1.1, R-1.2, R-2.2
3.2	Metering data	Metering data	The Meter Data Management (DB) sends requested DERs' metering data to the VPP.	REPORT	Meter Data Management (DB)	VPP	Metering data (I-1)	R-1.1, R-1.2, R-2.2
3.3	Activation performance report	Activation performance report	VPP calculates the amount and the value of delivered flexibility and sends a report to the balancing service market platform.	REPORT	VPP	Balancing service market platform	Performance analysis report (I-6)	R-2.4
3.4	Approval message	Approval message	Balancing service market platform sends confirmation or disagreement about send reports.	REPORT	Balancing service market platform	VPP	Performance analysis report (I-6)	
3.5	Activation performance report	Activation performance report	VPP calculates the amount and the value of delivered flexibility and sends a report to the power exchange intra-day market platform.	REPORT	VPP	Power exchange intra-day market platform	Performance analysis report (I-6)	R-2.4

3.6	Approval message	Approval message	Power exchange intra-day market platform sends confirmation or disagreement about send reports.	REPORT	Power exchange intra-day market platform	VPP	Performance analysis report (I-6)	
3.7	Activation performance report	Activation performance report	VPP calculates the amount and the value of delivered flexibility and sends a report to the DSO ancillary service.	REPORT	VPP	DSO ancillary service	Performance analysis report (I-6)	R-2.4
3.8	Approval message	Approval message	DSO balancing service sends confirmation or disagreement about send reports.	REPORT	DSO ancillary service	VPP	Performance analysis report (I-6)	
3.9	Activation performance report	Activation performance report	VPP calculates the amount and the value of received flexibility and sends a report to the DERs owner.	REPORT	VPP	DERs	DER Performance analysis report (I-6a)	
3.10	Approval message	Approval message	DERs owner sends confirmation or disagreement about send reports.	REPORT	DERs	VPP	DER Activation invoice (I-9a)	

Scenario No. 2								
Scenario name:		***Monetisation of DERs is disabled due to DER data not reaching VPP***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***

1.1	Price forecasting	Price forecasting	The VPP – price forecasting system makes predictions about market prices and sends the predicted values to VPP - market arbitrage tool.	REPORT	VPP - price forecasting system	VPP - market arbitrage tool	Markets price forecast (I-10)	
1.2.1	DER measurement not working properly	DER measureme nt	DERs failed to send directly or via RTUs real-time consumption and/or generation measurements to VPP – flexibility forecasting system	REPORT	DERs, RTU	VPP – flexibility forecasting system	Metering data (I-1)	R-1.1, R-1.2, R-2.2
1.2.2	DER flexibility forecasting not working properly	DER flexibility forecasting not working properly	S Due to lack of data received from DERs, VPP cannot calculate and predict available flexibility for the future	REPORT	VPP - flexibility forecasting system	VPP - market arbitrage tool	DER flexibility forecast (I-11)	
1.2.3	DER flexibility forecasting (optional)	DER flexibility forecasting (optional)	Due to lack of data received from DERs, VPP doesn't know the available flexibility for the future	REPORT	DERs, RTU	VPP - market arbitrage tool	DER flexibility forecast (I-11)	
1.3	Bid optimization is not possible	Bid optimization is not possible	The VPP – market arbitrage tool cannot create bidding strategy nor generate bids.	CREATE	VPP - market arbitrage tool	VPP - market arbitrage tool		

Scenario No. 3								
Scenario name:		***Monetisation of DERs is disabled due to VPP not being able to participate on flexibility markets***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information*** ***Exchanged (IDs)***	***Requirement, R-IDs***

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1.1	Price forecasting	Price forecasting	The VPP – price forecasting system makes predictions about market prices and sends the predicted values to VPP - market arbitrage tool.	REPORT	VPP - price forecasting system	VPP - market arbitrage tool	Markets price forecast (I-10)	
1.2.1	DER measurement	DER measurement	DERs send directly or via RTUs real-time consumption and/or generation measurements to VPP – flexibility forecasting system	REPORT	DERs, RTU	VPP – flexibility forecasting system	Metering data (I-1)	R-1.1, R-1.2, R-2.2
1.2.2	DER flexibility forecasting	DER flexibility forecasting	Based on received DERs' consumption and/or generation measurements, VPP – flexibility forecasting calculates and predicts available flexibility for the future and sends the info to VPP - market arbitrage tool	REPORT	VPP - flexibility forecasting system	VPP - market arbitrage tool	DER flexibility forecast (I-11)	
1.2.3	DER flexibility forecasting (optional)	DER flexibility forecasting (optional)	DERs send directly or via RTU real-time or scheduled flexibility forecast to VPP – market arbitrage tool	REPORT	DERs, RTU	VPP - market arbitrage tool	DER flexibility forecast (I-11)	
1.3	Bid optimization	Bid optimization	The VPP - market arbitrage tool calculates optimal bidding strategy for flexibility monetization and generates bids accordingly.	CREATE	VPP - market arbitrage tool	VPP - market arbitrage tool	List of available bids (I-13)	
1.4.1	Bid submission not possible	Bid submission not possible	The VPP - market arbitrage tool cannot send bids to power exchange intra-day market platform.	REPORT	VPP - market arbitrage tool	Power exchange intra-day market platform	List of available bids (I-13)	
1.4.2	Bid submission not possible	Bid submission not possible	The VPP - market arbitrage tool cannot send bids to balancing service market platform.	REPORT	VPP - market arbitrage tool	Balancing service market platform	List of available bids (I-13)	

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
I-1	Metering data	1 min load profile of active power for each DER	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
I-2	Constraint of distribution grid	Constraint Locations of dis. grid. Sides generating constraints and solution to solve these constraints.	
I-4	Aggregated forecast of DER	1 min aggregated baseline of all DERs	R-3.5
I-5	Flexibility Perimeter Declaration (VPP level)	Information of aFRR, mFRR, intraday and DSO market activation of VPP: - flexibility capacity - starting time - ending time or duration of an activation (maximum full activation time FAT is defined in the contract or market rules)	
I-5a	Flexibility Perimeter Declaration (DER level)	Information of aFRR, mFRR, intraday and DSO market activation of DER: - flexibility capacity - starting time - ending time or duration of an activation (maximum FAT is defined in contract or market rules)	
I-6	Performance analysis report	Report of aggregated measurements and baselines of DER in VPP with evaluation of delivered energy and power in 1 min interval; incl. comparison with setpoint or expected behaviour. This information is the basis for invoices (flexibility operator/VPP to ancillary service market platform, and DER to Flexibility operator/VPP).	R-3.4
I-6a	DER Performance analysis report	Report of individual measurements and baselines of DER with evaluation of delivered energy and power in 1 min interval; incl. comparison with setpoint or expected behaviour. This information is the basis for invoices (Flexibility operator/VPP to ancillary service market platform, and DER to Flexibility operator/VPP).	R-3.4
I-7	Analysis report	Information of activated DER is updated by VPP or flexibility operator every time DER are activated or deactivated.	R-3.5
I-8	DER activation schedule	15min average of activated power of DER	

I-9	VPP Activation invoice	Invoice for activation of VPP in predefined format according to contract or market rules	
I-9a	DER Activation invoice	Invoice for activation of DER in predefined format according to contract	
I-10	Markets price forecast	Forecast (or estimation) of aFRR, mFRR, intraday and DSO market price for capacity and energy for the next relevant trading interval (bidding period or tendering phase, …)	
I-11	DER flexibility forecast	Forecast of flexibility per DER (or group of DER) Time series must cover the upcoming trading period and contain: - positive flexibility [MW] - direction [+, -] - energy costs [EUR/MWh] (optional) - capacity costs [EUR/MW/h] (optional) - baseline [MW] (optional)	
I-12	Trading period schedule	schedule of auctions, tendering or trading periods containing: - start/end of bidding interval(s) - start/end of provision period(s) - min./max. bid size - other requirements and market rules (TSO specific)	
I-13	List of available bids	Bids which can be fulfilled by the VPP containing: - Energy price [EUR/MWh] - Capacity price [EUR/MW/h] - Capacity [MW] - Direction [+, -] - Period of provision	
I-14	List of bidding volume per grid area (I-14), of VPP only	Information contained: - Capacity [MW] - Direction [+, -] - Period of provision - distribution grid area code	R-3.6
I-14a	List of bidding volume per grid area (I-14) all market participants	Information contained: - Capacity [MW] - Direction [+, -]	R-3.6

		- Period of provision - distribution grid area code Condensed volumes, not containing any information about particular market participants	
I-15	List of accepted bids	Bids which are accepted by TSO, intraday or DSO and thus must be reserved by VPP: - Energy price [EUR/MWh] - Capacity price [EUR/MW/h] - Capacity [MW] - Direction [+, -] - Period of provision	
I-16	List of reserved capacity per grid area, of VPP only	Information contained: - Capacity [MW] - Direction [+, -] - Period of provision - Distribution grid area code	R-3.6
I-16a	List of reserved capacity per grid area, of all market participants	Information contained: - Capacity [MW] - Direction [+, -] - Period of provision - Distribution grid area code	R-3.6
I-17	Information about required reservation of DER capacity OPTIONAL	The demanded capacities must be reserved by the DER. Information contains: - Energy price [EUR/MWh] of contract, *(optional)* - Capacity price [EUR/MW/h] of contract, *(optional)* - Capacity [MW] - Direction [+, -] - Period of provision	

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
C-1	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems,

		expected growth of the system over time, locations, distances, communication types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable.
Requirement R-ID	**Requirement name**	**Requirement description**
R-1.1	Communication bandwidth	56 kbps – 5Mbps
R-1.2	Number of Information Producers	Few to a hundred
R-1.3	Communication media	Wireless possible

Categories ID	Category name for requirements	Category description
C-2	Data Management	Covers both the management of the data exchanges in each Use Case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions. It should not address database design, but should concentrate on the user requirements for the interfaces to databases and other data handling applications."
Requirement R-ID	**Requirement name**	**Requirement description**
R-2.1	Type of source data	Source data was directly measured
R-2.2	Up-to-date management	Received data must be up-to-date within minute of source data changing
R-2.3	Up-to-date management	Received data must be up-to-date within seconds of source data changing
R-2.4	Up-to-date management	Data must be provided until 3 am of following day.
R-2.5	Up-to-date management	Must be provided in less than one minute
R-2.6	Distribution grid area code list	A list of areas or section of the distribution grid represented by unique area codes

Categories ID	Category name for requirements	Category description
C-3	Quality of Service	Address availability of the system, such as acceptable downtime, recovery, backup, rollback, etc. QoS issues also address accuracy and precision of data, the frequency of data exchanges, and the necessary flexibility for future changes.

Requirement R-ID	Requirement name	Requirement description
R-3.1	Availability of information flows	99.9% + availability - Allowed outage: 9 hours per year
R-3.2	Accuracy of data	Device has error class 1% or better
R-3.3	Frequency of data exchanges	1 min interval

Categories ID	Category name for requirements	Category description
C-4	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable. Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors. At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures.
Requirement R-ID	**Requirement name**	**Requirement description**
R-4.1	Network security measures commonly used with this data exchange	VPN or private network

Categories ID	Category name for requirements	Category description
C-5	Other constraints	Constraints and issues not captured in the previous characteristics may be political, legal, financial, or just very specific to a particular step. For instance, one step may involve data received from another utility that requires special handling: format conversions or manual intervention. This is a catch-all for such special issues.
Requirement R-ID	**Requirement name**	**Requirement description**
R-5.1	Full activation time	Resource must provide 100% of requested flexibility within 15 min (TSO requirement)
R-5.2	Full activation time	Resource must provide at least 90% of requested flexibility within 25 min (DSO requirement)

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
CONF	Configuration
DR	Demand Response
DG	Distributed Generation
DM	Data Management

HEMS	Home Energy Management System
HLUC	High Level Use Case
LV	Low Voltage
SAREF	Smart Applications REFerence
SEC	Security
UC	Use Case

HLUC02 - Energy community DES utilization

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
HLUC02	Markets / Residential	Energy community Distributed Energy Storage (DES) utilisation

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	16.03.2023	Peter Nemček, CYG	Initial definition of the use-case characteristics

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The participation of citizens and communities as partners in renewable and storage energy projects are transforming the energy system. Community energy initiatives are offering new opportunities for citizens to get actively involved in energy matters and to promote their self-sufficiency and sustainability. Energy communities could generate flows of real time data from electricity meters placed at renewable electricity sources (e.g., solar, wind, CHP), consumption sites (households, schools, commercial buildings, farms, etc.), battery energy storage systems, electric vehicle charging stations, heat pumps, etc. Most of these could provide some electric flexibility which can be utilized either locally, within the community supporting self-sufficiency mode or at different electricity markets, like helping balance the transmission grid, improving voltage levels at distribution grid or taping into price opportunities of intraday markets.
Objective(s)	Enhance community self-sufficiency mode
Related business case(s)	HLUC 1: Distributed Energy Storage (DES) Flexibility Market Monetisation

1.4 Narrative of use case

Narrative of Use Case
Short description
A user, a Community Manager, would like to digitalize the community energy assets and their energy flows to manage and optimize energy community's operation. To technically achieve this, Community Manager, deploys and operates a Flexibility Management Platform – an ICT system which aggregates and manages flexibility from diverse Distributed Energy Resources

(DER) including a set of novel Energy Community data management functionalities. It will receive real time DES assets' data via novel interoperable software tools, implement the latest regulatory and business/community rules (energy accounting, static and dynamic distribution key specification and utilisation, reporting etc.), calculate baselines and forecasts, aggregate energy assets data using advanced algorithms, optimize pooling of available flexibility resources for various events (self-sufficient community, grid balancing, wholesale, etc.), de-aggregate, and dispatch them in a timely manner.
Complete description

Introduction

Energy community is a group of households and small enterprises that participate in the electrical system as a semi-independent unit. Their active approach eases the burden of TSO and DSO at managing stability of the grid but also benefits the individual households as they can make addition revenue. However, to be able to create such a community different criterion must be met.

Requirements

In the case of our Austrian pilot energy community will be developed and managed on the advanced EMS CyberNoc, which is a middle layer in the resources pooling process. Therefore, to be able to join the energy community, every specific appliance and DES must provide timely 5 min readings of the required asset's data (e.g., state of charge, active power measurement, …) to the EMS and then respond to the requests from EMS on how to manage its operation by adjusting its production or consumption accordingly.

Objectives

The solution of the project is unique compared to other solutions in closing the chain from the

customer flexible assets to the different markets. The algorithm for using device for both self-consumption and VPP purposes is based on forecasts of PV/renewable yield and successfully tested with e.g., battery storage systems.

The primary objective of energy community is the self-sustainability. To achieve this, community energy resources will be managed in the way that distribution and storage of the produced electrical energy covers as much energy community consumption as possible. The congestions will also try to be managed in an organised in a systematic mode, meaning that the CyberNoc ensures minimal spikes in community demand and supply to the DSO. To be operational, the latest regulatory and business/community rules must be provided by an energy community operator. These guidelines cover topics such as:

- energy accounting,
- static and dynamic distribution key specification and utilisation (rules for produced energy distribution between members)
- self-sufficiency and other KPIs reporting,
- baseline calculations and forecasts,
- energy assets aggregation,
- billing and cost calculation for specific member regarding his energy generation and location of the DER.

Tools or functions included in this step
Energy Community toolkit Interoperability toolkit Flexibility management platform (CyberNoc)

Another aspect which ought to be specified is the establishment and management of the community renewable power plant, which is a DER that has been funded by energy community members.

However, if the produced energy surpasses the needs of the community, then the secondary objective of the energy community is to be followed: monetization of the generated energy from DERs. For this step to be as benefiting as it can be the importance of EMS (CyberNoc) tools and modules is crucial.

First step of the monetization is the pooling of the different resources, monitoring their performance and based on your past data predicting future generation. Once the baseline and predicted resources are evaluated the bids can be sent to different balancing and wholesale energy markets, in order to choose the best option and therefore, maximise income. The proposed market is intra-day wholesale energy market.

The process of bidding, activation, dispatching in the timely manner and reporting is more thoroughly described in HLUC1 DES Flexibility Market Monetisation.

Tools or functions included in this step
Energy Community toolkit Market arbitrage tool Flexibility management platform (CyberNoc)

Storage

In terms of storage system (battery, thermal…) there are 2 main use cases based on a forecast of the

PV yield (which must be accurate in terms of energy produced per day per location):

- Optimal charging of the storage for self-consumption
- Optimal usage of price signals/ancillary services from the VPP

Our goal and solution

There will be days where there is not nearly sufficient PV yield to charge the storage, and there will be days with a lot more PV yield than the storage can store, and in both cases, this gives rise to the need for an aggregation on a higher layer. Proposed approach is to integrate Energy Communities in the management system as semi-independent units, which solves some of the problems in a systematic way.

The reason being the implemented technology, that is: controlling decentralised assets, which will bring a full vertical integration in terms of making several optimization steps from behind the meter optimization over a possible optimization in an energy community to an aggregation in the VPP System and active flexibility management in real time. The VPP offers the possibility to decide quickly and switch between different markets, making it fully integrated horizontally.

VPP operator's point of view

This fully integrated solution allows the operator to monitor the system and change parameters instead of handling the single devices separately. This is more and more important as upcoming changes in regulation require to handle many quarter-hourly products at the same time. Unless the operator has a highly functional interface that allows for good monitoring tools and is highly automated. Handling devices of such an amount would be impossible manually.

End-customer's point of view

For the end-customer, the concept is very innovative for manifold reasons. The solutions provide new ways to fully use the potential of devices, support the energy system and possibly generate new revenue streams (today it is a fixed investment subsidy through the grant). It does give the user new insights in his system and opportunities to fully understand his/her energy consumption/production patterns. It will provide new digital services and does equip an energy community member to actively contribute to net zero society.

1.5 Key performance indicators (KPI)

ID(*)	Name	Description	Reference to mentioned use case objectives
KPI3	Battery capacity	Amount of Flexibility provision in the demos from HESS	Flexibility
KPI4	Diversity of DER	Number of different DER devices successfully tested and demonstrated	Assets
KPI5	Asset management monitored by EMS	Number of assets monitored by the InterSTORE EMS solutions	EMS
KPI6	No. of assets	Number of assets integrated with the Aggregation platform presenting hybrid market bids (Target: 60)	Bigger number of assets makes it easier for the community to self-sustain.
KPI7	N° of end users	N° of end users (workers, EV users, consumers) engaged in the demonstration of interoperable HESS solutions (Target: 500).	Number of households which will participate in the use case scenario gives us.
KPI8	Demand Response	This KPI evaluates the electricity cost per kWh which is to check the optimization of the energy plan of flexible demands.	Maximising profit of sold produced electrical energy is a secondary goal and should be maximised accordingly.
10	Nbr of DER assets tested with IEEE2030.5	Number of different DER devices and EMS successfully tested with the IEEE2030.5 and demonstrated in real-life pilots	Interoperability
11	Data space digitized assets	Amount of digitized storage systems/platforms/hubs assets integrated in the common data space exchanging data	Data Spaces
25	Integrated capacity	Integrated power of the HESS within the project demos	HESS
26	Increase of flexibility	Demand side flexibility potential increase due to hybridization implementation	Flexibility

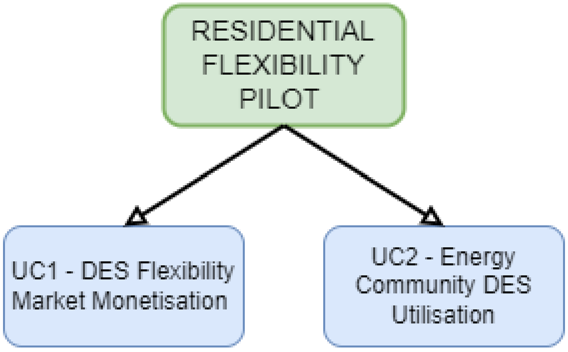
(*) The ID number is based on the project KPI reference list

1.6 Use case conditions

Use case conditions
Assumptions
• Preparedness of every member to contribute to energy community
Prerequisites
• Timely readings on all assets and consumers loads • Administrative agreement between members and EMS • Ability of EMS operator to participate on different markets

1.7 Further Information to the use case for classification / mapping

Classification Information

Relation to other use cases
 Relation to other HLUCs: HLUC 1: market monetisation and revenue maximisation approach are used in this use case.
Level of depth
High level use case (HL-UC) use case which describes a general concept of energy community, it's management and benefits it brings.
Prioritisation
High level
Generic, regional or national relation
Generic
Nature of the use case
Business use case
Further keywords for classification
Energy community, DER pooling, self-sufficiency, flexibility, monetization

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case
HLUC-PUC Relation Diagram

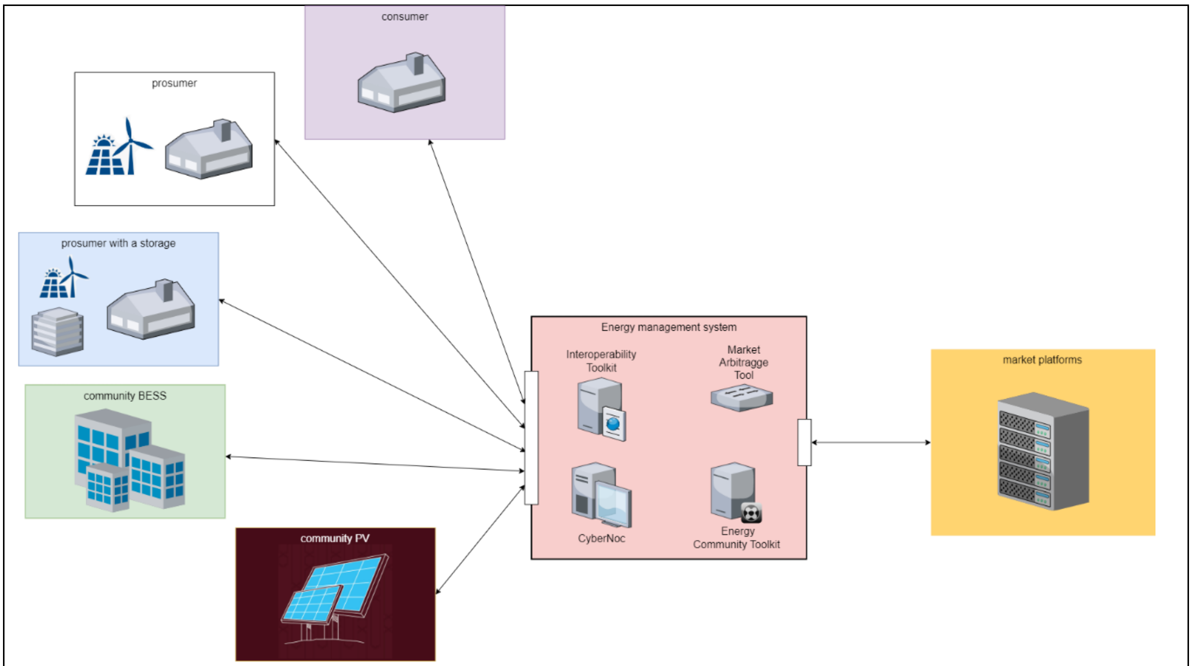


Figure 19 Schematic view of energy community

<u>HLUC Sequence Diagram:</u>

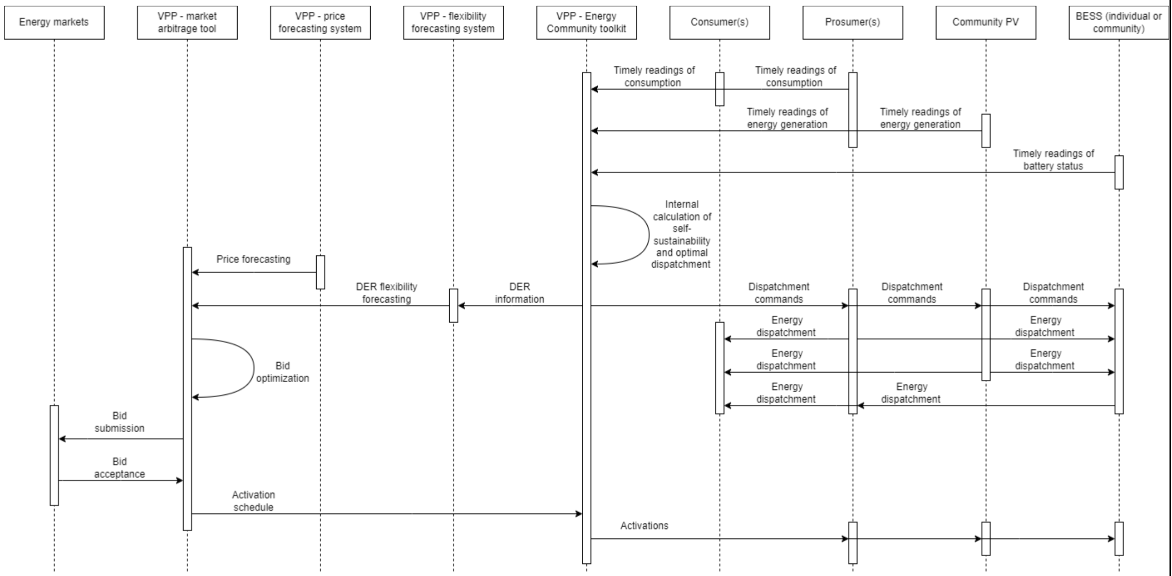


Figure 20 Energy community

3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Energy Community	System	A group of individuals who reside relatively close to each other and participate in electrical energy system as semi-independent actor, meaning that they actively monitor their group consumption and minimise the strain on the DSO and TSO by generating electrical energy (through community-owned PV, wind turbines, generators, HPPs, etc.) and distributing among members. To support all that administrative and legal documents are in place.
Flexibility operator	Role	Offers services to aggregate energy production from DER (generators, renewables or storage) and acts towards the grid as one entity, including local aggregation of demand (Demand Response management) and supply (generation management). In cases where the flexibility operator is not a supplier, it maintains a contract with the supplier.
Consumer (User)	Role	Citizen who is end-user of electricity, gas, water or heat.
Prosumer	Role	Consumer that can also generate energy using a Distributed Energy Resource
Service Provider	Role	Entity providing energy services to consumers - could be a retailer or a DSO. In the remainder of this document, the terms customer/consumer and grid user are used interchangeably where appropriate.
Distribution System Operator (DSO)	Actor	According to the Article 2.6 of the Directive: "a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity". Moreover, the DSO is responsible for regional grid access and grid stability, integration of renewables at the distribution level and regional load balancing.
Transmission System Operator (TSO)	Actor	According to the Article 2.4 of the Electricity Directive 2009/72/EC (Directive): "a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity". Moreover, the TSO is responsible for connection of all grid users at the transmission level and connection of the DSOs within the TSO control area.
DER	Role	A Distributed Energy Resource (DER) can be a generator, renewable generator, demand response unit or storage unit.
VPP (EMS)	System	A Flexibility Management Platform or Virtual Power Plant (VPP) is a cloud-based Energy Management System (EMS) that aggregates the flexibility of different DERs for the purposes of trading on the various electricity markets, supporting grid or wholesale supply

Energy markets	System	Energy market is a type of commodity market that deal with electricity. To be able to participate in it, certain criteria must be met by asset owner or flexibility operator.
Community PV/BESS	Role	This refers to any DERs that are a collective property or a property of more than one owner. Because of administrative issues that may occur, a legal framework is put in place to define establishment, monitoring and monetization of it.

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Standard	IEC 62559-2 Use Case Methodology	Published	Definition of the presented template	International Electrotechnical Commission	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Energy community self-sufficiency	VPP (EMS) calculates amount of EnC consumption and accordingly allocates amount of energy to specific load.	VPP (EMS)	Household consumption	All households, their assets and community assets are correctly connected to VPP (EMS).	Time when EnC is self-sufficient/Load reduction on electrical grid to EnC.
2	Monetization of excess electricity	VPP (EMS) recognises the peak of electricity production and trades it on electricity markets.	VPP (EMS)	Excess of produced electricity	An abundance of electricity produced.	Amount of revenue from trading.
3	Energy community grid dependency	There are not enough resources for self-sufficiency, therefore, grid electricity is used for EnC consumption.	VPP (EMS)	Lack of produced electricity	All households, their assets and community assets are correctly connected to VPP (EMS).	Amount of energy from the grid needed.

4.2 Steps – Scenarios

Scenario No. 1 and 2								
Scenario name:		*Energy community self-sufficiency and monetization of excess electricity*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1.1	Timely readings of consumption	Timely readings of consumption	Real-time consumption measurements are being reported to VPP - Energy Community toolkit.	REPORT	Consumer(s)	VPP - Energy Community toolkit	Consumption data (I-3)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
1.2	Timely readings of consumption	Timely readings of consumption	Real-time consumption measurements are being reported to VPP - Energy Community toolkit.	REPORT	Prosumer(s)	VPP - Energy Community toolkit	Consumption data (I-3)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
2.1	Timely readings of energy generation	Timely readings of energy generation	Real-time generation measurements are being reported to VPP - Energy Community toolkit.	REPORT	Prosumer(s)	VPP - Energy Community toolkit	Metering data (I-1)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
2.2	Timely readings of energy generation	Timely readings of energy generation	Real-time generation measurements are being reported to VPP - Energy Community toolkit.	REPORT	Community PV	VPP - Energy Community toolkit	Metering data (I-1)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
3	Timely readings of battery status	Timely readings of battery status	Real-time battery status measurements are being reported to VPP - Energy Community toolkit.	REPORT	BESS (individual or community)	VPP - Energy Community toolkit	Metering data (I-1)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
4	Internal calculation of self-sustainability and optimal dispatchment	Internal calculation of self-sustainability and optimal dispatchment	The VPP - Energy Community toolkit internally calculates optimal dispatchment of energy among community members.	CREATE	VPP - Energy Community toolkit	VPP - Energy Community toolkit		

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5	Price forecasting	Price forecasting	The VPP - price forecasting system makes predictions about market prices and sends the predicted values to VPP - market arbitrage tool.	REPORT	VPP - price forecasting system	VPP - market arbitrage tool	Markets price forecast (I-10)	
6.1	Dispatchment commands	Dispatchment commands	The VPP Energy Community toolkit sends dispatchment commands of produced energy from energy sources to different household loads and battery charging stations.	EXECUTE	VPP - Energy Community toolkit	Prosumer(s)	Flexibility Perimeter Declaration (I-5a)	R-2.5
6.2	Dispatchment commands	Dispatchment commands	The VPP Energy Community toolkit sends dispatchment commands of produced energy from community energy sources to different household loads and battery charging stations.	EXECUTE	VPP - Energy Community toolkit	Community PV	Flexibility Perimeter Declaration (I-5a)	R-2.5
6.3	Dispatchment commands	Dispatchment commands	The VPP Energy Community toolkit sends dispatchment commands of stored energy different batteries to different household loads.	EXECUTE	VPP - Energy Community toolkit	BESS (individual or community)	Flexibility Perimeter Declaration (I-5a)	R-2.5
6.4	DER information	DER information	The VPP Energy Community toolkit sends information about statuses of different DERs to flexibility forecasting system.	REPORT	VPP - Energy Community toolkit	VPP - flexibility forecasting system	Aggregated baseline of DER (I-4)	R-2.5
6.5	DER flexibility forecasting	DER flexibility forecasting	Based on received information VPP - flexibility forecasting system calculates and predicts available flexibility for the future and sends the info to VPP - market arbitrage tool	REPORT	VPP - flexibility forecasting system	VPP - market arbitrage tool	DER flexibility forecast (I-11)	

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7.1	Energy dispatchment	Energy dispatchment	The prosumer(s) dispatch the produced energy in accordance with received dispatchment commands.	EXECUTE	Prosumer(s)	Consumer(s), BESS (individual or community)	Flexibility Perimeter Declaration (I-5a)	R-2.5
7.2	Energy dispatchment	Energy dispatchment	The community PV dispatches the produced energy in accordance with received dispatchment commands.	EXECUTE	Community PV	Consumer(s), BESS (individual or community)	Flexibility Perimeter Declaration (I-5a)	R-2.5
7.3	Energy dispatchment	Energy dispatchment	The BESS (individual or community) dispatches the produced energy in accordance with received dispatchment commands.	EXECUTE	BESS (individual or community)	Consumer(s), Prosumer(s)	Flexibility Perimeter Declaration (I-5a)	R-2.5
7.4	Bid optimization	Bid optimization	The VPP - market arbitrage tool calculates optimal bidding strategy among all the options.	CREATE	VPP - market arbitrage tool	VPP - market arbitrage tool	List of available bids (I-13)	
8	Bid submission	Bid submission	The VPP - market arbitrage tool sends bids to different energy markets.	REPORT	VPP - market arbitrage tool	Energy markets	List of available bids (I-13)	
9	Bid acceptance	Bid acceptance	The energy markets inform VPP - market arbitrage tool whether the specific bids were accepted or not.	REPORT	Energy markets	VPP - market arbitrage tool	List of accepted bids (I-15)	
10	Activation schedule	Activation schedule	The VPP - market arbitrage tool sends VPP – Energy Community toolkit a schedule of activations.	REPORT	VPP - market arbitrage tool	VPP - Energy Community toolkit	Information about required reservation of DER capacity (I-17)	
11.1	Activations	Activations	The VPP – Energy Community toolkit activates different household owned DERs in accordance with activation schedule and availability of energy.	EXECUTE	VPP - Energy Community toolkit	Prosumer	Flexibility Perimeter Declaration (I-5)	R-5.1

11.2	Activations	Activations	The VPP – Energy Community toolkit activates Community PV in accordance with activation schedule and availability of energy.	EXECUTE	VPP - Energy Community toolkit	Community PV	Flexibility Perimeter Declaration (I-5)	R-5.1
11.3	Activations	Activations	The VPP – Energy Community toolkit activates different BESS in accordance with activation schedule and availability of energy.	EXECUTE	VPP - Energy Community toolkit	Community PV	Flexibility Perimeter Declaration (I-5)	R-5.1

Scenario No. 3								
Scenario name:		***Energy community grid de-pendency***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
1.1	Timely readings of consumption	Timely readings of consumption	Real-time consumption measurements are being reported to VPP - Energy Community toolkit.	REPORT	Consumer(s)	VPP - Energy Community toolkit	Consumption data (I-3)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
1.2	Timely readings of consumption	Timely readings of consumption	Real-time consumption measurements are being reported to VPP - Energy Community toolkit.	REPORT	Prosumer(s)	VPP - Energy Community toolkit	Consumption data (I-3)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
2.1	Timely readings of energy generation	Timely readings of energy generation	Real-time generation measurements are being reported to VPP - Energy Community toolkit.	REPORT	Prosumer(s)	VPP - Energy Community toolkit	Metering data (I-1)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
2.2	Timely readings of energy generation	Timely readings of energy generation	Real-time generation measurements are being reported to VPP - Energy Community toolkit.	REPORT	Community PV	VPP - Energy Community toolkit	Metering data (I-1)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1

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3	Timely readings of battery status	Timely readings of battery status	Real-time battery status measurements are being reported to VPP - Energy Community toolkit.	REPORT	BESS (individual or community)	VPP - Energy Community toolkit	Metering data (I-1)	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
4	Internal calculation of self-sustainability and optimal dispatchment	Internal calculation of self-sustainability and optimal dispatchment	The VPP - Energy Community toolkit internally calculates optimal dispatchment of energy among community members.	CREATE	VPP - Energy Community toolkit	VPP - Energy Community toolkit		
5.1	Dispatchment commands	Dispatchment commands	The VPP Energy Community toolkit sends dispatchment commands of produced energy from energy sources to different household loads and battery charging stations.	EXECUTE	VPP - Energy Community toolkit	Prosumer(s)	Flexibility Perimeter Declaration (I-5a)	R-2.5
5.2	Dispatchment commands	Dispatchment commands	The VPP Energy Community toolkit sends dispatchment commands of produced energy from community energy sources to different household loads and battery charging stations.	EXECUTE	VPP - Energy Community toolkit	Community PV	Flexibility Perimeter Declaration (I-5a)	R-2.5
5.3	Dispatchment commands	Dispatchment commands	The VPP Energy Community toolkit sends dispatchment commands of stored energy different batteries to different household loads.	EXECUTE	VPP - Energy Community toolkit	BESS (individual or community)	Flexibility Perimeter Declaration (I-5a)	R-2.5
6.1	Energy dispatchment	Energy dispatchment	The prosumer(s) dispatch the produced energy in accordance with received dispatchment commands.	EXECUTE	Prosumer(s)	Consumer(s), BESS (individual or community)	Flexibility Perimeter Declaration (I-5a)	R-2.5

6.2	Energy dispatchment	Energy dispatchment	The community PV dispatches the produced energy in accordance with received dispatchment commands.	EXECUTE	Community PV	Consumer(s), BESS (individual or community)	Flexibility Perimeter Declaration (I-5a)	R-2.5
6.3	Energy dispatchment	Energy dispatchment	The BESS (individual or community) dispatches the produced energy in accordance with received dispatchment commands.	EXECUTE	BESS (individual or community)	Consumer(s), Prosumer(s)	Flexibility Perimeter Declaration (I-5a)	R-2.5
7	Usage of grid electricity	Usage of grid electricity	Due to insufficient levels of energy generation VPP - Energy Community toolkit consumes grid electricity in order to meet the Energy community electrical demand.	EXECUTE	VPP - Energy Community toolkit	Electrical grid, VPP - Energy Community toolkit		

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
I-1	Metering data	1 min load profile of active power for each DER	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
I-2	Constraint of distribution grid	Constraint Locations of dis. grid. Sides generating constraints and solution to solve these constraints.	
I-3	Consumption data	1 min load profile of consumptions of each household	R-1.2, R-1.3, R-3.1, R-3.2, R-3.1, R-3.2, R-3.3, R4.1
I-4	Aggregated forecast of DER	1 min aggregated baseline of all DERs	R-3.5
I-5	Flexibility Perimeter Declaration (VPP level)	Information of aFRR, mFRR, intraday and DSO market activation of VPP: - flexibility capacity - starting time - ending time or duration of an activation (maximum full activation time FAT is defined in the contract or market rules)	
I-5a	Flexibility Perimeter Declaration (DER level)	Information of aFRR, mFRR, intraday and DSO market activation of DER: - flexibility capacity - starting time - ending time or duration of an activation (maximum FAT is defined in contract or market rules)	
I-6	Performance analysis report	Report of aggregated measurements and baselines of DER in VPP with evaluation of delivered energy and power in 1 min interval; incl. comparison with setpoint or expected behaviour. This information is the basis for invoices (flexibility operator/VPP to ancillary service market platform, and DER to Flexibility operator/VPP).	R-3.4
I-6a	DER Performance analysis report	Report of individual measurements and baselines of DER with evaluation of delivered energy and power in 1 min interval; incl. comparison with setpoint or expected behaviour. This information is the basis for invoices (Flexibility operator/VPP to ancillary service market platform, and DER to Flexibility operator/VPP).	R-3.4

I-7	Analysis report	Information of activated DER is updated by VPP or flexibility operator every time DER are activated or deactivated.	R-3.5
I-8	DER activation schedule	15min average of activated power of DER	
I-9	VPP Activation invoice	Invoice for activation of VPP in predefined format according to contract or market rules	
I-9a	DER Activation invoice	Invoice for activation of DER in predefined format according to contract	
I-10	Markets price forecast	Forecast (or estimation) of aFRR, mFRR, intraday and DSO market price for capacity and energy for the next relevant trading interval (bidding period or tendering phase, …)	
I-11	DER flexibility forecast	Forecast of flexibility per DER (or group of DER) Time series must cover the upcoming trading period and contain: - positive flexibility [MW] - direction [+, -] - energy costs [EUR/MWh] (optional) - capacity costs [EUR/MW/h] (optional) - baseline [MW] (optional)	
I-12	Trading period schedule	schedule of auctions, tendering or trading periods containing: - start/end of bidding interval(s) - start/end of provision period(s) - min./max. bid size - other requirements and market rules (TSO specific)	
I-13	List of available bids	Bids which can be fulfilled by the VPP containing: - Energy price [EUR/MWh] - Capacity price [EUR/MW/h] - Capacity [MW] - Direction [+, -] - Period of provision	
I-14	List of bidding volume per grid area (I-14), of VPP only	Information contained: - Capacity [MW] - Direction [+, -] - Period of provision - distribution grid area code	R-3.6

I-14a	List of bidding volume per grid area (I-14) all market participants	Information contained: - Capacity [MW] - Direction [+, -] - Period of provision - distribution grid area code Condensed volumes, not containing any information about particular market participants	R-3.6
I-15	List of accepted bids	Bids which are accepted by TSO, intraday or DSO and thus must be reserved by VPP: - Energy price [EUR/MWh] - Capacity price [EUR/MW/h] - Capacity [MW] - Direction [+, -] - Period of provision	
I-16	List of reserved capacity per grid area, of VPP only	Information contained: - Capacity [MW] - Direction [+, -] - Period of provision - Distribution grid area code	R-3.6
I-16a	List of reserved capacity per grid area, of all market participants	Information contained: - Capacity [MW] - Direction [+, -] - Period of provision - Distribution grid area code	R-3.6
I-17	Information about required reservation of DER capacity OPTIONAL	The demanded capacities must be reserved by the DER. Information contains: - Energy price [EUR/MWh] of contract, *(optional)* - Capacity price [EUR/MW/h] of contract, *(optional)* - Capacity [MW] - Direction [+, -] - Period of provision	

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
C-1	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communications types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable.
Requirement R-ID	Requirement name	Requirement description
R-1.1	Communication bandwidth	56 kbps – 5Mbps
R-1.2	Number of Information Producers	Few to a hundred
R-1.3	Communication media	Wireless possible

Categories ID	Category name for requirements	Category description
C-2	Data Management	Covers both the management of the data exchanges in each Use Case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions. It should not address database design, but should concentrate on the user requirements for the interfaces to databases and other data handling applications."
Requirement R-ID	Requirement name	Requirement description
R-2.1	Type of source data	Source data was directly measured
R-2.2	Up-to-date management	Received data must be up-to-date within minute of source data changing
R-2.3	Up-to-date management	Received data must be up-to-date within seconds of source data changing
R-2.4	Up-to-date management	Data must be provided until 3 am of following day.
R-2.5	Up-to-date management	Must be provided in less than one minute
R-2.6	Distribution grid area code list	A list of areas or section of the distribution grid represented by unique area codes

Categories ID	Category name for requirements	Category description
C-3	Quality of Service	Address availability of the system, such as acceptable downtime, recovery, backup, rollback, etc. QoS issues also address accuracy and precision of data, the frequency of data exchanges, and the necessary flexibility for future changes.
Requirement R-ID	Requirement name	Requirement description
R-3.1	Availability of information flows	99.9% + availability - Allowed outage: 9 hours per year
R-3.2	Accuracy of data	Device has error class 1% or better
R-3.3	Frequency of data exchanges	1 min interval

Categories ID	Category name for requirements	Category description
C-4	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable. Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors. At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures.
Requirement R-ID	Requirement name	Requirement description
R-4.1	Network security measures commonly used with this data exchange	VPN or private network

Categories ID	Category name for requirements	Category description
C-5	Other constraints	Constraints and issues not captured in the previous characteristics may be political, legal, financial, or just very specific to a particular step. For instance, one step may involve data received from another utility that requires special handling: format conversions or manual intervention. This is a catch-all for such special issues.
Requirement R-ID	Requirement name	Requirement description
R-5.1	Full activation time	Resource must provide 100% of requested flexibility within 15 min (TSO requirement)
R-5.2	Full activation time	Resource must provide at least 90% of requested flexibility within 25 min (DSO requirement)

7 Common Terms and Definitions

Common Terms and Definitions

Term	Definition
CONF	Configuration
DR	Demand Response
DG	Distributed Generation
DM	Data Management
HEMS	Home Energy Management System
HLUC	High Level Use Case
LV	Low Voltage
SAREF	Smart Applications REFerence
SEC	Security
UC	Use Case

HLUC03 - Grid supporting BESS

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
UC03	Area: Energy Systems Domain: DER Zones: Process, Field, Station, Operation	Grid supporting BESS

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	03/03/2023	FZJ	Initial definition of the use-case characteristics
0.2	24/05/2023	FZJ	Inclusion of diagrams
0.3	03/07/2023	FZJ	Final version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	A hybrid energy storage system will be integrated, for operation, in an internal Network (grid). In this use case, the ICT deployment tool (connection with the EMS), i.e. using the IEEE2030.5 approach compared to a traditional deployment approach will be carried out. The subsequent HESS operation will then verify the successful deployment of the system.
Objective(s)	(1) To demonstrate that the required DER IEEE2030.5 standard deployment is more seam-less when compared to a traditional approach (even with just one battery) (2) Verify the IEEE2030.5 interoperability tool, with different inverters (same and different manufacturer) (3) Share operation data of the HESS through the connected data spaces tool
Related business case(s)	

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case investigates the integration of hybrid energy storage systems (HESSs) in the already-existing ICT platform of FZJ (FIWARE-based). The aim is to verify that the integration of the HESS using the InterSTORE solution (IEEE2030.5 based) is seamless when compared to the integration using the current solution (FIWARE-based). The Use case will then verify the correct deployment by operating the HESS connected to the grid, providing setpoints and receiving operational data.

Complete description
To take advantage of the different features and to monitor the performance of the storage systems, their dedicated energy management systems are of utmost importance. The ecosystem they may be integrated into may be in many cases, complex structures, part of wider ICT networks and their impacts, limitations and challenges need to be considered, including deployment efforts. A single battery energy storage system may have multiple inverters, meaning that the efforts for their integration are individualised. The IEEE.2030.5 standards are intended to bring together DER from different and multiple manufacturers, which is the case of hybrid energy storage systems (HESSs). The effort related to the deployment of the communication of these systems with the dedicated energy management systems, should not be overlooked and are in fact an element to be taken into consideration in the overall performance. This UC investigates how HESS can be successfully integrated into the already existing ICT platform of FZJ, and its Energy Campus Management. The InterSTORE legacy converters will be integrated for this purpose. A series of commissioning tests will be performed to verify the effective interoperability of the communication interface. Then, the integration of the HESSs in the already available Energy Campus Management will be evaluated, with respect to the successful exchange of control set-points. The HESS system is composed of 2 battery systems. The first is a Riello system, and the second one is a TESLA Megapack system. The former is considered to be a high-power system, with 1.5 MW and 500 kWh, while the latter is high-energy, with 0.5 MW/2.6MWh. The UC will compare two installations (of the HESS and EMS) procedures. First, it will follow a traditional deployment with message exchange (through APIs/other) and perform a set of verification operational activities. The second part of the UC will deploy the same HESS system but using the InterSTORE legacy converters and then verify it with the same operational test activities. The length and procedures will be described in order to compare the two deployments. The following steps are common to the two approaches: 1. COLLECT DATA First of all, the HESS will be integrated in the FIWARE-based ICT platform of FZJ by means of the current solution. During this phase, relevant data will be collected in order to be able to perform a meaningful comparison with the solution developed in the InterSTORE project. In particular, we will collect: - time required for the installation of hardware and software, until the successful operation of the interface; - capacity of handling multiple data flows. 2. COMMISSIONING TESTS A set of commissioning tests aimed at verifying the operability of the software tools will be performed. In particular, it will be verified: 2.1. operability of single communication interfaces. In this phase, tests will be performed to verify the successful communication between the developed tool, the ICT platform and the BESSs. Following a progressive testing approach, the tests will be carried out starting from a local connection, up to the remote connection with the FIWARE platform. The successful integration with FIWARE will be verified also in terms of required time, for the evaluation of the time-saving with respect to the traditional integration; 2.2. controllability of the BESSs over the defined operating ranges. Following a progressive testing approach, preliminary, small scenarios that aim at verifying the operation of the control coordination, will be executed. 3. CONNECTED DATA SPACES The operational data of the HESS will be shared after the deployment of the InterSTORE/OneNet True Connector for the connected data spaces demonstration.

1.5 Key performance indicators (KPI)

ID(*)	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI3	Battery capacity	Amount of Flexibility provision in the demos from HESS	2
KPI4	Diversity of DER	Number of different DER devices successfully tested and demonstrated	2
KPI5	Asset management monitored by EMS	Number of assets monitored by the InterSTORE EMS solutions	2
KPI9	Time savings	Time saved for end customers integrating DER (end customer target: 20% of time savings)	1
KPI10	Nbr of DER tested	Number of different DER devices and EMS successfully tested with the IEEE2030.5 and demonstrated in real-life pilots (pilot target:2)	2
KPI11	Data space	Amount of digitized storage systems/platforms/hubs assets integrated in the common data space exchanging data (pilot Target: 50% of the assets)	3
KPI25	Integrated capacity	Integrated power of the HESS within the project demos	2
KPI26	Increase of flexibility	Demand side flexibility potential increase due to hybridization implementation	2

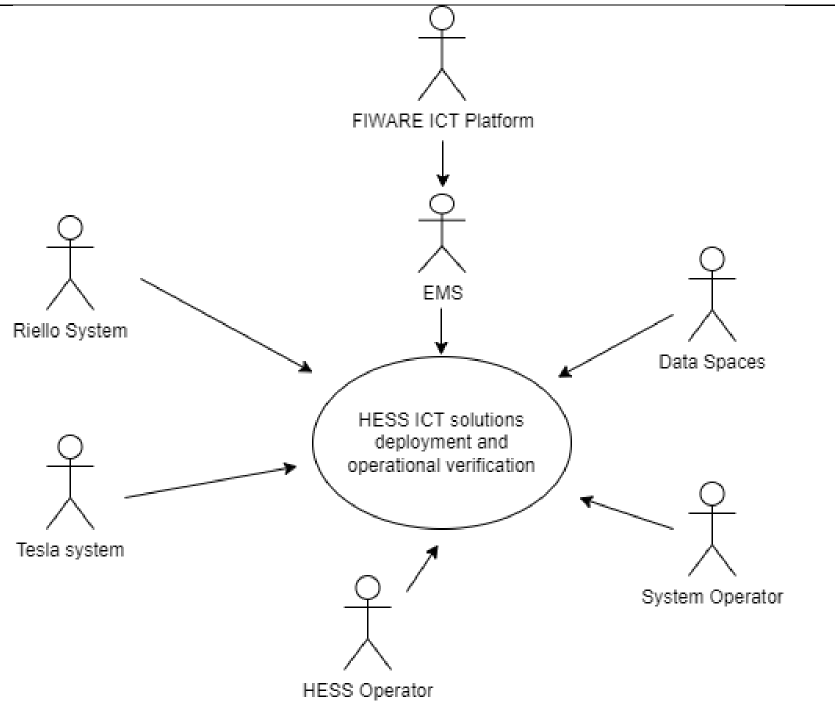
(*) The ID number is based on the project KPI reference list

1.6 Use case conditions

Use case conditions
Assumptions
• The existing ICT platform is FIWARE-based and does not support IEEE 2030.5 • The legacy converters need to be deployed as an alternative to the inverter firmware update • Raspberry Pi 4 will be used as hardware for the Legacy Protocol Converter • The limits of operation of the HESS is limited to defined boundaries imposed by the system operator • A Public IP addressed cannot be assigned directly to the installation related internet connections. An alternative way must be put in place • LTE communication is not allowed
Prerequisites
• The batteries need to be commissioned • Local connection (intranet) and registry with internal IP address will be needed • The interface with the ICT platform (thus with the EMS) is MQTT-based • The interface with the batteries (more specifically, with their control) is based on Modbus • The same team performing the deployment should be ensured (to avoid miscomparisons)

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases

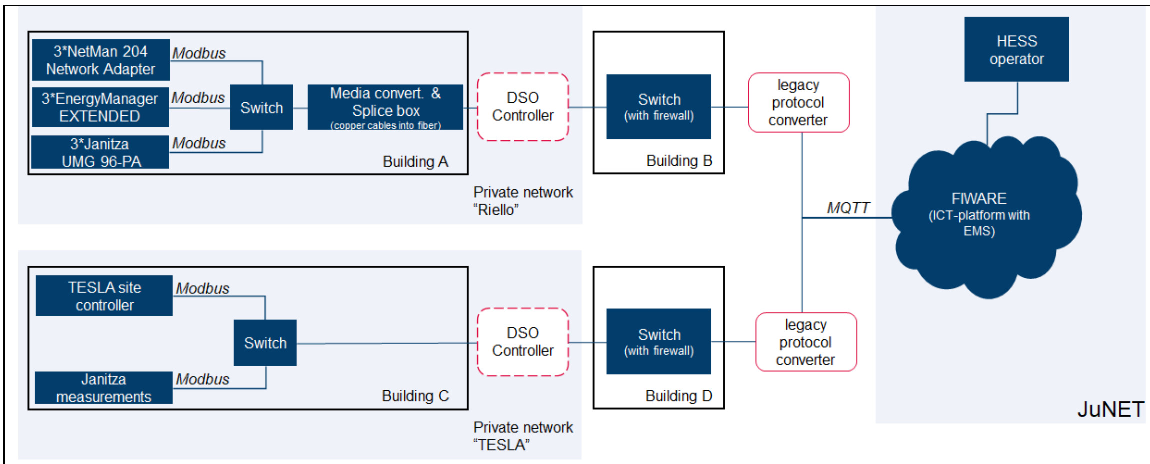
 Relation to other HLUCs: UC 8: Multiphysics flexibility optimization for Home Management Systems and their global integration. The same battery systems will be used.
Level of depth
High level use case (HL-UC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution
Prioritisation
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Technical/system use case
Further keywords for classification
Battery systems, EMS, communication interfaces.

1.8 General Remarks

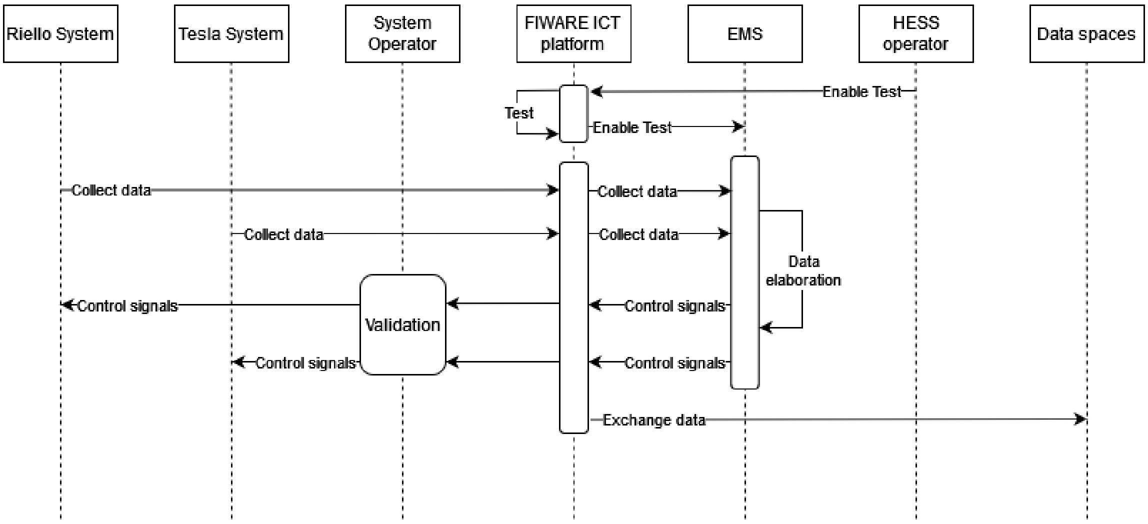
General Remarks
None for now

2 Diagrams of use case

Diagram(s) of use case
HLUC Diagram of components



HLUC Sequence Diagram:



3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
System Operator	Actor	It's the distribution system operator of the internal grid or an external DSO. It can enforce control setpoints with the highest priority.
Data Spaces	System	Is the InterSTORE platform that will be used to store collected data during the tests
FIWARE ICT Platform	System	Is the ICT platform of FZJ
EMS	System	Is the energy management system running on the ICT platform of FZJ
Riello System	Device	Is the high-power battery system
Tesla System	Device	Is the high-energy battery system
HESS operator	Actor	Is the FZJ partner that will coordinate and perform the tests

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
1	Standard	IEC 62559-2 Use Case Methodology	Published	Definition of the presented template	International Electrotechnical Commission	
2	Standard	IEEE2030.5	Published	Provision of possible actors and roles	IEEE	
3	Spreadsheet Document	InterSTORE KPI List		Provision of KPIs to be included	InterSTORE internal document	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition

1	Integration time evaluation	The time required for the integration of the solution developed in InterSTORE will be compared with the one required by the traditional integration. The aim is to prove that the former is seamless and faster.	HESS operator	Deployment by the HESS operator	Traditional FIWARE integration in place at FZJ.	The solution develop in InteSTORE is integrated and can fully replace the traditional one.
2	Successful BESS operation via EMS	The FZJ EMS computes the current state of operation of the network and determine the best operations that should be performed by the two battery systems. The main goal is to maintain a certain power profile and to compensate for the lack of supply.	EMS	Data collected from the FZJ network (at the PCC of the batteries)	The default control system of the batteries is active.	The control via the EMS proves to be effective in regulating the voltage profile and compensate for the lack of supply.
3	Data sharing via connected data spaces	Operational data collected from the battery systems and the EMS will be shared in the connector interface. This data can be accessed by authorized subscribers. The provision of data is considered as successful deployment.	EMS Riello system Tesla system	Operational data are published in the connected data spaces	Successful deployment of the connector on a server machine where operational data are hosted	Data are successfully shared via the connected data spaces.
4	No time saving due to integration of InterSTORE solution	The integrated InterSTORE solution is not able to fully replace the traditional one because does not receive/forward the necessaries data. Or the integration takes more time than the traditional one.	HESS operator	Deployment by the HESS operator	Traditional FIWARE integration in place at FZJ.	The solution developed in InteSTORE is integrated but cannot fully replace the traditional one and/or is not faster.
5	Unsuccessful BESS operation via EMS	The FZJ EMS computes the current state of operation of the network and determine the best operations that should be performed by the two battery systems. The EMS is not able to maintain a certain power profile or to compensate for the lack of supply.	EMS	Data collected from the FZJ network (at the PCC of the batteries)	The default control system of the batteries is active.	The control via the EMS is not effective in regulating the voltage profile or compensate for the lack of supply.
6	Impossible data sharing via connected data spaces	Operational data collected from the battery systems and the EMS cannot be provided or cannot be shared in the connector interface.	EMS Riello system Tesla system	Operational data are not available or cannot be successfully published in the connected data spaces	Unavailability of the operational data or unsuccessful deployment of the connector	Data are not shared via the connected data spaces.

4.2 Steps – Scenarios

Scenario								
Scenario name:		*No. 1*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1	Traditional integration (FIWARE) solution is deployed and working	Communication of commands and variables runs over traditional solution	Evaluation of the time required for the integration of the traditional interface. Integrated solution is used to interface the BESSs and the EMS.	Executes	HESS operator	HESS operator	SP-1 (Traditional performance metric)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.4, R-DM.5
2	InterSTORE solution (legacy protocol converter) is deployed and working	Communication of commands and variables runs over InterSTORE solution	The time for the deployment of the InterSTORE solution is monitored. After the deployment, BESSs and EMS systems can communicate and exchange information seamlessly	Executes	HESS operator	HESS operator	SP-2 (InterSTORE per-formance metric)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.4, R-DM.5

Scenario								
Scenario name:		*No. 2*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*

1	Voltage profile sent	Voltage measurement is sent to the EMS	The monitoring devices at the PCC of each battery send the voltage value at the PCC at regular intervals	Report	PCC smart meter	EMS	SP-3 (Voltage profile)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
2	UPS request sent	A lack of power supply is detected	The inverter of the battery system detects a lack of the main supply and the information is sent to the EMS	Report	Riello system Tesla system	EMS	SP-4 (UPS request)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
3	Get operation command	Command charge/discharge	Based on the data received from the BESSs, the EMS determine that a BESS should be charged/discharged	Execute	EMS	Riello system Tesla system	SP-5 (BESS operation schedule)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

Scenario								
Scenario name:		***No. 3***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***

1	Operational data available	Data sharing via Data spaces	The server where the operational data of BESSs and EMS is successfully connected to the Data spaces and operational data are updated regularly.	Change	Server where operational data is stored	Data Space connector	SP-6 (Operational data shared)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

Scenario								
Scenario name:		***No. 4***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
1	InterSTORE solution deployed after a long time	Communication of commands and variables run over InterSTORE solution	The time for the deployment of the InterSTORE solution was longer than expected (more than the traditional one).	Report	HESS operator	HESS operator	SP-7 (InterSTORE per-formance metric error)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4
2	InterSTORE solution not working	Communication of commands and variables unable to run over InterSTORE solution	After the deployment, BESSs and EMS systems cannot fully communicate and exchange information seamlessly.	Report	HESS operator	HESS operator	SP-7 (InterSTORE per-formance metric error)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4

Scenario

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Scenario name:		No. 5						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1	Get operation command	Command charge/discharge	The EMS is not able to determine if a BESS should be charged/discharged	Report	EMS	Riello system Tesla system	SP-8 (BESS operational schedule error)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

Scenario								
Scenario name:		No. 6						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1	Operational data not available	Data sharing via Data spaces impossible	Operational data are not properly stored in the Server connected to the data spaces	Report	Server where operational data should be stored	Data Space connector	SP-9 (Operational data shared error)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

2	Operational data not sharable	Data sharing via Data spaces impossible	Server where operational data are stored, cannot be connected to the data spaces	Report	Server where operational data is stored	Data Space connector	SP-9 (Operational data shared error)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
SP-1	Traditional performance metric	Required time (hours) needed to successfully deploy traditional FIWARE interface	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.4, R-DM.5
SP-2	InterSTORE performance metric	Required time (hours) needed to successfully deploy InterSTORE interface	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1,R-DM.4, R-DM.5
SP-3	Voltage profile	Voltage profile in V, reported every minute	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-4	UPS request	Request sent from the inverter, when lack of power supply is detected	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

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SP-5	BESS operation schedule	Scheduling of operations of the BESS (charge/discharge) determined by the EMS	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-6	Operational Data Shared	Set of operational data shared with the Data Spaces	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-7	InterSTORE per-formance metric error	Unexpected behaviour of the InterSTORE solution	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.4, R-DM.5
SP-8	BESS operational schedule error	Unexpected behaviour of the EMS (erroneous operational schedule determined)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-9	Operational data shared error	Unexpected behaviour when sharing data to Data Spaces	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
CONF	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communications types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable. It includes: - information exchanged with external entities (e.g. service provider, weather data provider, etc.) - information related to the electricity tariff scheme in current use (e.g., variable price and fixed price components). The includes both consumption and generation tariff information. - information related to the weather conditions for the next day/hours to be used by the optimal scheduling methodology to include the local generation. - all the characteristics and configuration parameters related to the use of devices by the HEMS to produce an optimized schedule - all the configuration parameters related to the user preferences in the production of an optimized schedule - the requirements for the information presentation to the end-user - the communication solutions the data models used.

DM	Data Management	Covers both the management of the data exchanges in each use case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions. It should not address database design but should concentrate on the user requirements for the interfaces to databases and other data handling applications. It includes: - all the metering data related with the house consumption and, if applicable, local generation. This information can be obtained by a central metering equipment, like a DSO smart meter or a user electric panel meter. It can also be obtained through distributed meters from electric panel meters, smart plugs or directly from a smart device/system. - the requirements related to the storage of information locally and remotely to the HEMS a structured access to data related to devices and user preferences
SEC	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable. Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors. At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures. Includes all the security related requirements to allow data between devices, systems and entities to be exchanged in a trustworthy way.
Requirement R-ID	**Requirement name**	**Requirement description**
R-CONF.1	Communication access services requirements	Provides access to the EMS platform remotely to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities like the availability of DNS lookup, security credentials, firewall configurations, etc.
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R-CONF.3	Existence of legacy systems	Addresses the necessary changes (quantification of the effort) and adaptations necessary to the equipment as related devices to accommodate the integration of legacy systems.

R-CONF.4	Operation mode of Information Receiver	Defines if the target device is operating in manual or automatic mode
R-CONF.5	Operation mode of Information Producer	Defines if the source device is operating in manual or automatic mode
R-SEC.1	Authentication: Masquerade and/or spoofing - Ensuring that data comes from the stated source or goes to authenticated receiver is:	Warrants protected access to the platform locally to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities, security credentials, firewall configurations, etc.
R-SEC.2	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Guarantees the conformity of all the data exchange between the EMS and its service providers
R-SEC.3	Authentication and Access Control mechanisms commonly used with this data exchange	Requires authentication and/or encryption of the data exchanged between the EMS, dataspace connector and additional internal devices as well as with external systems (e.g., from service providers). Key encryption, certificates and other access control mechanisms are necessary.
R-SEC.4	Network security measures commonly used with this data exchange	Establishes communication network separation (including physical one) and the firewall control list to allow external access to the database.
R-DM.1	Correctness of source data	Ensures that the data is correctly interpreted and used for the purpose it was designed to.
R-DM.2	Management of accessing different types of data to be exchanged	Sets the type of data being exchanged and the expected periodic update (asynchronous or every x time). This is applicable to data exchange internally (e.g., with local database) in the EMS, and with other devices and systems on the field.
R-DM.3	Validation of data exchange	Guarantees that data exchanged between parties (devices, systems, entities) is valid. It can provide confirmation to originally sending party.
R-DM.4	Management of data across organizational boundaries	Defines the necessary changes and adaptations to the data exchanges across the building boundaries, between the EMS and other external systems.

R-DM.5	Data format requirements	Sets specific formats for the data exchange between devices, systems and entities (Data space connector, EMS, FIWARE platform etc). The following formats are required to be supported by the EMS: standard computer formats (e.g., binary, integers and floating pt, files); Serial transfer formats (e.g., DNP, Mobdus, LonTalk, BACnet); Graphics formats; Mark-up based HTML, XML; Human readable CSV and JSON; etc.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
BESS	Battery Energy Storage System
HMS	Home Management system
UC	Use Case

HLUC04 - Innovative Frequency services BESS

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
HLUC04	Grid users / Residential	Innovative Frequency services BESS

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	20.03.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Initial definition of the use-case characteristics
0.2	20.04.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updating with new KPI, table1.5
1.0	15.05.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updates with Actors, Table and texts.
2.0	15.06.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updates on actors, sequences, and tables up to the table 4.1
2.2	19.06.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Sequence diagram update, reference and table 4.1 added.
3.0	02/07/2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updates of the remaining tables

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The main focus of this HLUC can be broke-down as follows: 1. This Use Case identify and analyse how the system can be used for providing different innovative grid services with grid forming capabilities in low inertia networks. 2. Test and validate the possibility of HESS conversion system in island mode and reconnection, after synchronization activation, with the main grid with proper communication. 3. Offer additional services in grid connected mode such as frequency regulation with the goal of improving the dynamic response of the system consisting of different type of storages (High power UCAPS + High energy Batteries). 4. Fast advanced control solution for virtual inertia emulation with sufficient damping.
Objective(s)	(1) Enabling a grid forming capability with flexibility to work in both island and grid connected modes with hybrid storage conversion system (2) Enabling and validation of the HESS conversion unit for providing different grid services such as frequency regulation. (3) Enabling fast functionalities such as virtual inertia control and oscillation damping.
Related business case(s)	HLUC 7: Data sharing, inputs for implementation of full HyDEMS in UC7. Inputs of the network and selected services for UC7.

1.4 Narrative of use case

Narrative of Use Case
Short description
This use-case presents a procedure to test and validate the performance of the HESS unit for providing fast grid services to cope with future challenges of low inertia systems. To do so, first the grid forming capability of the HESS conversions system will be tested in island mode and then provision of fast services such as virtual inertia, frequency regulation and oscillation damping, which will be evaluated in grid connected mode.
Complete description
This HLUC describes how the user can provide different functionalities such as grid forming system in island mode and in grid connected mode for providing fast frequency control services taking into account hybrid solution of different storage technologies. In low inertia systems there is a need to define new strategies for power electronics connected devices, with a mix of different types of storage technologies, for providing different functionalities behaving as a conventional power plants. In the field of fast dynamic frequency support in terms of virtual inertia and virtual damping, it is supposed to be an emerging need in the close future. Such a service would require the adaptation of internal control parameters of the storage system so to provide the appropriate behavior. As result it may actually be necessary to foreseen that the inverter would have the capability from the so-called grid-following mode to the grid-forming mode. Different level of involvement and then different implementation can be considered within use case. From the point of view of this project, it would be critical to define the data exchange necessary to activate this kind of service. This service can be seen in combination with the more classical grid support services to create a more significant business case particular during the transition when inertia may be only seldom required. Briefly, the current HLUC includes the following steps: 3. COLLECT DATA At this step the necessary data for all the components need to be collected from previous WPs. This information can be used by the software algorithms to define the condition of the test environment. 4. MONITOR SYSTEM COMPATIBILITES The necessary monitoring system with the needed data exchange need to be defined for activating such a service. 5. BLACK START/STARTING UP IN ISLAND MODE After ensuring about the availabilities of needed data with exchange monitoring/exchange data capabilities, the HESS system can be tested in island mode for testing the Grid-Forming (GFM) capabilities of the developed system. The unit will start to work in island mode feeding the local loads. Decision on switch between island and grid connected mode can be activated by grid conditions and DSO commands. 6. SYNCHRONIZATION TEST AND SWITCH TO GRID CONNECTED MODE 7. FAST SERVICE TESTS IN GRID CONNECTED MODE 7.1. Fast frequency regulation 7.2. Virtual inertia emulation tests 7.3. Damping capability tests

1.5 Key performance indicators (KPI)

ID(*)	Name	Description	Reference to mentioned use case objectives
KPI12	Time savings	Demand side Flexibility potential increase due to hybridization implementation (Target: >20%)	2
KPI13	Monitoring	N° of assets monitored in GridLab for the project	1
KPI14	Time response	is considered as the overall HESS system time response which will be needed for providing the service complying TSO grid codes.	2, 3
KPI15	System DADIR	indicator that corresponds to the lower frequency value during frequency regulation services	3
KPI16	System ROCOF	Indicator which results during the first instants after the time of occurrence of an event during fast services	3

(*) The ID number is based on the project KPI reference list –

1.6 Use case conditions

Use case conditions
Assumptions
• Provide information to the HyDEMS, mode to start the system; Island or grid connected and the order to sync and connect to the grid in case of start in island mode. • DES components are available with proper communication structures.
Prerequisites
• For oscillation damping, need profile with the characterization of the event in frequency. • For frequency regulation services, need the characterization of the generator to simulate and the frequency droop.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Relation to other HLUCs: HLUC 7: Inputs and Data sharing
Level of depth
High level use case (HL-UC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution
Prioritisation
Demonstration of advanced frequency services in GridLab with Hybrid DER.
Generic, regional or national relation
Regional and national depend on the application
Nature of the use case
Use case for large scale Lab demonstration for the hybridization and services to the grid

Further keywords for classification
Flexibility, DES, HyDEMS, Grid forming converter, Grid following, Virtual inertia, Inherent damping, Hybridization, Power oscillation damping, Frequency regulation.

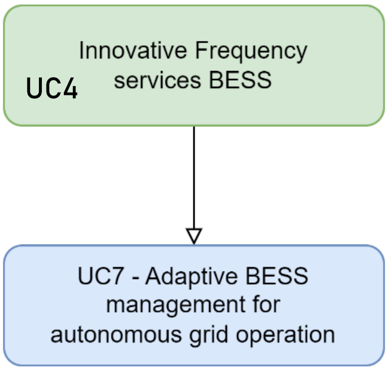
1.8 General Remarks

General Remarks
The methodology described in this UC4, is generic steps and test to be followed for demonstrating the successfulness of the HESS on providing fast services such as virtual inertia and frequency regulation with inherent virtual inertia and damping of oscillations. This may involve developing protocols for communication and control and ensuring that the different technologies can be connected and managed in a way that maximizes their performance.

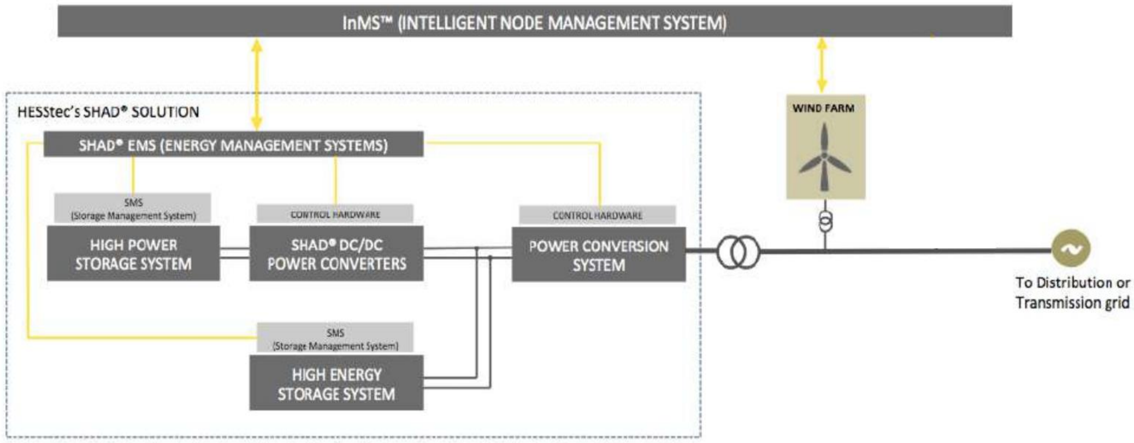
2 Diagrams of use case

Diagram(s) of use case

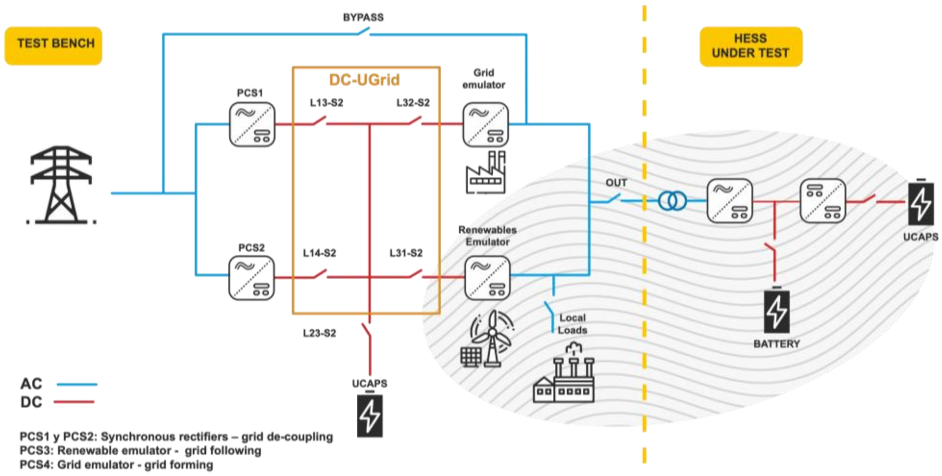
HLUC- Relation Diagram:



HLUC- general architecture:

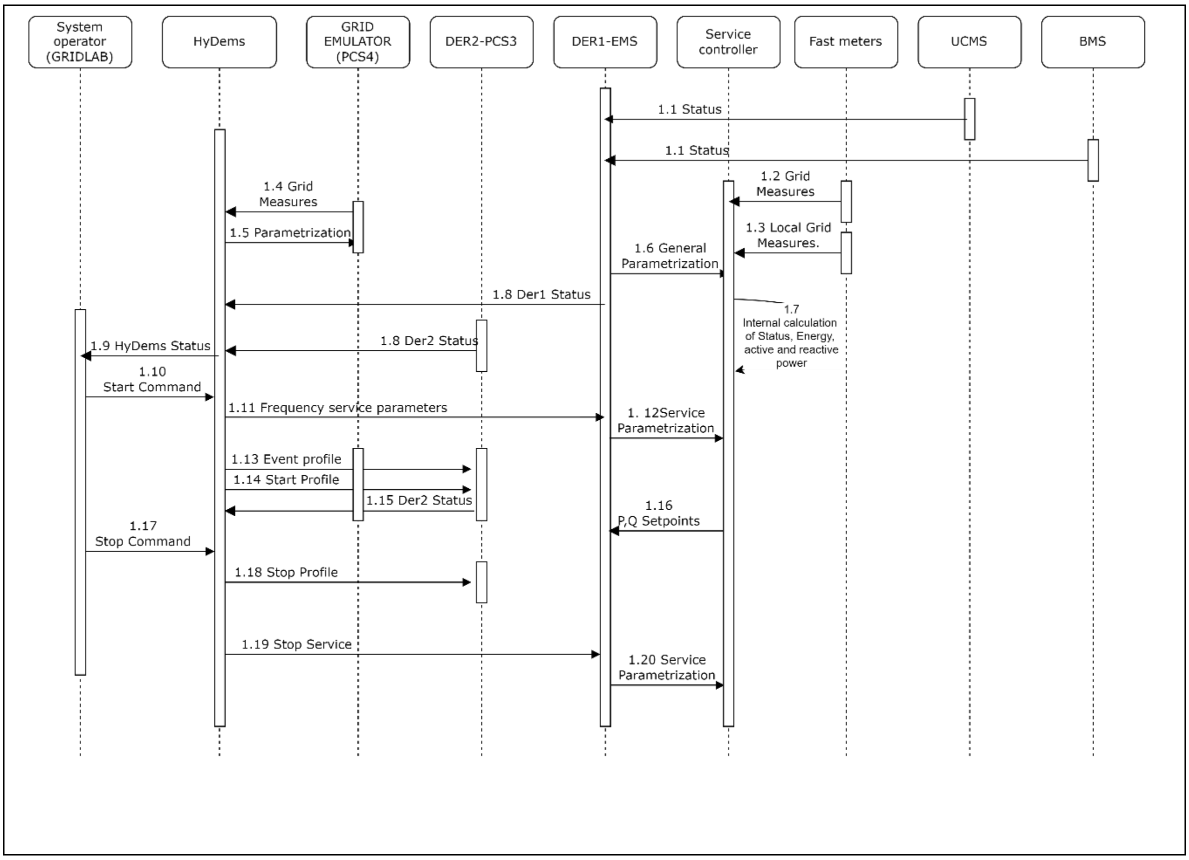


Generic schematic of the use case 4 for Lab demonstration of the services.



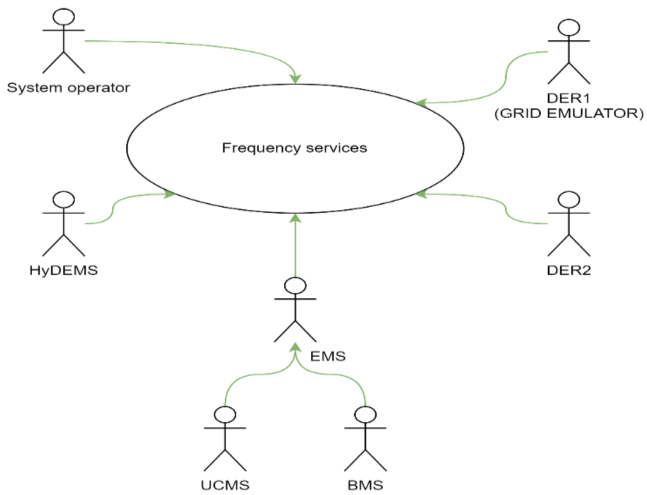
GridLab scenario for implementing the UC4 for fast dynamic grid service test

<u>HLUC 4 General Sequence Diagram:</u>



3 Technical details

Relationships of different actors:



3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
System Operator	Actor	It's the distribution system operator of the internal grid that will provide the services to apply

GRIDLAB	Site	The Lab where the Devices are installed, and the UC will be performed.
HyDems	System	Hybrid energy management system running over the EMS and the DER2.
DER1-EMS	System	Is the Energy management system to control ultracapacitors and battery.
DER1-BMS	System	Is de battery management system.
DER1-BATTERY	Device	Is the High-energy battery device.
DER1-UCMS	System	Is the ultracapacitors management system.
DER1-UCAPS	Device	Is the High-Power ultracapacitors device.
DER1-ACDC	Device	ACDC converter controlled by EMS.
DER1-DCDC	Device	DCDC converter for UCAPS, controlled by EMS.
DER2-PCS3	Device	Inverter to simulate for event and simulation.
PCS4 – Grid Emulator	Device	Inverter to simulate a grid with high impedance.

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Datasheet	Battery specifications	Ready- confidential	Technical information of battery asset	Narada	
2	Datasheet	Ultracapacitors specifications	Ready- confidential	Technical information of ultra camacitors asset	Hesstec	
3	Spredsheet Document of signals	ModBus communication table of different commponents	Pending	Modbus directions for different commponents	Hesstec	
4	Spredsheet Document	Profile to generate the grid event in frequency	Pending	Event profiles of events.	Hesstec	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	No Grid event detected	DER1-EMS collect data from UCMS and BMS and update the DER1-	DER1-EMS	Data gathering	Need the Service parametrization and inertia.	Generate a valid P,Q setpoint

		EMS Status values like SoF to the HyDEMS control. Service Controller, collect data of the local and external grid to get the metrics needed for service.				waiting for the service activation.
2	Service activation & event compensation	HyDEMS send orders to the assets to Start the services and send the event profile.	HyDEMS	Service Controller order	Valid HyDEMS Status. The DER1-EMS have a valid SoF to execute the service	The Grid frequency event must me compensated

4.2 Steps – Scenarios

Scenario								
Scenario name:		No. 1						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1	Data gathering	1.1 Status	Recovering status of the asset and calculating the total SoF	GET/REPEAT	UCMS & BMS	DER1-EMS	SP-1	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
2	Updating SoF	1.8 DER1 Status	The SoF is sent to HyDEMS	SET	DER1-EMS	HyDEMS	SP-2	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
3	Data gathering	1.8 DER2 Status	Recovering status of the asset.	GET	DER2_RENEWABLE	HyDEMS	SP-3	R-CONF.2, R-SEC.1 R-SEC.3, R-DM.3
4	Updating SoF	1.9 HyDEMS status	The SoF is sent to System Operator	SET	HyDEMS	System Operator	SP-4	R-CONF.1, R-CONF.4, R-SEC.3, R-DM.3
5	Updating Status	1.4 Grid Emulator Status	Updating the Grid Emulator parameters.	SET	HyDEMS	GRID-EMULATOR	SP-5	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3

Scenario								
Scenario name:		No. 2						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs

6	Service Controller	1.10 Start Command	Order to start the The services.	SET	System Operator	HyDEMS	SP-6	
7	HyDEMS parametriza tion	1.11 Frequency service parametrizati on	Parameters for Service	SET	HyDEMS	DER1-EMS	SP-7	
8	Parameters for service	1.12 Service parametrizati on	Load in the service controller parameters of the Grid Service	SET	DER1-EMS	Service Controller	SP-7	
9	parametriza tion	1.13 Event Profile	Sending Event profile	SET	HyDEMS	DER1-EMS/ GRID-EMULATOR	SP-8 SP-9	
10	Data gathering	1.15 DER2 Status	Recovering status of the asset.- Profile ready to run.	GET	DER2_RENEWA BLE	HyDEMS	SP-3	R-CONF.2, R-SEC.1 R-SEC.3, R-DM.3
11	Profile ready to Run	1.14 Start Profile	Sending Start Command to the Event generator.	SET	HyDEMS	GRID-EMULATOR	SP-10	
12	New Service Controller P,Q setpoint	1.16 P,Q Setpoint	The Service Controller generate a new P,Q setpoint calculate with the Gird event detected	SET	Service Controller	DER1-EMS	SP-11	
13	New P,Q setpoint	1.16 P,Q Setpoint	The new Setpoint is sent to the inverters	REPEAT	DER1-EMS	Inverters	SP-11	
14	Data gathering	1.15 DER2 Status	Recovering status of the asset.- Profile finished status.	GET	DER2_RENEWA BLE	HyDEMS	SP-3	R-CONF.2, R-SEC.1 R-SEC.3, R-DM.3
15	Updating SoF	1.9 HyDEMS status	The SoF is sent to aggregator, Profile finished.	SET	HyDEMS	Service Controller	SP-4	R-CONF.1, R-CONF.4, R-SEC.3, R-DM.3

16	Profile Finished	1.17 Stop command	Send Stop command	SET	System Operator	HyDEMS	SP-12	
17	Stop Command	1.19 Stop Service	Send new parametrization to stop service	SET	HyDEMS	DER1-EMS	SP-5	

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
SP-1	Recovering Status of assets	Recovering current information of UCMS and BMS and check any warning, alarm.	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
SP-2	Generated SoF	Using the SP-1 and assets specifications DER1-EMS generate the SoF.	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
SP-3	Recovering Status of assets	Recovering current information of DER2-RENEWWABLE and check any warning, alarm.	R-CONF.2, R-SEC.1 R-SEC.3, R-DM.3
SP-4	Generated SoF	Using SoF of DER1-EMS and SP3 HyDEMS generate the SoF	R-CONF.1, R-CONF.4, R-SEC.3, R-DM.3
SP-5	Grid Emulator parameters.	Updating Grid Service parameters.	R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4
SP-6	Start Service Controller	Service Controller send command to enable the Gird Service.	R-CONF.2, R-SEC.1
SP-7	Frequency service parametrization	HyDEMS send to DER1-EMS the list of the Grid Service and the enable flag.	R-CONF.2, R-SEC.1, R-SEC.4, R-SEC.3, R-DM.3
SP-8	Event Profile	Send the profile to DER1-EMS modelling the emulation.	R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4
SP-9	Event Profile	Send the event profile to generate the grid event. To GRID-EMULATOR .	R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.3
SP-10	Start Profile	Send The command to start de Freq event.	R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4
SP-11	P,Q setpoint	Separate Setpoint for UCAPS and Battery generated in the Service that will be sent to the inverters.	R-CONF.2, R-SEC.4, R-DM.3
SP-12	Stop Grid event	Command to the HyDEMS to stop the event in the next cycle	R-CONF.1, R-CONF.2, R-CONF.4, R-SEC.1, R-SEC.3, R-DM.3

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
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R-SEC.1	Authentication: Masquerade and/or spoofing - Ensuring that data comes from the stated source or goes to authenticated receiver is:	Warrants protected access to the HEMS platform locally to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities, security credentials, firewall configurations, etc.
R-SEC.2	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Guarantees the conformity of all the data exchange between the HEMS and its service providers
R-SEC.3	Authentication and Access Control mechanisms commonly used with this data exchange	Requires authentication and encryption of the data exchanged between the HEMS and internal building devices as well as with external systems (e.g., from service providers). Key encryption, certificates and other access control mechanisms are necessary.
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R-DM.4	Management of data across organizational boundaries	Defines the necessary changes and adaptations to the data exchanges across the building boundaries, between the HEMS and other external systems.
R-DM.5	Data format requirements	Sets specific formats for the data exchange between devices, systems and entities. The following formats are required to be supported by the HEMS: standard computer formats (e.g., binary, integers and floating pt, files); Serial transfer formats (e.g., DNP, Mobdus, LonTalk, BACnet); Graphics formats; Mark-up based HTML, XML; Human readable CSV and JSON; etc.
R-DM.6	SAREF compliant data	The data structures exchanged between systems is SAREF compliant

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
CONF	Configuration
DM	Data Management
SEC	Security
UC	Use Case
HyDEMS	Home Energy Management System
HLUC	High Level Use Case
EMS	Energy Management System
BMS	Battery Management System
HyDEMS	Hybrid Distributed Energy Management System
INMS	Intelligent Node Management System
DER	Distributed Energy Resources
DES	Distributed Energy System
HESS	Hybrid Energy Storage System
BESS	Battery Energy Storage System
SoC	State of the Charge
SoF	State of the Function
UCMS	UCAP Management System
GFM	Grid Forming converter
GFL	Grid Following converter
VI	Virtual Inertia

HLUC05 – Hybrid storage higher performance and flexibility provision

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
HLUC05	Area: Energy Systems Domain: DER Zones: Process, Field, Station, Operation	Hybrid storage higher performance and flexibility provision

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	10.03.2023	INESC TEC	Initial definition of the use-case characteristics
0.2	26.04.2023	INESC TEC	KPI revision and actor mapping inclusion
0.3	31.05.2023	CAPWATT	Scope and definition adjusted
0.4	14.06.2023	INESC TEC	Scenarios, message exchange definition and requirements

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	In this use case (UC), the objective is to demonstrate how it can optimize the cost of supplying electric energy to a generic load (which is the associated building, which has a HESS (hybrid energy storage system), while increasing the lifetime of the Storage Systems, compared to a base case of a single battery. Currently, the electric energy of the building is supplied by the grid, by the onsite PV, by the storage system or by all, with different values of "cost/carbon intensity" of energy. In this UC it is also an objective to test the interoperability of distributed resources by installing the IEEE2030.5 standard to the already installed equipment, between the inverter and BMS (battery management system), according to the data of the HESS in operation. Operational data is exported to a database of Inesctec (HEMS backend) and made available to the connected dataspace.
Objective(s)	Objectives: 1) Implementation of the IEEE 2030.5 in the HESS and test its implementation in the inverter of the 2nd life battery of the HESS and BMS of the HESS. 2) Compare the performance in an optimization exercise with a hybrid energy storage system vs base case of a single battery. 3) Demonstrate the reporting of operational data from the hybrid Storage system to the InterSTORE connected data space.
Related business case(s)	HLUC 6 - Management of battery systems for Node capacity increase

1.4 Narrative of use case

Narrative of Use Case
Short description
A HESS is installed in a building basement. The HESS is composed by two batteries: One is a vanadium redox flow, with 10kW and 40kWh and the other is a set of second life lithium batteries with 100kW and 92 kWh. Those batteries are connected to their inverters and are operated according to an EMS installed in a local PC. The HESS is connected to the building, 'behind the meter'. The building also has a PV system of 100kW installed on the top. In the present UC, it is expected to be demonstrated strategies for the HESS operation, that aim to optimize a cost function (minimize the system degradation), comparing Hybrid systems to single battery systems. The UC will also integrate the IEEE2030.5 in the 2nd life battery inverter/BMS, to showcase the interoperable solution of InterSTORE, applied to distributed resources. It will also share data with the connected data spaces developed in T2.4.
Complete description
This UC will be demonstrated using the real case of a HESS in operation at Sonae Campus.The HESS includes a redox vanadium energy storage system and second life lithium energy storage system, which is connected behind the meter to a building low voltage general supply electrical board. The HESS management systems is already managing all the HESS, with a local PC, running lab-view. The UC foresees the following steps to ensure the demonstration implementation. 1. MONITOR ENERGY CONSUMPTION The historical energy consumption of the building will be collected and shared with InescTec EMS and data will be stored in a DB. 2. FORECAST The historical data (load diagrams) of the building, will be retrieved collected and shared with InescTec, and a ML model will forecast the consumption for the following day and establish a baseline. 3. FLEXIBILITY/ARBITRAGE PROVISION EVALUATION Based on an incentive forecast of an environmental signal, in a day ahead exercise, the Inesctec HEMS will provide a set of recommendations to charge and discharge the HESS, in order to achieve the optimized "cost" for supplying energy to the building, while maximizing the lifetime of the batteries. 4. IEEE2030.5 DEMONSTRATION Local testing of the native IEEE 2030.5 in the equipment of the HESS will be carried out, assuring that no interference of the normal operation conditions of the HESS will occur. Another option will be the installation of the IEEE converter toolkit, between the battery inverters and the EMS PC the correct functioning of communication will be assessed over the IEEE2030.5 tool implementation. 5. VERIFICATION OF THE HESS PERFORMANCE In order to evaluate the performance of the HESS and be possible to compare it to an ESS with a single battery, a set of metrics will be evaluated such as, for example, the reduction in the cost function due to the utilization of the hybrid system in comparison to a simulated single battery, or the impact in its lifetime. 6. CONNECTION TO DATA SPACES The operational data from charging and discharging the HESS will be shared with a database where a connector will be deployed to enable the sharing with the connected data spaces created in InterSTORE.

1.5 Key performance indicators (KPI)

ID(*)	Name	Description	Reference to mentioned use case objectives
KPI3	Battery capacity	Amount of Flexibility provision in the demos from HESS	2
KPI4	Diversity of DER	Number of different DER devices successfully tested and demonstrated	1
KPI5	Asset management monitored by EMS	Number of assets monitored by the InterSTORE EMS solutions	2
KPI7	N° of end users involved in HESS	N° of end users (workers, EV users, consumers) engaged in the demonstration of interoperable HESS	2
KPI10	Nbr of DER assets tested with IEEE2030.5	Number of different DER devices and EMS successfully tested with the IEEE2030.5 and demonstrated in real-life pilots	1
KPI11	Data space digitized assets	Amount of digitized storage systems/platforms/hubs assets integrated in the common data space exchanging data	3
KPI18	HESS performance	Optimization of cost reduction / lifetime extension vs energy supply due to HESS when compared to a ESS with only one single battery	2
KPI19	Data Spaces	Number. of shared services/files subscribed and published	3
KPI25	Integrated capacity	Integrated power of the HESS within the project demos	2
KPI26	Increase of flexibility	Demand side flexibility potential increase due to hybridization implementation	2

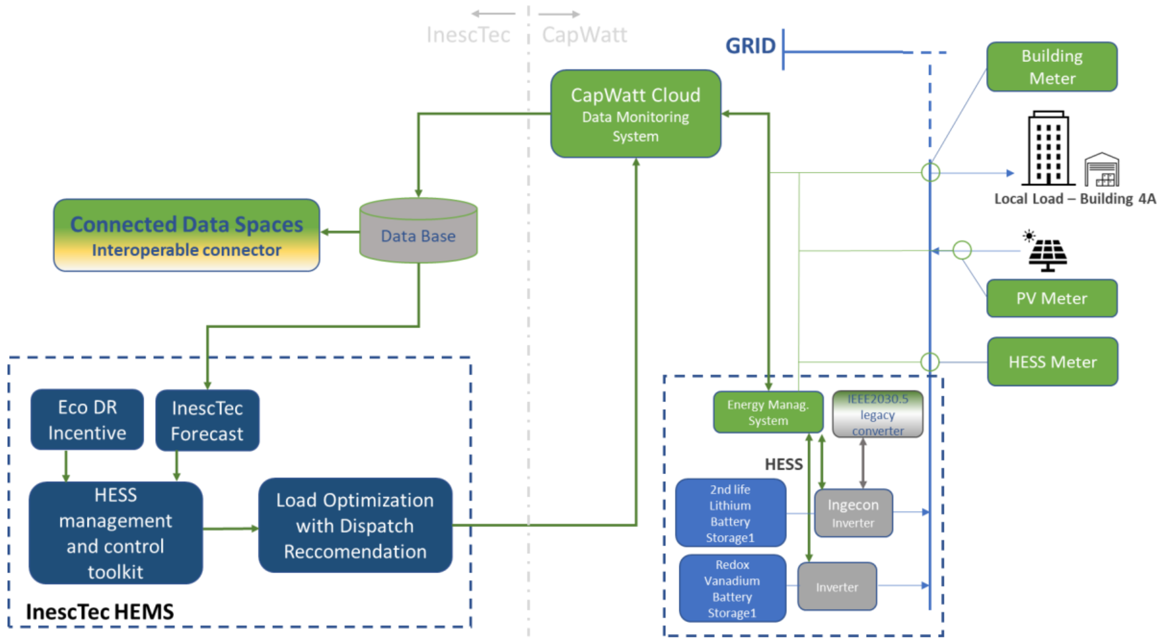
(*) The ID number is based on the project KPI reference list

1.6 Use case conditions

Use case conditions
Assumptions
• For the implementation of the IEEE2030-5, the inverters and BMS need to be compatible to communicate with the IEEE2030.5 legacy protocol converter in the sense that they are reach-able and available for external connections and the owners and manufacturers accept its implementation. Otherwise, the converter will be used • Assumes that there is connection facilitated for the NATS implementation. • Assumes that the data of the electrical energy (load and production) is available every day with at least 15 minute time step granularity • Assumes that the dispatch recommendations are provided via a dedicated channel to be agreed between parties • Assumes that all the UC demonstration will be developed in real case conditions (local in-stallation), but in case some demonstration is not possible to be done in reality, it will be simulated • Assumes that the CapWatt Cloud data monitoring system has the necessary information/monitoring of the HESS and building everyday
Prerequisites

- During the period of agreed demonstration, the HESS needs to be controlled according to the control recommendations provided (in the time window to be defined) in order to verify the metrics of cost and lifetime extension impact.
- The operational data of the batteries can be retrieved and exported to a database to be made available for the connected data spaces

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases

Level of depth
High level diagram of the use case (HL-UC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution
Prioritisation
High level
Generic, regional or national relation
Generic
Nature of the use case
Business use case
Further keywords for classification
Flexibility, forecast, interoperability, optimization, incentives, data spaces

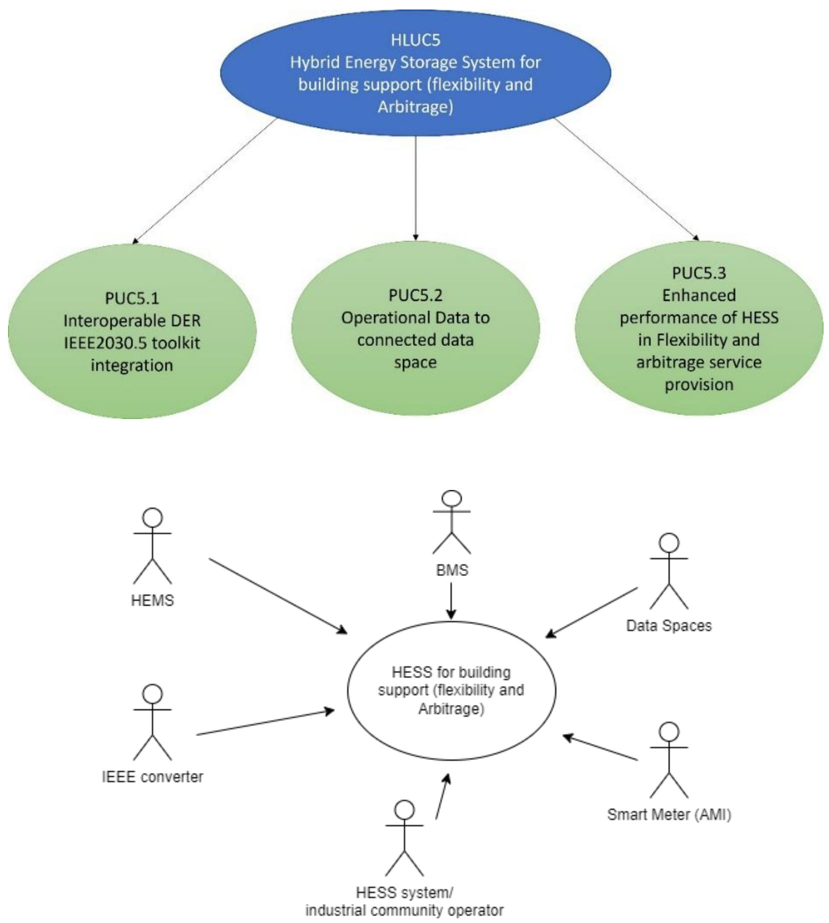
1.8 General Remarks

General Remarks
The methods and algorithms described in this section are solely software functions that can be embedded in the Energy Manager of InescTec or of HessTec (which can be, for example, a cloud where the measured data is securely stored). It is important to guarantee a standardized data structure for the information exchange between assets and the BMS and middle layer where the EMS pre-processes the measured information before being available to the optimization/control functions.

The use of the smart meter is also a crucial point that should be guaranteed before the integration phase. The meter should be a gateway to get electrical energy consumption measures.

2 Diagrams of use case

Diagram(s) of use case
HLUC-PUC Relation Diagram



<u>HLUC Sequence Diagram:</u>

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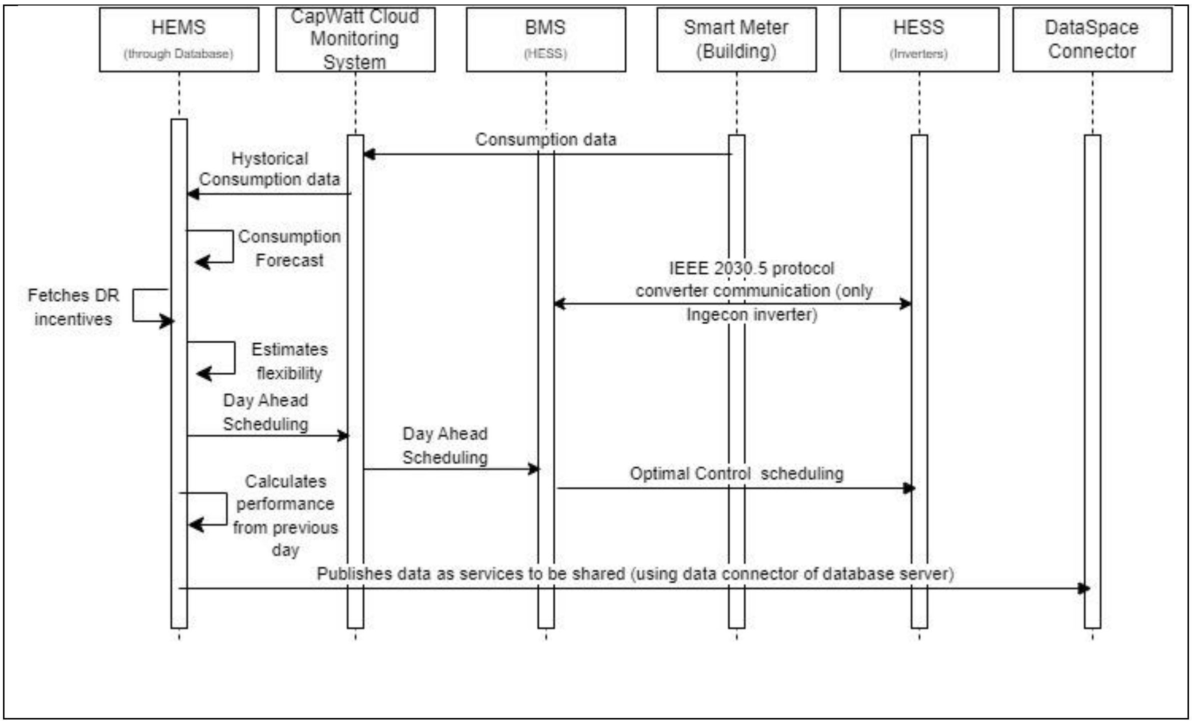

3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
BMS – Battery Management System-Local	System	Battery management system for the batteries, that is part of the HESS
HESS Hybrid Energy storage System	System	Hybrid Storage system composed by two batteries, inverters, the BMS, and all auxiliary systems (fire detection and extinction), telecommunications, etc.
Smart Meter	Device	Authorized communicating device responsible for registering energy consumption with a 15 min time step reporting period.
HEMS	System	Backend of InescTec Home energy management system, which collects information from different sources storing it in a database. Its capable of load optimization, forecast and flexibility estimation and recommendations according to external incentives. In InterSTORE it will incorporate the battery and HESS management features like cost minimization and degradation.
IEEE converter	Device	IEEE legacy protocol converter. Physically it will be based on a IOTMAx or equivalent hardware device loaded with a software converter protocol
Data Space connector	System	Internet connected Software enabling peer-to-peer file and service sharing

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Standard	IEC 62559-2 Use Case Methodology	Published	Definition of the presented template	International Electrotechnical Commission	
2	Standard	IEEE2030.5	Published	Provision of possible actors and roles	IEEE	
3	OneNet Connector	Deliverable 6.1	Published	Clarification of the connector's deployment and functioning	OneNet H2020 project Deliverable	
4	Spreadsheet Document	InterSTORE KPI List		Provision of KPIs to be included	InterSTORE internal document	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Using Building data to operate HESS with higher performance	The HEMS computes the consumption data and based on environmental incentives it scheduled the HESS to operate minimizing the cost of supply to the building while minimizing the degradation. The metrics are estimated already by the model.	HEMS	Data gathering from the building from the CapWatt cloud data monitoring system	There is an historical amount of data that enables the scheduling of the batteries to charge and discharge and this is followed	A quantifiable measure of performance such as cost and degradation should be achieved if the schedule is followed
2	HESS integrating IEEE2030.5 in success mode of operation	HESS Ingecon inverter sends operational variables through the IEEE 2030.5 connector and the BMS receives them in the expected format, time and conditions for seamless operation	HESS	Messages are exchanged via de IEEE converter	The converter is successfully deployed in the inverter and BMS	All set variables are exchanged without disruption
3	HESS Operational data	The operational data from the HESS will be made available as services	HEMS	Data Variables are published in	Successful deployment of the	The success of this scenario will

	shared via Connected data space	published in the connector interface. This data can be accessed by authorized subscribers. The provision of data means the successful deployment.		the connector platform as services and subscribed by users	connector in a server machine where a data base with Capwatt information is installed hosting the data	be observed with the correct data retrieval of a service by a connector subscriber
4	No higher performance of operation achieved.	The HEMS computes the consumption data and based on environmental incentives it scheduled the HESS to operate minimizing the cost of supply to the building while minimizing the degradation. The metrics are estimated already by the model.	HEMS	Data gathering from the building from the CapWatt cloud data monitoring system	There is an historical amount of data that enables the scheduling of the batteries to charge and discharge and this is not followed	The schedule is not followed and for that day the higher performance of operation in terms of cost and degradation cannot be assured and considered cumulatively
5	HESS integrating IEEE2030.5 does not operate successfully	HESS Ingecon inverter sends operational variables through the IEEE 2030.5 connector and the BMS does not receive some or all variables in the expected format, time and conditions ensuring seamless operation	HESS	Messages are not capable of being exchanged via de IEEE converter	The converter is successfully deployed in the inverter and BMS	Not all set variables are exchanged and operation of the HESS is compromised
6	HESS Operational data not able to be shared via Connected data space	The operational data from the HESS cannot be published as services, shared and data cannot be provided	HEMS	Data Variables and operational data is available to be shared but the connector platform is not correctly deployed or working	Data base with Capwatt information is installed hosting the data but cannot be shared via the connector	No subscriber can consume data or even see it published as a service.

4.2 Steps – Scenarios

Scenario								
Scenario name:		*No. 1, 2 and 3*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
	Event that triggers the step	Action verbs should be used ("Fault occurs in the grid")	Interaction and info flow between actors of this step	Create, get, change, delete, cancel, close, execute, report, timer, repeat	Smart Meter Building	HEMS	Info exchange (to be replaced by a ID SP1,2,3,4 etc and detailed in section)	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2; R-DM.1; R-DM.3, R-DM.4, R-DM.5,
1	Daily load profile complete	Load profile is sent	The building 4A dedicated meter will report periodically the electricity load consumption daily profile	Report	Building Smart Meter	CapWatt cloud data monitoring system	SP-1 (load consumption)	R-CONF.1, R-CONF.2,
2	Daily load profile and HESS operation complete	Building Load profile and HESS operational data are sent	The CapWatt cloud data monitoring system will send the daily electricity load profile of the previous day to HEMS (via a database). (The first time it does so, it provides a full year dataset for training purposes (happens once offline)	Report	CapWatt cloud data monitoring system	HEMS (InescTec database)	SP-1 (load consumption)	R-CONF.1, R-CONF.2, R-SEC.3, R-SEC.4, R-DM.2, R-DM.3, R-DM.5

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3	Has consumptio n historical dataset	Runs a forecast algorithm	Based on the historical consumption of the building, weather forecasts and other attributes collected from third party services, the HEMS runs a consumption forecast for the following day	Execute	HEMS ad external third party services	HEMS	SP-2 (load consumption forecast)	R-DM.2
4	Fetches Eco incentives	Receives DR incentives	The HEMS receives third party information regarding implicit DR incentives corresponding to gCO2/kWh dataset for the following day	Execute	HEMS ad external thirdparty services	HEMS	SP-3 (DR Eco incentives)	R-CONF.1, R-CONF.2, R-DM.2
5	Has eco signal and baseline forecast	Estimates flexibility potential and load optimization	Given a baseline which is the load forecast and the incentive data for the following day the HEMS runs an estimation of the flexibility potential by optimizing the load operation. This load operation adjusts the schedule of the batteries to supply the building with energy ensuring the building load indirectly follows the DR scheme	Execute	HEMS	HEMS	SP-4 (Load scheduling)	
6	Load optimization estimation process completed	Sends load scheduling	The HEMS send the load optimization schedule to Capwatt cloud data monitoring system.	Report	HEMS	Capwatt Cloud data monitoring system	SP-4 (Load scheduling)	R-CONF.1, R-CONF.2, R-SEC.3, R-DM.3, R-DM.5
7	Gets optimization estimation	Sends load scheduling	The Capwatt cloud data monitoring system creates a new entry (or changes/updates the existing one) in the BMS for the load optimization schedule for the HESS for the next day	Create	Capwatt Cloud data monitoring system	BMS	SP-4 (Load scheduling)	

8	Gets optimization estimation	Sends load scheduling	The BMS executes in the HESS the load optimization schedule for the HESS for the next day	Executes	BMS	HESS	SP-4 (Load scheduling)	
9	IEEE2030.5 is deployed and working	Communication of commands and variables runs over NATS	The IEEE2030.5 is deployed and the Ingecon and BMS devices/systems can communicate and exchange information seamlessly	Executes	BMS	HESS	SP-5 (set of HESS operational data)	R-CONF.3
10	Gets previous day daily profile update and HESS operational data	Calculates/verifies performance from previous day flexibility/HESS activation	The HESS calculates the metrics related to cost and degradation and consumption of the building verifying HESS activation and adds to a cumulative counter the avoided degradation and costs	Execute	HEMS	HEMS	SP-6 HESSPerformance metrics	R-DM.1
11	Step 2 triggers it. Having load and operational data of the HESS	Shares HESS operational data via the connector in the Data base server machine	The database server machine hosting the connector, updates the data of the services it had published the first time (done once) with the new data from that day.	Changes	Data Base server machine (supported by HEMS)	Data Space connector	SP-5 (set of operational data)	R-CONF.1; R-SEC.1, R-DM.5

Scenario								
Scenario name:		***No. 4***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***

10	Gets previous day daily profile update and HESS operational data	Verifies that the HESS schedule was not followed and is not able to cumulative add the cost gains and degradation avoided	The HEMS is not able to verify that the HESS was scheduled according to the recommendations and is unable to process the cumulative avoided costs and degradations due to the HESS operation	Repeat	HEMS	HEMS	SP-7 Performance metrics not updated	

Scenario								
Scenario name:	***No. 5***							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
9	HESS communication using IEEE2030.5 does not operate successfully, (error in response time, no reaction or patrial data loss)	Loss of communication	HESS Ingecon inverter sends operational variables through the IEEE 2030.5 connector and the BMS does not receive (or the other way round) some or all variables in the expected format, time and conditions ensuring seamless operation. It verifies loss of communication	Cancel/Report	BMS	HESS	SP8- Operational error	

Scenario								
Scenario name:		No. 6						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
11	HESS Operational data not able to be shared via Connected data space	Error occurs when sharing data using the connector	The operational data from the HESS cannot be published as services, shared and data cannot be provided.	Cancel/Report	Connector	Connector	SP9-Connector error	

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
SP-1	Load consumption	Daily electricity load profile with power in kW and time step of 15 minutes	R-CONF.1, R-CONF.2, R-SEC.3, R-SEC.4, R-DM.2, R-DM.3, R-DM.5
SP-2	Load consumption forecast	Daily electricity load profile forecast for the following day with power in kW and time step of 15 minutes. The forecast will serve as the baseline	R-DM.2
SP-3	DR Eco incentives	Data set containing CO2/kWh during the hours of a specific day on at least an hourly basis	R-CONF.1, R-CONF.2, R-DM.2
SP-4	Load scheduling	Data set containing a day-ahead time series for the HESS operation with discharging and charging intervals with power and time of activation.	R-CONF.1, R-CONF.2, R-SEC.3, R-DM.3, R-DM.5
SP-5	set of HESS operational data	Data corresponding to HESS operation such as cycle number, State of charge, operating hours, charge/discharge power rate and times, wear out, degradation, maintenance events, Capex, operational costs, voltage, current.	R-CONF.3, R-CONF.1; R-SEC.1, R-DM.5
SP-6	HESS performance metrics	Total Cost of energy consumed by the load (building) from HESS, Grid, PV and Degradation from HESS after a working day with the registry of confirmed activation day of the HESS following recommendations. Both compared to a baseline of a single lithium battery. Both cost and degradation will add to corresponding cumulative variables of "total cumulative cost" and "total cumulative degradation"	R-DM.1
SP-7	Performance metrics not updated	Cost and Degradation remain the same. Cumulative values remain the same. A message saying "no operational values to update. And no daily operating registry will be observed.	
SP-8	IEEE 2030.5 Converter Operational Error	Error of communication between the Ingecon inverter and the BMS	
SP-9	Data Space Connector Error	Error in the connector interface or backend implementation informing that there was an error in consuming data.	R-DM.3, R-DM.4, R-DM.5

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
CONF	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communications types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable. It includes: - information exchanged with external entities (e.g. service provider, weather data provider, etc.) - information related to the electricity tariff scheme in current use (e.g., variable price and fixed price components). The includes both consumption and generation tariff information. - information related to the weather conditions for the next day/hours to be used by the optimal scheduling methodology to include the local generation. - all the characteristics and configuration parameters related to the use of devices by the HEMS to produce an optimized schedule - all the configuration parameters related to the user preferences in the production of an optimized schedule - the requirements for the information presentation to the end-user - the communication solutions the data models used.

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DM	Data Management	Covers both the management of the data exchanges in each use case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions. It should not address database design but should concentrate on the user requirements for the interfaces to databases and other data handling applications. It includes: - all the metering data related with the house consumption and, if applicable, local generation. This information can be obtained by a central metering equipment, like a DSO smart meter or a user electric panel meter. It can also be obtained through distributed meters from electric panel meters, smart plugs or directly from a smart device/system. - the requirements related to the storage of information locally and remotely to the HEMS a structured access to data related to devices and user preferences
SEC	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable. Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors. At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures. Includes all the security related requirements to allow data between devices, systems and entities to be exchanged in a trustworthy way.
Requirement R-ID	**Requirement name**	**Requirement description**
R-CONF.1	Communication access services requirements	Provides access to the HEMS platform remotely to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities like the availability of DNS lookup, security credentials, firewall configurations, etc.
R-CONF.2	Data exchange methods	Defines the way data is exchanged between different parties (devices, systems, entities)
R-CONF.3	Existence of legacy systems	Addresses the necessary changes (quantification of the effort) and adaptations necessary to the equipment as related devices to accommodate the integration of legacy systems.

R-CONF.4	Operation mode of Information Receiver	Defines if the target device is operating in manual or automatic mode
R-CONF.5	Operation mode of Information Producer	Defines if the source device is operating in manual or automatic mode
R-SEC.1	Authentication: Masquerade and/or spoofing - Ensuring that data comes from the stated source or goes to authenticated receiver is:	Warrants protected access to the a platform locally to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities, security credentials, firewall configurations, etc.
R-SEC.2	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Guarantees the conformity of all the data exchange between the HEMS and its service providers
R-SEC.3	Authentication and Access Control mechanisms commonly used with this data exchange	Requires authentication and/or encryption of the data exchanged between the HEMS, dataspace connector or CapWatt Cloud and internal building devices as well as with external systems (e.g., from service providers). Key encryption, certificates and other access control mechanisms are necessary.
R-SEC.4	Network security measures commonly used with this data exchange	Establishes communication network separation (including physical one) and the firewall control list to allow external access to the database.
R-DM.1	Correctness of source data	Ensures that the data is correctly interpreted and used for the purpose it was designed to.
R-DM.2	Management of accessing different types of data to be exchanged	Sets the type of data being exchanged and the expected periodic update (asynchronous or every x time). This is applicable to data exchange internally (e.g., with local database) in the HEMS, with the CapWatt clous and with other devices and systems external to the building.
R-DM.3	Validation of data exchange	Guarantees that data exchanged between parties (devices, systems, entities) is valid. It can provide confirmation to originally sending party.

R-DM.4	Management of data across organizational boundaries	Defines the necessary changes and adaptations to the data exchanges across the building boundaries, between the HEMS and other external systems.
R-DM.5	Data format requirements	Sets specific formats for the data exchange between devices, systems and entities (Data space connector, HEMS, CapWatt clous etc). The following formats are required to be supported by the HEMS: standard computer formats (e.g., binary, integers and floating pt, files); Serial transfer formats (e.g., DNP, Mobdus, LonTalk, BACnet); Graphics formats; Mark-up based HTML, XML; Human readable CSV and JSON; etc.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
CONF	Configuration
DR	Demand Response
BMS	Battery Management System
DM	Data Management
HEMS	Home Energy Management System
HLUC	High Level Use Case
LV	Low Voltage
HESS	Hybrid Energy Storage System
SEC	Security
UC	Use Case

HLUC06 - Management of battery system for Node capacity increase and user DR

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
HLUC06	Area: Energy Systems Domain: DER Zones: Process, Field, Station, Operation	Management of battery system for Node capacity increase and user DR

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	13.03.2023	INESC TEC	Initial definition of the use-case characteristics
0.2	27.04.2023	INESC TEC	Added KPIs and actor mapping
0.3	02.06.2023	Capwatt	Scope and Narrative, KPIs and all except from detailed info revised
0.4	14.06.2023	INESC TEC	Scenarios, message exchange definition and requirements

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The use case aims to demonstrate the increase in Node power of the internal electric network of a parking lot, next to a hub of electrical vehicles charging station (due to upstream infrastructure limitation), by installing an energy storage system on that grid node. If a charging simultaneity that exceeds the present power limits occurs, the battery will ensure the additional capacity. It will also consider the consumer engagement element requested in the call, shown by implicit DR incentives, for example, where users receive an environmental signal in CO2/kWh to deviate from their baseline (forecast part of InescTec backend). The deviation assessment (flexibility) and the verification of the baseline deviation will also be calculated in the backend by InescTec's EMS.
Objective(s)	Objectives: 1) Increase local electric node capacity by using power supply from a local ESS 2) To demonstrate implicit DR for a virtual capacity of EVs batteries by ecological signal. 3) Evaluate user acceptance and engagement, by reaction to the incentive.

HLUC06 – Management of battery system for Node capacity increase and user DR

Related business case(s)	HLUC 5: Hybrid storage higher performance and flexibility provision

1.4 Narrative of use case

Narrative of Use Case
Short description
At a parking lot in the Sonae Campus site, there is a set of EV chargers whose total power exceeds the upstream board and cable power capacity, or in some cases with a high simultaneity factor. Installing and using a local ESS, expected to be around 40-50kW, it will enable the simultaneous operation of the chargers and even install others surpassing, as a whole, the upstream installed power at the moment. Included in this Use Case, is also defining a set of EV users that typically charge in that parking lot and share with them an incentive schedule for implicit demand response, based on an environmental signal.
Complete description
This use case will be demonstrated in the Sonae Capital car parking lot where there is currently already a set of EV chargers installed. This UC aims to demonstrate how an ESS can contribute to the increase of the power capacity for short periods, of the parking lot node according to the needs, enabling the operation of power demands above the upstream power limitation of the installation. This can avoid the refurbishment and investment in infrastructures, by increasing the capacity of upstream cables, electrical boards, transformer etc… The controlling system of this UC shall be able to analyze the load of the board, the load of the chargers and the ESS condition status, in order to provide information for limit power of each EV charger. Historical data will be used to create baselines and train the forecast model. It will also be analyzed and demonstrated in this UC the consumer engagement regarding implicit DR incentives, for example, where they receive an environmental signal in CO2/kWh to deviate from their baseline (forecast part of InescTec backend). The deviation assessment (flexibility) and the verification of the baseline deviation will also be calculated in the backend by InescTec' EMS. The incentives will be made available to the consumer for the demonstration purposes, such as integrated in the App already in use, direct message, in the company's intranet or making use of informative screens in the campus. The current HLUC includes the following steps: 1. USER SELECTION AND SURVEY The users will be identified and approached by Capwatt, owner of the Portuguese pilot. The number of users should ideally, include frequent users of the charging infrastructure selected for the demonstration and under monitoring (to be defined). The users will provide consent to their participation and be informed of what is expected from them from the demonstration. Initial feedback will be collected regarding expectations for the demos, restrictions, and preferred communication channel. A survey at the end of the demo will also be conducted to understand challenges, acceptance of DR schemes, recommendations, and insights on engagement. Information from each user card will be made available for each session to monitor energy consumption and timings, for DR verification. 2. INSTALLATION OF THE ESS AND BMS An ESS will be installed in the same network node as the electrical switchboard that connects to the electric vehicle chargers in the selected location. This ESS will have to be charged in periods when the consumption power is lower than the power currently installed and discharged when there is a need for more power than available in the board, by consumers (EV chargers). This management will be guaranteed by the battery EMS/BMS, which will communicate with the local meters at the main metering points for on-time definition of the power values and maximum load of EV chargers. 3. MONITOR ENERGY CONSUMPTION

The energy consumption information of the total upstream installation will be monitored. Also the information from the demo users and its session details will have to be identified, to pin down the events with the analysis of the incentives impact. This information will be shared with InescTec HEMS

4. FORECAST

Based on the historical data of the charging events, a machine learning ML model will forecast the consumption for the following day and establish a baseline.

5. FLEXIBILITY ASSESSEMENT

The HEMS of InescTec will be able to receive two signals. One for implicit DR based on an environmental signal in gCO_2/kWh, or similar, and another one (be at least ready) to receive explicit DR signals from a system operator.

6. DR SIGNAL AND DISPATCH COMMUNICATION

The EMS of INESCTEC will provide information about the preferred periods for the EV charging to occur. It will be decided the best way to do it, according to the systems available, if possible, using users' smart phone/intranet/campus screens, or other option.

7. FLEXIBILITY PROVISION EVALUATION

An analysis about the consumption of the EV users will be developed, in order to define a baseline forecast (provisional profiles). This will enable the identification of the user participation and the flexibility provision according to the signals provided.

8. COMPARATIVE FINANCIAL STUDY FOR A TYPICAL INFRASTRUCTURE UPDATE OF STEP 2

At the end, a study/report comparing the installed solution with an infrastructure update solution capable of generating the same results, should be made.

1.5 Key performance indicators (KPI)

ID(*)	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI3	Battery capacity	Amount of Flexibility provision in the demos from HESS	2
KPI4	Diversity of DER	Number of different DER devices successfully tested and demonstrated	1
KPI5	Asset management monitored by EMS	Number of assets monitored by the InterSTORE EMS solutions	2
KPI7	N° of end users involved in HESS	N° of end users (workers, EV users, consumers) engaged in the demonstration of interoperable HESS	2
KPI20	User Engagement	Improved acceptance and perception by end users (surveys at start and end of demo)	(3)
KPI21	Demand Response amount	Amount of flexibility provided (measured in kWh). Amount of kWh resulting from shift from baseline (forecast consumption)	(3, 2)

KPI22	Node power surpassed time	Time (in minutes) in which the power demand was higher than the upstream capacity, by using the battery support for that increase.	(1)
KPI23	Node power increase percentage	Maximum percentage of Power surpassing the installation's capacity due to the use of the battery to charge the EVs	(1)
KPI24	User participation	Percentage of users (being monitored) actively following the DR incentive. Actively meaning that they follow the incentive (deviate from past behaviour) on the majority of days during the demonstration	(3)
KPI25	Integrated capacity	Integrated power of the HESS within the project demos	1
KPI26	Increase of flexibility	Demand side flexibility potential increase due to hybridization implementation	1

(*) The ID number is based on the project KPI reference list

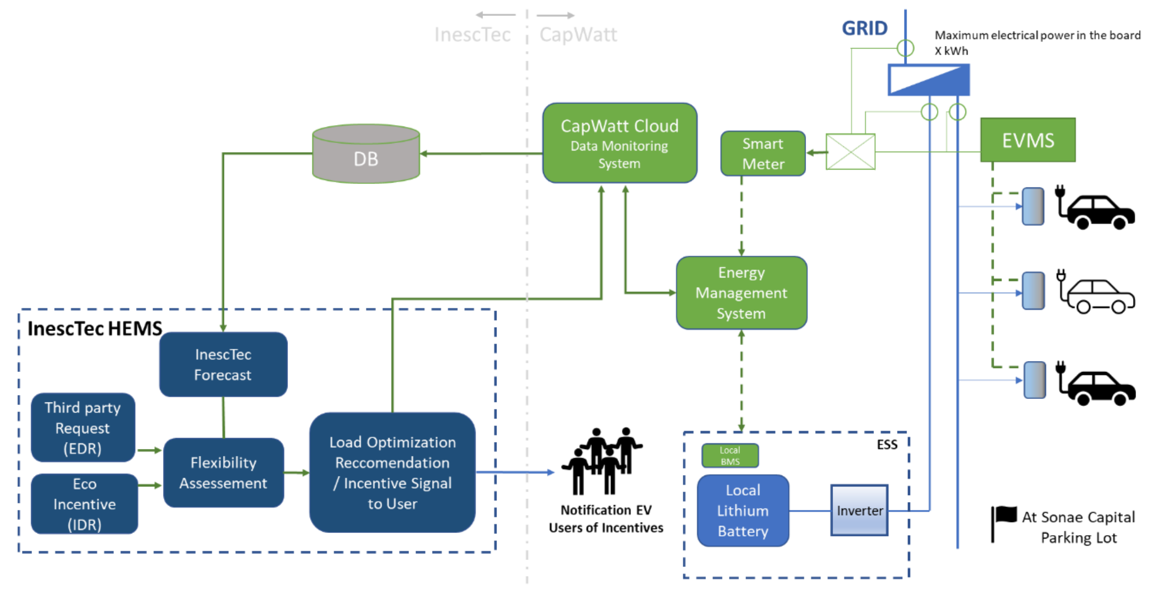
1.6 Use case conditions

Use case conditions
Assumptions
• EV users will receive and check the DR incentives, and are aware of what they mean • Access to the parking lot consumption load diagram disaggregated. • The charging session of the EVs, will have to be matched with the specific users participating in the demo, • EV users have a smartphone and are willing to receive the DR incentives, or other type of method to receive the information, • The EMS is connected to the LV general supply board and is able to support the demand from the EVs. The EMS is controlled by a local BMS.
Prerequisites
• EV chargers' local consumption is monitored • EV users participating in the demo need to be identified for each charging session during the demo period • The ESS will be operational and connected to the parking lot busbar •

1.7 Further Information to the use case for classification / mapping

Classification Information
General Architecture

HLUC06 – Management of battery system for Node capacity increase and user DR



Level of depth
High level use case (HL-UC) use case which describes a general requirement, idea, or concept, independently from a specific technical realization like an architectural solution
Prioritisation
High level or priority
Generic, regional or national relation
Generic
Nature of the use case
Business use case
Further keywords for classification
Consumer engagement, tariffs, incentives, demand response, electric vehicles, Battery system, node capacity

1.8 General Remarks

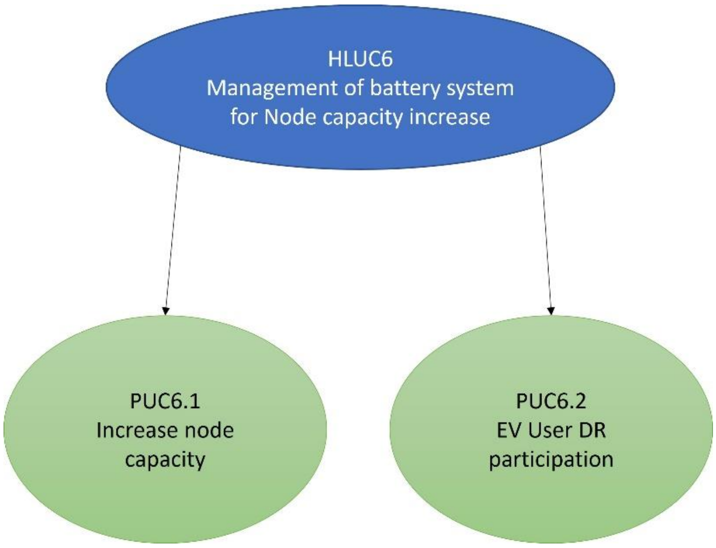
General Remarks
The methods and algorithms described in this section are solely software functions that can be embedded in Energy Manager of a BEMS (Battery Energy Systems) or part of InescTec' HEMS backend functions. It is important to guarantee a standardized data structure for the information exchange between the EV chargers, the meters ("smart", with ModBus communications) and the EMS system that will control the ESS on real-time. The EMS will be responsible to share that information with Capwatt. The integration with the smart meter is also a point that should be analysed before integration phase. The meter should be a gateway to get electrical energy consumption measures. The effectiveness of the incentive communication to the consumers should be assessed when implementing the Use case. Reduce the effort to receive information but adjusting the effort to the use case implementation.

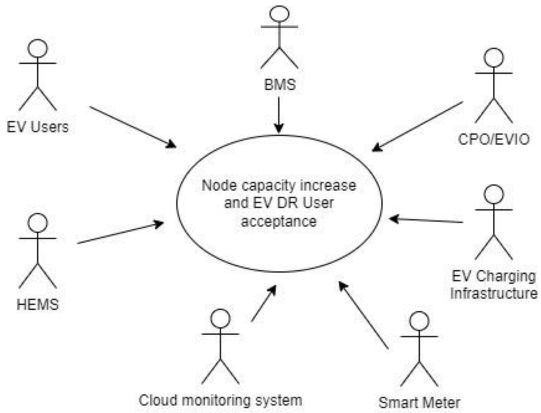
2 Diagrams of use case

Diagram(s) of use case

HLUC06 – Management of battery system for Node capacity increase and user DR

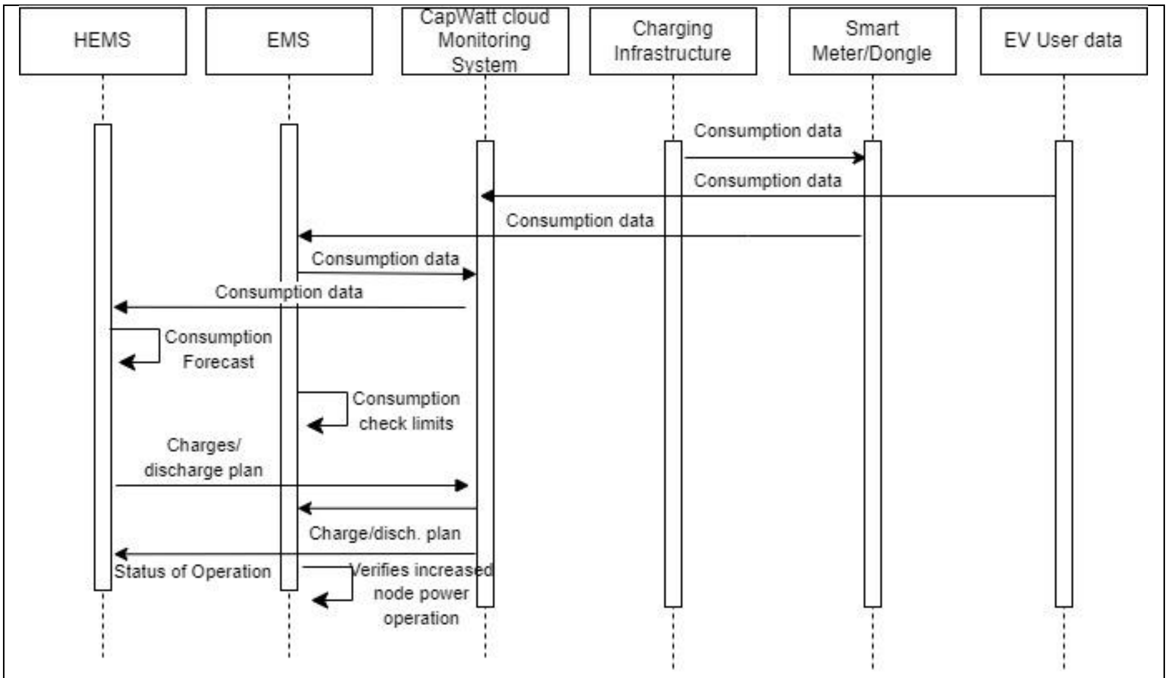
HLUC-PUC Relation Diagram



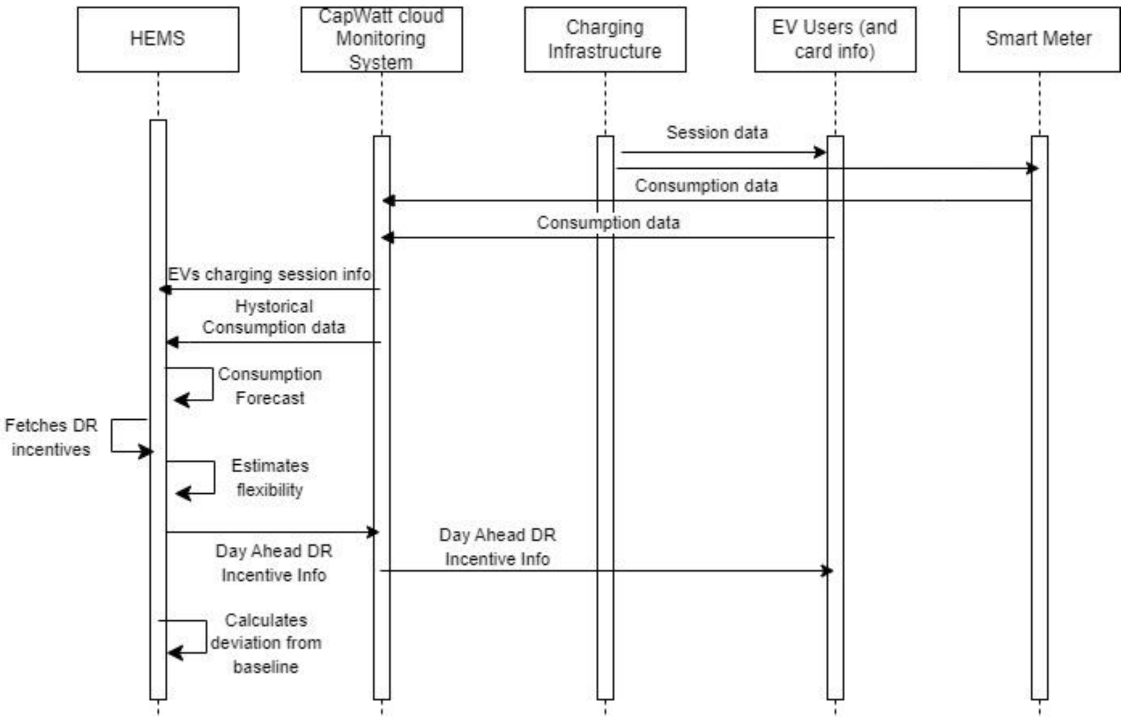


<u>PUC 6.1 General Sequence Diagram:</u>

HLUC06 – Management of battery system for Node capacity increase and user DR



PUC 6.2 General Sequence Diagram:



3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
EMS	System	System that controls the charge and discharge of the battery according to third party recommendations and local limitations and requirements
Home Energy Management System	System	Energy management system for energy customers to optimize the utilization of energy according to supply contracts or other incentives. Is responsible for gathering flexibilities within the customer premises, provide incentive based complementary scheduling for the batteries and incentive info for the users.
EV User (User)	Role	User of an electric vehicle that charges in the location under analysis owner of a unique card from which the charging session can be identified.
Electric Vehicle charger infrastructure	Device	Electric vehicle charging infrastructure that has several charges and modes of charging.
Cloud data monitoring system	Role	Entity providing data to EMS and HEMS so that processing can take place and DR, scheduling, forecasting can be achieved.
Smart Meter	Device	Device capable of registering metering data of electricity consumption, capable of exporting that data in an aggregated way with a time step of 15 minutes.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
1	Standard	IEC 62559-2 Use Case Methodology	Published	Definition of the presented template	International Electrotechnical Commission	
2	Document	InterSTORE KPI reference list		Provision of KPIs to be included		

4 Step by step analysis of use case

4.1 Overview of scenarios

HLUC06 – Management of battery system for Node capacity increase and user DR

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Increase local electric node capacity by using power supply from a local ESS	Making use of the local BESS, the parking lot will enable higher simultaneity, hence power, of EV charging operation, using the energy and power of the charged battery.	EV charging infrastructure	Power limit being reached in the parking lot meter	There is energy stored in the battery	Battery will be discharged and if higher power is still required, it will not be met.
2	Demonstration and assess of implicit DR for a virtual capacity of EVs batteries by ecological signal.	Users will receive an implicit DR incentive with an ecological signal to shift their consumption to the most favourable hours	EV Users	Information sent to the EV Users with incentives for most favourable charging hours	EV users see and act consciously	There is a change regarding the baseline
3	No increase in node capacity	Higher than the limit power capacity is requested by the EV infrastructure but the battery in unable to provide sufficient power/energy	EV charging infrastructure	Power limit is surpassed	Battery does not have energy	EVs connecting at a later stage will not be charged

4.2 Steps – Scenarios

Scenario								
Scenario name:		*No. 1*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1	Continuous monitoring	EV chargers provide energy consumption information	A dedicated meter will register all the consumption of the EV charging infrastructure. It does so as any normal meter, monitoring continuously the power and with time records the energy.	Report	EV Chargers	Smart Meter	SP1 – Aggregated load diagrams from EV charging infrastructure	R-CONF.2, R-DM.2
2	EV Charging event registered by a card	The EV card system sends the session log file	The EV users charge their cars by tapping an individual card (allocated to an individual car and user). Every session information is sent to the Capwatt cloud system.	Report	EV user card	Capwatt cloud data monitoring system	SP2- Individual EV user load consumption (per EV user per session)	R-CONF.2, R-SEC.3, R-DM.5
3	Smart Meter, gets information from the charging infrastructure	The meter sends aggregated load data do the EMS	The Smart Meter sends the information of the Aggregated load consumption diagrams from the EV charging infrastructure with the EMS, that checks if the power limits are being approached to assess the need of the BESS activation	Report	Smart Meter	EMS	SP1	R-CONF.2, R-DM.2, R-DM.5
4	Receives data from the BESS and Meter	Sends operations data from the BESS and charging infrastructure	The EMS, shares the data it receives from the smart meter and its decisions regarding the BESS activation and operational data with the CapWatt Cloud	Report	EMS	CapWatt Cloud system	SP1 SP3 – Operational Data from the BESS	R-CONF.1, R-CONF.2, R-DM.5

HLUC06 – Management of battery system for Node capacity increase and user DR

5	End of day of data collection from systems	The Capwatt cloud sends data to the HEMS	Every day The Capwatt cloud send aggregated and disaggregated data from the chargers and operational data from the BESS. The historical data for a full year is sent once for training the forecast model)	Report	Capwatt Cloud	HEMS	SP1 SP2 SP3	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.2, R-DM.5
6	Receives data from the CapWatt Cloud monitoring system	Performs the forecast of the consumption	Based on the historical data of the charging infrastructure and EV sessions, the HEMS performs a forecast for the next day	Execute	HEMS	HEMS	SP4 - Load forecast of the EV charging	R-DM.5
7	Gets information about consumptio n	Checks limits of power for battery activation	The EMS checks every time the load limits to accept or reject the dispatch plan and to activate deactivate the BESS	Execute	EMS	EMS	SP1	
8	Gets info for forecast and scheduling	The HEMS shares dispatch plan for the BESS with the EMS	Based on the power limitations and simultaneity of EVs the algorithm chooses the best moments to charge/discharge the battery and sends it to the CapWatt Cloud monitoring system	Report	HEMS	Capwatt Cloud	SP4 – dispatch plan for the BESS	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.2, R-DM.5
9	Needs to get the info from the HEMS	Send the dispatch plan to the EMS	The Capwatt Cloud monitoring system send the dispatch plan to the EMS to be accepted or rejected according the actual real time observations.	Report	Capwatt Cloud	EMS	SP4 – dispatch plan for the BESS	R-CONF.2, R-SEC.3, R-DM.5
10	Needs operation data from the BESS provided by the EMS	Sends BESS status and operation	HEMS gets information from the CapWatt cloud system and is able to verify the node power increase and compute KPIs regarding power surpassed and time.	Report	Capwatt Cloud	HEMS	SP5 – Send data regarding number of activations, SOC, charge discharge profiles	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.2, R-DM.5

11	Needs information from the BESS	Verifies that the Node capacity has been increases	EMS is able to verify the node power increase and compute KPIs regarding power surpassed and time per each day.	Execute	EMS	EMS	SP6- Node increase capacity is verified	

Scenario								
Scenario name:	***No. 2***							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
1	Charging session event	Individual profile of the charging session is created	Each charging session is recorded in each EV user card account. A log file is created	Create	Charging Infrastructure	EV user card	SP7- Individual charging session load profile	R-CONF.1, R-CONF.2
2	Continuous monitoring. Creates completes dataset at the end of the day	EV chargers provide energy consumption information	A dedicated meter will register all the consumption of the EV charging infrastructure. It does so as any normal meter, monitoring continuously the power and with time records the energy.	Report	EV Charging infrastructure	Smart Meter	SP1 – Aggregated load diagrams from EV charging infrastructure	R-CONF.2, R-SEC.3, R-DM.2
3	End of day Gets a complete daily dataset	Send daily dataset of load profile to the CapWatt cloud	The aggregated data of the charging infrastructure is received by the CapWatt cloud	Report	Smart Meter	CapWatt cloud system	SP1 – Aggregated load diagrams from EV charging infrastructure	R-CONF.2, R-DM.2, R-DM.5

HLUC06 – Management of battery system for Node capacity increase and user DR

4	EV card Log files are created	Sends disaggregated data to the CapWatt cloud	Each individual charging session with a card ID is sent to the CapWatt cloud	Report	EV Users card	CapWatt cloud system	SP7- Individual charging session load profile	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-DM.5
5	Gets users log files	Sends ID users card daily log files	The CapWatt cloud sends Individual charging session load profile per ID card user every day	Report	CapWatt cloud system	HEMS	SP7	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.5
6	End of day if it got the aggregated profiles	Sends load profile of charging infrastructure	The aggregated data of the charging infrastructure is sent to the HEMS	Report	CapWatt cloud system	HEMS	SP1	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.5
7	Has individual consumption data	EV charge forecast	The individual EV consumption forecast algorithm is run for the day ahead. The training data is received once for training.	Execute	HEMS	HEMS	SP8 – Individual EV consumption forecast	
8	Has the forecast for the following day	Gets DR incentives	The HEMS gets the forecast data of gCO2/kWh for the following day, to be used as an incentive for DR	GET	HEMS	HEMS (third party platform)	SP9- Incentive data set for day ahead	
9	Has incentives	Processes flexibility from EVs	Based on the incentives and the baseline (forecast of consumption) this step is able to assess the potential shift if the incentive schedule is followed	Execute	HEMS	HEMS	SP10- Flexibility estimation of EVs	
10	Has received the DR incentives from the HEMS third party service	Sends DR incentives	The HEMS sends the implicit DR incentives based on gCO2/kWh for each hour of the following day	Reports	HEMS	CapWatt Cloud system	SP9- Incentive data set for day ahead	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.2, R-DM.5

11	Has received the incentive table and end of day is reached (around 23h)	Sends day ahead data with DR incentives	The incentive schedule is shared with the EV Users for them to shift their forecasted consumption. The info is displayed in a campus resource starting late at night of the previous day, such as screens, intranet or personal accounts (sms, email) in the morning or late night day ahead.	Report/changes	CapWatt Cloud system	EV Users	SP9- Incentive data set for day ahead	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.2, R-DM.5
12	Gets previous day EV session information	Calculates deviation from baseline of previous day	Given the actual consumption of the previous day, the HEMS is capable of comparing the baseline profile with the actual consumption profile and estimate the difference from the DR (taking into account the accuracy of the forecast model)	Execute	HEMS	HEMS	SP10 – Effective DR (Load consumption deviation from baseline)	

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
SP-1	Aggregated load diagrams from EV charging infrastructure	The Information refers to the aggregated data set of the EV charging profiles under the same point of common coupling. The meter records all the consumption of the infrastructure, with power, time and energy.	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.2, R-DM.5
SP-2	Individual EV user load consumption (per EV user per session)	The info corresponds to the load diagrams log file of individual users per each EV charging session. This is possible to obtain due to the identification of the charging session by using an individual card to start/end the session.	R-CONF.2, R-SEC.3, R-DM.5
SP-3	Operational Data from the BESS	Data provided by the BESS local BMS, corresponding to operation data with several variables such as Soc, current, voltage, power, times, cycles.	R-CONF.1, R-CONF.2, R-DM.5
SP-4	Dispatch plan for the BESS	Time series with the activation, deactivation plan of the BESS, with the corresponding power and timings of operation.	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.2, R-DM.5
SP-5	EV Data regarding capacity, number of activations, SOC, charge discharge profiles	EV data set assigned to an individual card containing details about capacity, number of activations, SOC, charge discharge profiles	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.2, R-DM.5
SP-6	Node increase capacity verified	The surpassed power due to the BESS support of the charging infrastructure in amplitude and time each day	R-DM.5
SP-7	Verified Individual charging session load profile	Actual charging session took place, deviated from the baseline	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.5
SP-8	Individual EV consumption forecast	Load profile of an individual EV forecasted for the following day.	R-DM.5
SP-9	Incentive data set for day ahead	Time series for the following day with values of gCO2/kWh for each hour of the day. (lower is better)	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.3, R-SEC.4, R-DM.2, R-DM.5
SP-10	Effective DR (Load consumption deviation from baseline)	Effective energy estimation calculated from the difference from the actual consumption (shifter/or not) and the forecasted (baseline)	R-DM.5

6 Requirements

Requirements		
Categories ID	Category name for requirements	Category description
CONF	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communication types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable. It includes: - information exchanged with external entities (e.g. service provider, weather data provider, etc.) - information related to the electricity tariff scheme in current use (e.g., variable price and fixed price components). The includes both consumption and generation tariff information. - information related to the weather conditions for the next day/hours to be used by the optimal scheduling methodology to include the local generation. - all the characteristics and configuration parameters related to the use of devices by the HEMS to produce an optimized schedule - all the configuration parameters related to the user preferences in the production of an optimized schedule - the requirements for the information presentation to the end-user - the communication solutions the data models used.

HLUC06 – Management of battery system for Node capacity increase and user DR

DM	Data Management	Covers both the management of the data exchanges in each use case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions. It should not address database design but should concentrate on the user requirements for the interfaces to databases and other data handling applications. It includes: - all the metering data related with the house consumption and, if applicable, local generation. This information can be obtained by a central metering equipment, like a DSO smart meter or a user electric panel meter. It can also be obtained through distributed meters from electric panel meters, smart plugs or directly from a smart device/system. - the requirements related to the storage of information locally and remotely to the HEMS a structured access to data related to devices and user preferences
SEC	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable. Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors. At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures. Includes all the security related requirements to allow data between devices, systems and entities to be exchanged in a trustworthy way.
Requirement R-ID	**Requirement name**	**Requirement description**
R-CONF.1	Communication access services requirements	Provides access to the HEMS or CapWatt platform remotely to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities like the availability of DNS lookup, security credentials, firewall configurations, etc.
R-CONF.2	Data exchange methods	Defines the way data is exchanged between different parties (devices, systems, entities)
R-CONF.3	Existence of legacy systems	Addresses the necessary changes (quantification of the effort) and adaptations necessary to the HEMS or CapWatt cloud data monitoring system as related devices to accommodate the integration of legacy systems.

R-CONF.4	Operation mode of Information Receiver	Defines if the target device is operating in manual or automatic mode
R-CONF.5	Operation mode of Information Producer	Defines if the source device is operating in manual or automatic mode
R-SEC.1	Authentication: Masquerade and/or spoofing - Ensuring that data comes from the stated source or goes to authenticated receiver is:	Warrants protected access to the HEMS platform locally to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities, security credentials, firewall configurations, etc.
R-SEC.2	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Guarantees the conformity of all the data exchange between the HEMS and its service providers
R-SEC.3	Authentication and Access Control mechanisms commonly used with this data exchange	Requires authentication and encryption of the data exchanged between the HEMS and CapWatt and internal building devices as well as with external systems (e.g., from service providers). Key encryption, certificates and other access control mechanisms are necessary.
R-SEC.4	Network security measures commonly used with this data exchange	Establishes communication network separation (including physical one) and the firewall control list to allow external access to the HEMS and CapWatt cloud.
R-DM.1	Correctness of source data	Ensures that the data is correctly interpreted and used for the purpose it was designed to.
R-DM.2	Management of accessing different types of data to be exchanged	Sets the type of data being exchanged and the expected periodic update (asynchronous or every x time). This is applicable to data exchange internally (e.g., with local database) in the HEMS or CapWatt cloud, with the parking lot devices and with other devices and systems external to the parking lot.
R-DM.3	Validation of data exchange	Guarantees that data exchanged between parties (devices, systems, entities) is valid. It can provide confirmation to originally sending party.

R-DM.4	Management of data across organizational boundaries	Defines the necessary changes and adaptations to the data exchanges across the building boundaries, between the HEMS or CapWatt and other external systems.
R-DM.5	Data format requirements	Sets specific formats for the data exchange between devices, systems and entities. The following formats are required to be supported by the HEMS: standard computer formats (e.g., binary, integers and floating pt, files); Serial transfer formats (e.g., DNP, Mobdus, LonTalk, BACnet); Graphics formats; Mark-up based HTML, XML; Human readable CSV and JSON; etc.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
CONF	Configuration
DR	Demand Response
BMS	Battery Management System
CPO	Charging Point Operator
HEMS	Home Energy Management System
HLUC	High Level Use Case
LV	Low Voltage
EV	Electric Vehicle
EMS	Energy Management System

HLUC07 – Adaptive BESS management for autonomous grid operation

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
HLUC07	Grid users / Residential	Adaptive BESS management for autonomous grid operation

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	10.04.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Initial definition of the use-case characteristics
0.2	14.04.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updated version up to section 3.
1.0	20.04.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updating table 1.5, New KPIs
1.1	15.05.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updates with KPIs, Actors, Table and texts.
1.2	09.06.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updates of actors' info and the table 3.1
1.3	15.06.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Sequence diagram and table 4.1
2.0	19.06.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updates on sequence diagram, references and table 4.1 added.
3.0	02.07.2023	Elyas Rakhshani, Francisco Marcelo, HESStec	Updates of remaining tables.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The main focus of this HLUC can be broken-down as follows: 1. This use case should identify and analyse how the hybridization algorithm can be incorporated and tested for HyDEMS application with aggregator on top and multiple DER in laboratory scenario. 2. To test and incorporate the use of SoF for an interoperable distributed energy storage (DES) operation for one selected grid service. 3. To test and validate the developed energy management system on incorporation and coordination of different DERs with different mode of operation: Grid Forming (GFM) and Grid Following (GFL) in laboratory scenario.
Objective(s)	1) Assess the operation of both grid forming (GFM) and grid following (GFL) DERs on providing one selected grid service. 2) Analysis and assessment of hybrid solution with different DER assignment roles in distributed storage system for improved flexible and autonomous (micro-grid) operation considering SoF as DER figure of merit.
Related business case(s)	**HLUC 4**: Data sharing and inputs for selected services. **HLUC 6**: With application of hybridization and EMS platform for local batteries.

1.4 Narrative of use case

Narrative of Use Case
Short description
This use-case presents a procedure to test and validated the hybridization approach considering SoF, as interoperable tool, for providing gird services under different operational mode of DERs. In this UC, the actual and former grid condition/service needs from the aggregator, real time data such as SoC, SoF from the DERs will be collected to identify the appropriate operational mode of the DERs for autonomous grid operation.
Complete description

HLUC07 – Adaptive BESS management for autonomous grid operation

This HLUC describes how the developed hybridized interoperable tool can provide specific services seamlessly without causing any compatibility issues. The developed HyDEMS product in this project is a software-based control platform with cloud computing capabilities, conceive to seamlessly integrate and optimize energy resources in a distributed scenario. It comprises a set of proprietary hybridization, degradation, and virtualization algorithms, oriented towards an optimal planning and interoperable distributed energy storage (DES) operation with the final purpose of enabling the provision of a stacked pool of multiple flexibility services to grid operators.
A DERMS in this use case will analyse the real time data that can help integrate, manage, and control flexible and intermittent DERs and electric demand. In this scenario, HES envision to provide alternative solutions to integrate DERs more quickly into the energy mix. For this use case, two distinctive DER have been selected. One DER consist of two different storage technology, UCAP and battery while the other DER can be defined an intermitted source of renewable based generation. Additional components are employed in the lab facilities for emulating real grid conditions. The defined DER1 will be operated in grid forming mode (GFM) while DER number 2 will operate in grid following mode. At the lower level, each DER will have its own management system with hybridization (in this case DER1). At the upper level the HyDEMS tool will be operated as a bridge between the aggregator with data in cloud and local statue of different DERs. The SoF for different components of the defined DER will be generated and transmit a relative SoF for each selected service. So full operation of HyDEMS for hybridization considering the vector of SoF can be checked and tested.
The outcome of the lab tests of this UC7, will be provided to WP5 for deployment and testing at demo sites. The current HLUC includes the following steps:

1. COLLECT DATA

At this step the necessary data for all the components including the liked aggregator need to be collected from previous WPs.
This information can be used by the software algorithms to define the condition of the test environment.

2. MONITOR SYSTEM CAPABILITIES

The necessary monitoring system with the needed data exchange need to be defined for activating a service. At this step the calculation of SoF need to be checked for each relevant DER.

3. COMMUNICATION TEST

At this step, before initiating the full test for different services, a series of communication test need to be done to be sure that all the needed components (DERs) are compatible and the flow of the needed data for calculation are OK.

4. START UP TEST FOR DER1 WITH GFM MODE

At this step, after ensuring about the availabilities of needed data with exchange monitoring/exchange data capabilities, DER1 should be started in GFM mode for island mode operation.

5. START UP TEST FOR DER2 WITH GFL MODE

At this step, after ensuring about the availabilities of needed data with exchange monitoring/exchange data capabilities, DER2 should be started in GFL mode of operation.

6. SYNCHRONIZATION CHECK

At this step, synchronization block will be activated, and all different DER should get synchronized together. The error of the synchronization must be monitored continuously.

7. GRID CONNECTED MODE CHECK

At this step, after testing the synchronization with proper operation of each individual DER, especially GFM based DER1 in island mode, all the DER operational mode will be switched to grid connected mode for providing a unique service at the Point Of connection (POC).

8. INITIATE THE HyDEMS FOR SELECTED SERVICE

At this step, according to the received information from the aggregator, and monitored SoF, a relevant service will be selected for testing the HyDEMS algorithm. Once the algorithms have been initiated, they can be deployed in the 1full management system. The algorithms should be regularly monitored and updated to ensure that it is working in optimized way for the current grid conditions.

9. EVALUATE THE PERFORMANCE

The performance of the management system tool should be evaluated to ensure that it is meeting the grid's requirements for the selected services. Adjustments can be made to the algorithms as needed to improve performance.

1.5 Key performance indicators (KPI)

ID(*)	Name	Description	Reference to mentioned use case objectives
KPI12	Time savings	Demand side Flexibility potential increase due to hybridization implementation (Target: >20%)	2
KPI13	Monitoring	N° of assets monitored in GridLab for the project	1
KPI3	Battery capacity	Amount of Flexibility provision in the demos from HESS (Target: >220 kW)	(1) and (2)
KPI14	Time response	is considered as the overall HESS system time response which will be needed for providing the service complying TSO grid codes.	3

(*) The ID number is based on the project KPI reference list –

1.6 Use case conditions

Use case conditions
Assumptions
• Provide information to the HyDEMS, mode to start the system; Island or grid connected and the order to sync and connect to the grid in case of start in island mode. • DES components are available with proper communication structures.
Prerequisites
• HyDEMS need to be able to communicate with the aggregator for data exchange about receiving grid conditions/services needed and also sending the current capabilities of the HESS systems to the aggregator. • HyDEMS need to be able to communicate with all the different DERs for sending and receiving the needed data such as receiving the SoF of different DER and sending high level command signals to them. • Capability to Log the Grid, **DER1(GFM), DER2 (GFL)** and HyDEMS important values. • For frequency regulation, need the characterization of the generator to simulate and the frequency droop.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
HLUC 4: Data sharing HLUC 6: HyDEMS and hybridization assessment with data sharing, if needed.
Level of depth
High level use case (HL-UC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution.
Prioritisation
High level- Demonstration of HyDEMS in GridLab environment.
Generic, regional or national relation
Generic
Nature of the use case
Use case for large scale Lab demonstration for the hybridization and services to the grid.
Further keywords for classification
Flexibility, DES, HyDEMS, Grid forming converter, Grid following, Damping, Hybridization.

1.8 General Remarks

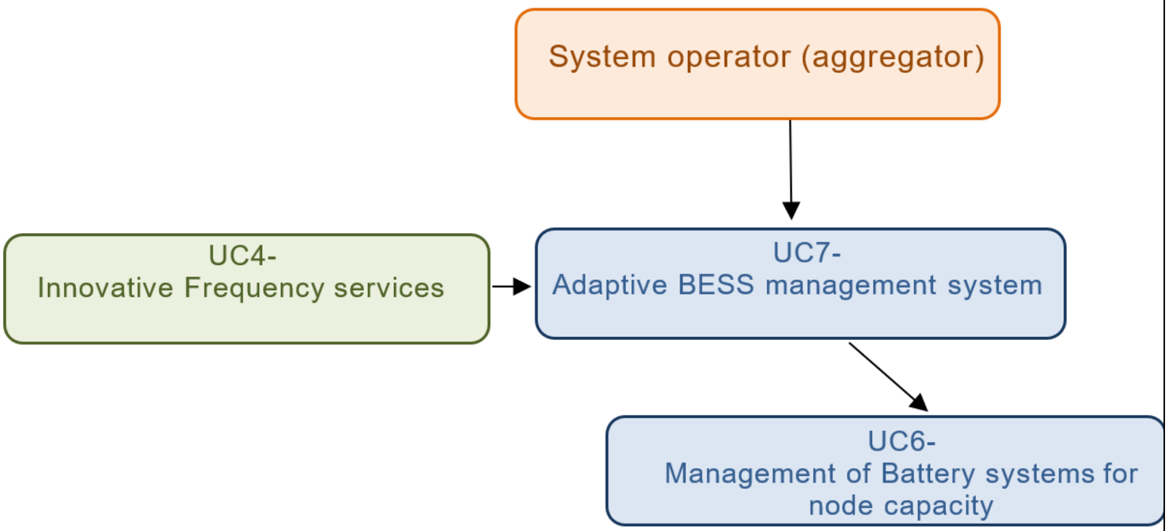
General Remarks
The methodology described in this UC7, is generic steps and test to be following for demonstrating the successfulness operation of the developed HyDEMS on hybridization with incorporation of SoF for smooth response on providing the selected services from the aggregator. This may involve developing protocols for communication and control and ensuring that the different technologies can be connected and managed in a way that maximizes their performance.

In this scheme, DER1 and DER2 are distributed source of energies. DER1 consists of hybrid storage (UCAP and Battery) operating in GFM approach and DER2 will play a role of a renewable source of generation working in GFL mode and PCS4 is a grid emulator creating the rest of the external grid during test in GridLab.

2 Diagrams of use case

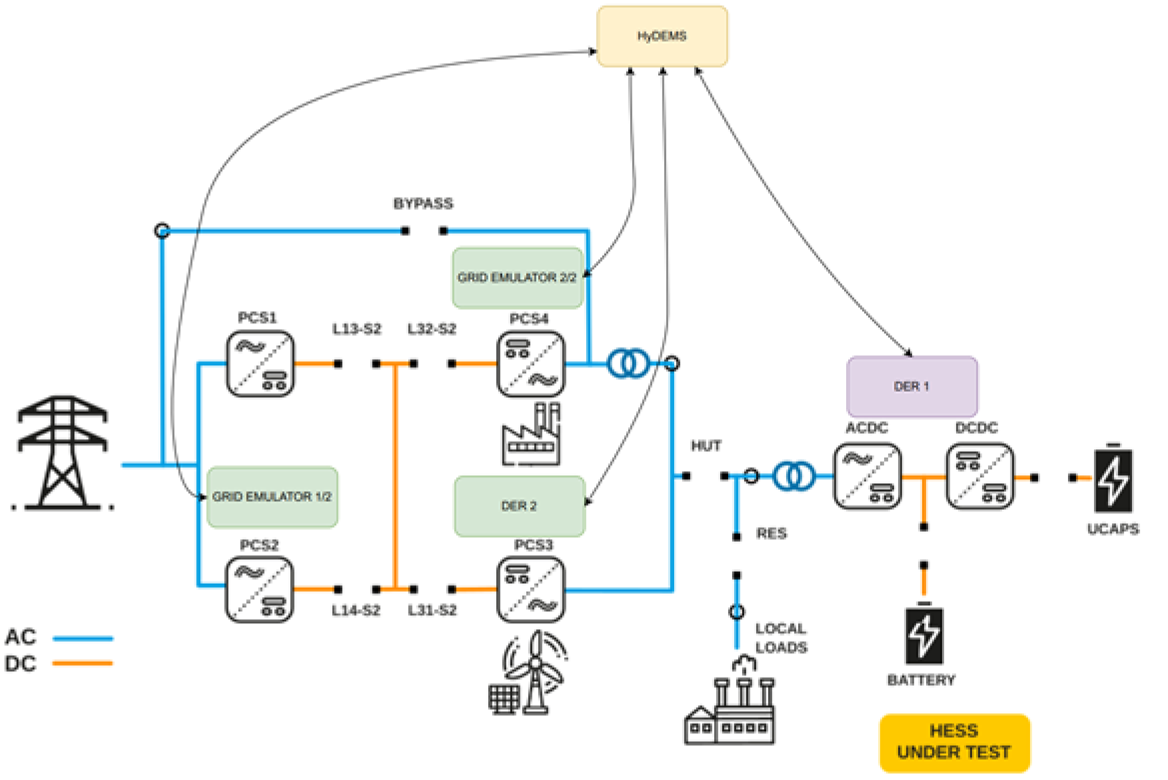
Diagram(s) of use case

HLUC- Relation Diagram:



HLUC- General Architecture

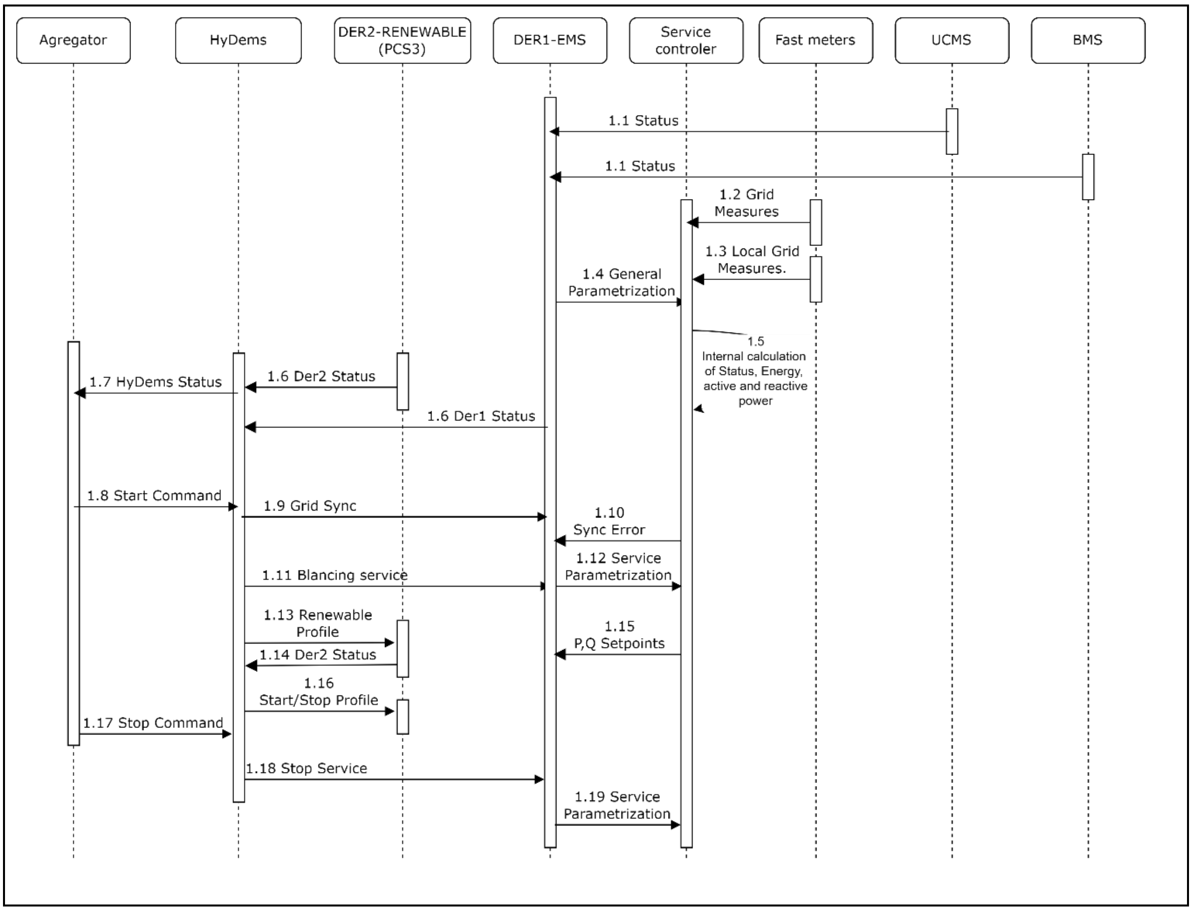
HLUC07 – Adaptive BESS management for autonomous grid operation



GridLab scenario for implementing the UC7 for HyDEMS generic test

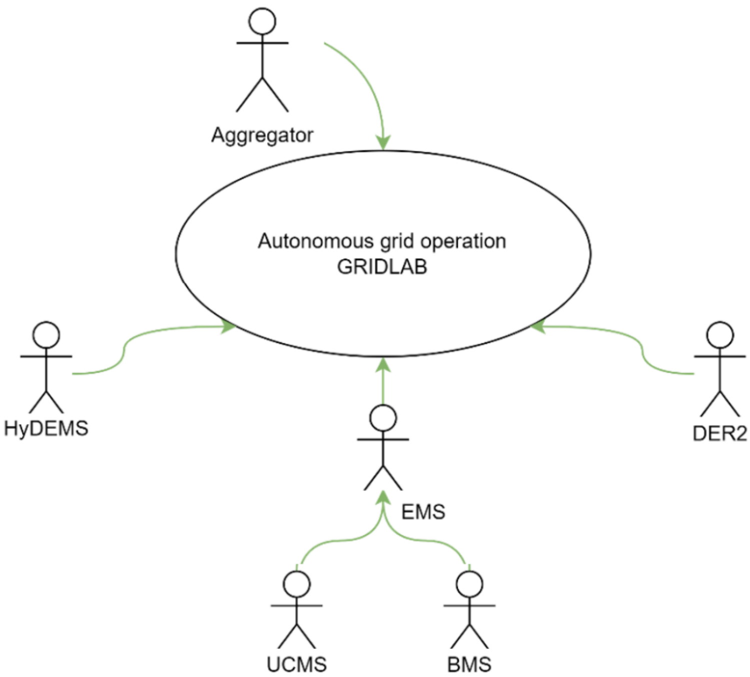
HLUC 7 General Sequence Diagram:

HLUC07 – Adaptive BESS management for autonomous grid operation



3 Technical details

Relationships of different actors:



3.1 Actors

Actors

Actor Name	Actor Type	Actor Description
GRIDLAB	Site	The Lab where the Devices are installed, and the UC will be performed.
Aggregator	System	The aggregator platform will provide the service to implement
HyDems	System	Hybrid energy management system running over the EMS and the DER2.
DER1-EMS	System	Is the Energy management system to control ultracapacitors and battery.
DER1-BMS	System	Is the battery management system.
DER1-BATTERY	Device	Is the High-energy battery device.
DER1-UCMS	System	Is the ultracapacitors management system.
DER1-UCAPS	Device	Is the High-Power ultracapacitors device.
DER1-ACDC	Device	ACDC converter controlled by EMS.
DER1-DCDC	Device	DCDC converter for UCAPS, controlled by EMS.
DER2-PCS3 (Renewable)	Device	Inverter to simulate for event and asset simulation.

3.2 References

References						
No.	References Type	Reference	Status	Impact on use case	Originator / organisation	Link
1	Datasheet	Battery specifications	Ready-confindential	Technical information of battery asset	Narada	
2	Datsheet	Ultracapacitors specifications	Ready-confindential	Technical information of ultra camacitors asset	Hesstec	
3	Spredsheet Document of signals	ModBus communication table of different commponents	Pending	Modbus directions for different commponents	Hesstec	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	No Grid event detected	DER1-EMS collect data from UCMS and BMS and update the DER1-EMS Status values like SoF to the HyDEMS control. Service Controller, collect data of the local and external grid to get the metrics needed for service.	DER1-EMS	Data gathering	Need the Service parametrization and inertia.	Generate a valid P,Q setpoint waiting for the service activation.
2	Service activation & event compensation	HyDEMS send orders to the assets to Start the services and send the event profile.	HyDEMS	Aggregator order	Valid HyDEMS Status.	The Grid frequency event

					The DER1-EMS have a valid SoF to execute the service	must me compensated

4.2 Steps – Scenarios

Scenario								
Scenario name:	*No. 1*							
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1	Data gathering	1.1 Status	Recovering status of the asset and calculating the total SoF	GET/REPEAT	UCMS & BMS	DER1-EMS	SP-1	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
2	Updating SoF	1.6 DER1 Status	The SoF is sent to HyDEMS	SET	DER1-EMS	HyDEMS	SP-2	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
3	Data gathering	1.6 DER2 Status	Recovering status of the asset.	GET	DER2_RENEWABLE	HyDEMS	SP-3	R-CONF.2, R-SEC.1 R-SEC.3, R-DM.3
4	Updating SoF	1.7 HyDEMS status	The SoF is sent to aggregator	SET	HyDEMS	Aggregator	SP-4	R-CONF.1, R-CONF.4, R-SEC.3, R-DM.3

Scenario								
Scenario name:	*No. 2*							
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
5	Aggregator order	1.8 Start Command	Order to start the connection of the local Grid to the Main Grid.	CREATE	Aggregator	HyDEMS	SP-5	R-CONF.1, R-CONF.5, R-SEC.3, R-DM.3
6	Sync order	1.9 Grid Sync	Order to DER1-EMS to Sync procedure	GET	HyDEMS	DER1-EMS	SP-6	R-CONF.2, R-SEC.1, R-DM.3
7	Sync procedure Start	1.10 Sync Error	After checking that it is possible to sync (not out of parametrization range) DER1-EMS starts the synchronization of local loads to the grid	GET	Service Controller	DER1-EMS	SP-7	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.2, R-DM.3
8	Sync procedure end	1.10.Sync Error	The Service Controller returns that the system can close the CGBT breaker	SET	Service Controller	DER1-EMS	SP-7	R-CONF.2, R-SEC.4, R-DM.2, R-DM.3
9	Updating Status	1.16 Der1 Status	The Status is sent to HyDEMS informing that it is ready to execute service	GET	DER1-EMS	HyDEMS	SP-2	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3

10	HyDEMS ready to execute service	1.12 Service Parametri-zation	The HyDEMS ena-bles the service.	SET	HyDEMS	DER1-EMS	SP-8	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
11	HyDEMS ready to execute service	1.13 Renew-able profile.	Send the Event Profile to the DER2-RENEWA-BLE and Start the Event	SET	HyDEMS	DER2_RE-NEWABLE	SP-9	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3, R-DM.5
12	New Ser-vice Con-troller P,Q setpoint	1.15 P,Q Setpoint	The Service Con-troller generates a new P,Q setpoint calculated with the detected Grid event	SET	Service Controller	DER1-EMS	SP-10	R-CONF.2, R-SEC.4, R-DM.3
13	New P,Q setpoint	1.15 P,Q Setpoint	The new Setpoint is sent to the in-verters	REPEAT	DER1-EMS	Inverters	SP-10	R-CONF.2, R-CONF.3, R-SEC.1, R-SEC.3, R-DM.3
14	Event fin-ished	1.17 Stop Command	The DER2_RE-NEWABLE finishes the event profile.	CLOSE	Aggregator	HyDEMS	SP-11	R-CONF.1, R-CONF.2, R-CONF.4, R-SEC.1, R-SEC.3, R-DM.3

5 Information exchanged

Information exchanged			
Information ex-changed (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
SP-1	Recovering Status of as-sets	Recovering current information of UCMS and BMS and check any warn-ing, alarm.	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
SP-2	Generated SoF	Using the SP-1 and assets specifica-tions DER1-EMS generate the SoF.	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
SP-3	Recovering Status of as-sets	Recovering current information of DER2-RENEWWABLE and check any warning, alarm.	R-CONF.2, R-SEC.1 R-SEC.3, R-DM.3
SP-4	Generated SoF	Using SoF of DER1-EMS and SP3 HyDEMS generate the SoF	R-CONF.1, R-CONF.4, R-SEC.3, R-DM.3
SP-5	Start Command	Aggregator orders to Start the synchro-nization	R-CONF.1, R-CONF.5, R-SEC.3, R-DM.3
SP-6	Sync command	HyDEMS sends the order to DER1-EMS to start synchronization of local loads to the external grid	R-CONF.2, R-SEC.1, R-DM.3
SP-7	Sync Status	A group of measures and the Error of synchronization.	R-CONF.2, R-SEC.4, R-DM.2, R-DM.3
SP-8	Service Activation	Send the order to enable the service.	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3
SP-9	Event profile	Send the event profile to generate the grid event.	R-CONF.2, R-SEC.1, R-SEC.3, R-DM.3, R-DM.5
SP-10	P,Q setpoint	Separate Setpoint for UCAPS and Bat-tery generated in the Service that will be sent to the inverters.	R-CONF.2, R-SEC.4, R-DM.3

SP-11	Stop Grid event	Command to the HyDEMS to stop the event in the next cycle	R-CONF.1, R-CONF.2, R-CONF.4, R-SEC.1, R-SEC.3, R-DM.3

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
CONF	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communication types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable. It includes: - information exchanged with external entities (e.g. service provider, weather data provider, etc.) - information related to the electricity tariff scheme in current use (e.g., variable price and fixed price components). The includes both consumption and generation tariff information. - information related to the weather conditions for the next day/hours to be used by the optimal scheduling methodology to include the local generation. - all the characteristics and configuration parameters related to the use of devices by the HEMS to produce an optimized schedule - all the configuration parameters related to the user preferences in the production of an optimized schedule - the requirements for the information presentation to the end-user - the communication solutions the data models used.
DM	Data Management	Covers both the management of the data exchanges in each use case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions. It should not address database design but should concentrate on the user requirements for the interfaces to databases and other data handling applications. It includes: - all the metering data related with the house consumption and, if applicable, local generation. This information can be obtained by a central metering equipment, like a DSO smart meter or a user electric panel meter. It can also be obtained through distributed meters from electric panel meters, smart plugs or directly from a smart device/system. - the requirements related to the storage of information locally and remotely to the HEMS a structured access to data related to devices and user preferences
SEC	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable. Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors. At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures. Includes all the security related requirements to allow data between devices, systems and entities to be exchanged in a trustworthy way.
Requirement R-ID	**Requirement name**	**Requirement description**

R-CONF.1	Communication access services requirements	Provides access to the HEMS platform remotely to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities like the availability of DNS lookup, security credentials, firewall configurations, etc.
R-CONF.2	Data exchange methods	Defines the way data is exchanged between different parties (devices, systems, entities)
R-CONF.3	Existence of legacy systems	Addresses the necessary changes (quantification of the effort) and adaptations necessary to the HEMS as related devices to accommodate the integration of legacy systems.
R-CONF.4	Operation mode of Information Receiver	Defines if the target device is operating in manual or automatic mode
R-CONF.5	Operation mode of Information Producer	Defines if the source device is operating in manual or automatic mode
R-SEC.1	Authentication: Masquerade and/or spoofing - Ensuring that data comes from the stated source or goes to authenticated receiver is:	Warrants protected access to the HEMS platform locally to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities, security credentials, firewall configurations, etc.
R-SEC.2	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Guarantees the conformity of all the data exchange between the HEMS and its service providers
R-SEC.3	Authentication and Access Control mechanisms commonly used with this data exchange	Requires authentication and encryption of the data exchanged between the HEMS and internal building devices as well as with external systems (e.g., from service providers). Key encryption, certificates and other access control mechanisms are necessary.
R-SEC.4	Network security measures commonly used with this data exchange	Establishes communication network separation (including physical one) and the firewall control list to allow external access to the HEMS.
R-DM.1	Correctness of source data	Ensures that the data is correctly interpreted and used for the purpose it was designed to.
R-DM.2	Management of accessing different types of data to be exchanged	Sets the type of data being exchanged and the expected periodic update (asynchronous or every x time). This is applicable to data exchange internally (e.g., with local database) in the HEMS, with the building devices and with other devices and systems external to the building.
R-DM.3	Validation of data exchange	Guarantees that data exchanged between parties (devices, systems, entities) is valid. It can provide confirmation to originally sending party.
R-DM.4	Management of data across organizational boundaries	Defines the necessary changes and adaptations to the data exchanges across the building boundaries, between the HEMS and other external systems.
R-DM.5	Data format requirements	Sets specific formats for the data exchange between devices, systems and entities. The following formats are required to be supported by the HEMS: standard computer formats (e.g., binary, integers and floating pt, files); Serial transfer formats (e.g., DNP, Mobdus, LonTalk, BACnet); Graphics formats; Mark-up based HTML, XML; Human readable CSV and JSON; etc.
R-DM.6	SAREF compliant data	The data structures exchanged between systems is SAREF compliant

7 Common Terms and Definitions

Common Terms and Definitions	
Term	Definition
CONF	Configuration
DM	Data Management
SEC	Security
UC	Use Case
HyDEMS	Home Energy Management System
HLUC	High Level Use Case
EMS	Energy Management System
BMS	Battery Management System
HyDEMS	Hybrid Distributed Energy Management System
INMS	Intelligent Node Management System
DER	Distributed Energy Resources
DES	Distributed Energy System
HESS	Hybrid Energy Storage System
BESS	Battery Energy Storage System
SoC	State of the Charge
SoF	State of the Function
UCMS	UCAP Management System
GFM	Grid Forming converter
GFL	Grid Following converter

UC08 - Multiphysics flexibility optimization for Home Management Systems and their global integration

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
UC08	Grid users / Residential	Multiphysics flexibility optimization for Home Management Systems and their global integration

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	03/03/2023	FZJ	Initial definition of the use-case characteristics
0.2	24/05/2023	FZJ	Inclusion of diagrams
0.3	03/07/2023	FZJ	Final version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	A hybrid energy storage system will be integrated, for operation, in an internal Network (grid). In this use case, thermal storage systems (heat pumps) will be integrated into a home management system (HMS), to enable flexibility optimization. Battery storage systems and photovoltaic systems will be also integrated into the home management system. The operation of the subsequent hybrid energy storage system (HESS) on the building level, and the coordination among multiple HMSs, will then verify the successful deployment of the system.
Objective(s)	(1) To demonstrate that the inclusion of heat pumps in the HMS can increase the flexibility optimization (2) Verify the IEEE2030.5 interoperability tool, with different inverters (for different demonstrators) (3) Demonstrate multi-scale flexibility optimization (different time-scales involved) (4) Demonstrate the integration of the HMSs in an energy community environment, with each HMS being a node (5) Share operation data of the HESS through the connected data spaces tool
Related business case(s)	

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case investigates the integration of hybrid energy storage systems (HESSs) on an already-existing home management system (HMS). The aim is to verify that the integration of the HESS using the InterSTORE solution (IEEE2030.5 based) is effective and enables the flexibility optimization of a multi-physics-based system on a local (building) level, and on a community (multiple buildings) level. The Use case will then verify the correct deployment by operating the HMS connected to the buildings, providing setpoints and receiving operational data.
Complete description
To take full advantage of the different features that can be enabled by coupling storage systems from different domains (e.g. electrical and thermal), their dedicated energy management systems are of utmost importance. Traditional home management systems (HMSs) are able to integrate only components from the electrical domain (batteries, PVs and the like). The integration of thermal storage, for example by means of the coupling of heat pumps, could enhance flexibility optimisation with a lot of benefits for the overall system. Then, HMSs from multiple buildings can be operated in a community framework, with each HMS being a node, to enable flexibility optimization on a global level. This UC investigates how HESS can be successfully integrated into an already existing HMS, provided by EATON. The InterSTORE legacy converters will be integrated for this purpose. A series of commissioning tests will be performed to verify the effective interoperability of the communication interface. Then, the integration of the HESSs in the novel HMS will be evaluated, with respect to the successful exchange of control set-points. The HESS system is composed of 2 battery systems, 1 heat pump and a photovoltaic installation. First, the UC will demonstrate the flexibility optimization of a multi-vendor and multi-physics-based storage ecosystem in residential buildings. Then, the concept for the integration of the home management system in the energy community will be demonstrated, to enable flexibility optimization on a global level with objectives that relate to this global level. The current UC includes the following steps: INTERFACE TESTS Before proceeding with the tests on the field, the software interface will be tested in a laboratory environment. In particular, the developed interface will be tested with a simulated HESS (especially the heat pump) representative of the real one. The successful exchange of data and setpoints will determine the validation of this step. HOME MANAGEMENT SYSTEM TESTS In consideration of the two different objectives, the tests of the home management system can be divided in two parts. Building level During the tests, the main focus will be on evaluating the flexibility that can be achieved on building level, by means of the coordination among a mix of multi-physics energy storage systems. First, tests will verify that the extended HMS can effectively be interfaced with heat pumps and the other electrical storage systems. The effectiveness will be evaluated in terms of the ability of the HMS to handle data from/to the different storage systems connected to it. Then the ability of the HMS to coordinate these resources, and to enhance the overall flexibility,

	providing meaningful setpoints will be evaluated. In particular, following a progressive testing approach, preliminary, small scenarios that aim at verifying the operation of the control coordination, will be executed. Community level In a scenario where the HMS of multiple buildings are virtually connected together, tests will be performed to evaluate the capability of each HMS to deal with real-time data exchange. Within this framework, the coordination will be evaluated among multiple HMSs, verifying the successful exchange of meaningful setpoints and information.

1.5 Key performance indicators (KPI)

ID(*)	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI3	Battery capacity	Amount of Flexibility provision in the demos from HESS	2
KPI4	Diversity of DER	Number of different DER devices successfully tested and demonstrated	1
KPI5	Asset management monitored by EMS	Number of assets monitored by the InterSTORE EMS solutions	1
KPI10	Nbr. of DER tested	Number of different DER devices and EMS successfully tested with the IEEE2030.5 and demonstrated in real-life pilots (pilot target: 5)	1, 2
KPI25	Integrated capacity	Integrated capacity of the HESS within the project demos (pilot target: 1 MW)	1, 2
KPI26	Increase of flexibility	Demand side flexibility potential increase due to hybridization implementation (Target: >20%)	1, 2, 3, 4
KPI11	Data space	Amount of digitized storage systems/platforms/hubs assets integrated in the common data space exchanging data (Pilot Target: 50%)	5

(*) The ID number is based on the project KPI reference list

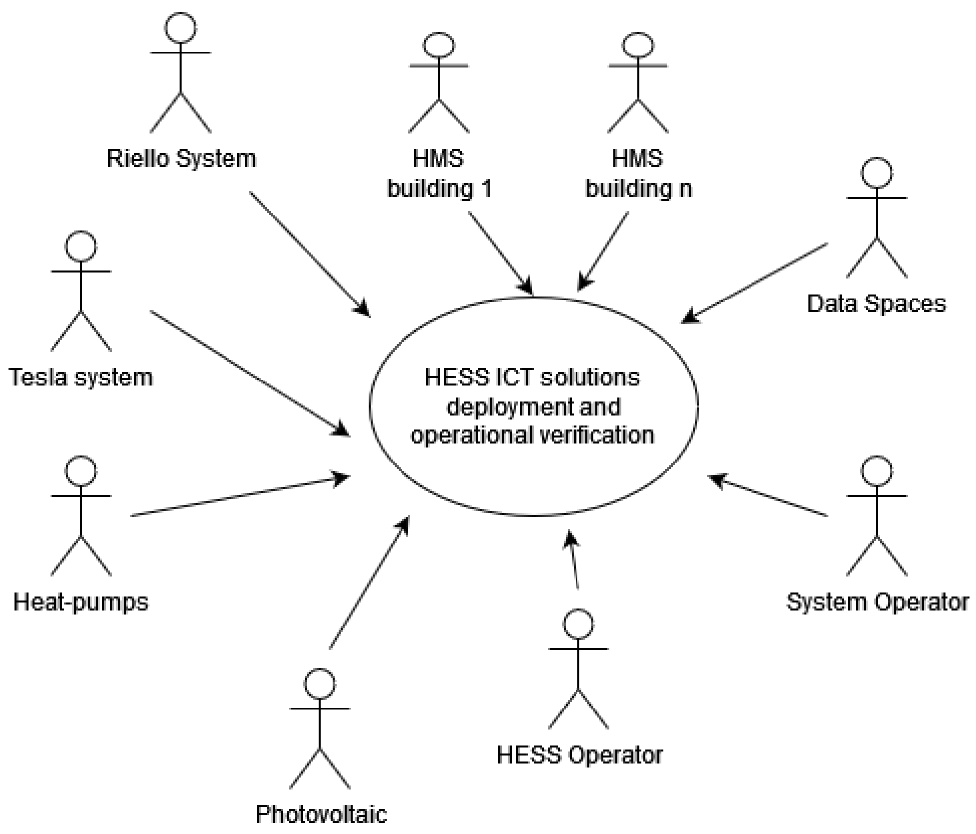
1.6 Use case conditions

Use case conditions
Assumptions
• The existing HMS has to be adapted by EATON for the integration of the heat-pump • The legacy converters need to be deployed as an alternative to the inverter firmware update • Raspberry Pi 4 will be used as hardware for the Legacy Protocol Converter • The limits of operation of the HESS is limited to defined boundaries imposed by the system operator • A Public IP addressed cannot assigned directly to the installation related internet connections. An alternative way must be put in place • LTE communication is not allowed
Prerequisites

HLUC08 – Multiphysics flexibility optimization for Home Management Systems and their global integration

- The batteries, heat pumps, and PV need to be commissioned
- Local connection (intranet) and registry with internal IP address will be needed
- The protocol(s) used in the interface with the heat pumps and PVs has to be defined by FZJ
- The interface with the HMS has to be defined by EATON

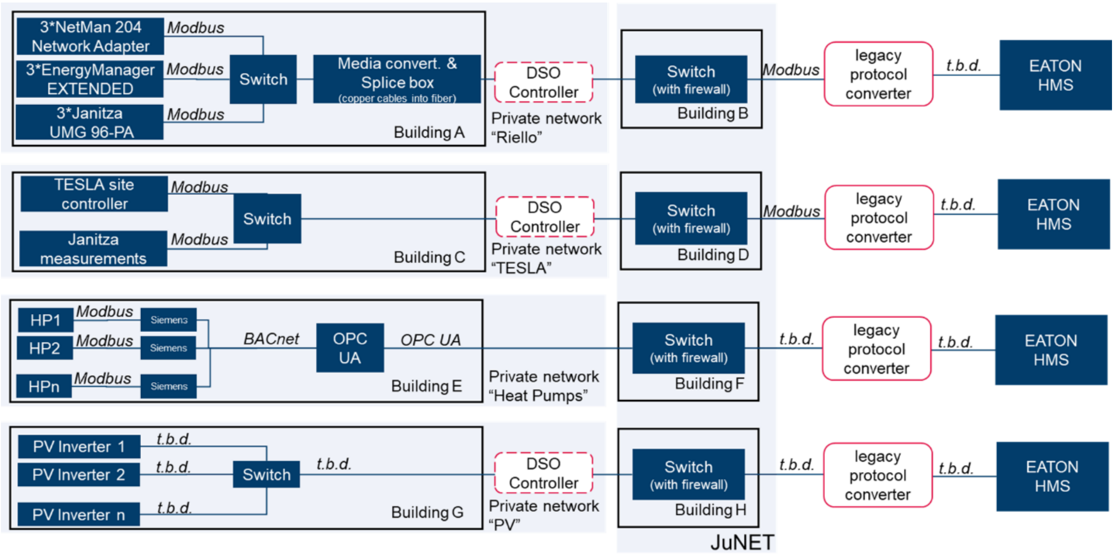
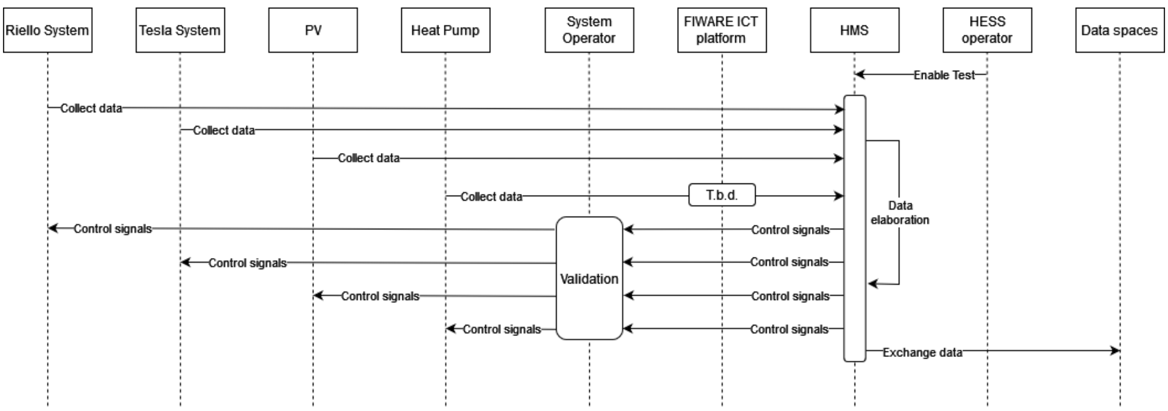
1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
 Relation to other HLUCs: UC 3: Grid supporting BESS. The same battery systems will be used.
Level of depth
High level use case (HL-UC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution
Prioritisation
Mandatory
Generic, regional or national relation
Generic
Nature of the use case
Technical/system use case
Further keywords for classification
Battery systems, Photovoltaic, heat pumps, HMS, communication interfaces.

1.8 General Remarks

General Remarks
None for now.

2 Diagrams of use case

Diagram(s) of use case
HLUC Diagram of components  HLUC Sequence Diagram: 

3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
System Operator	Actor	It's the distribution system operator of the internal grid or an external DSO. It can enforce control setpoints with the highest priority.
Data Spaces	System	Is the InterSTORE platform that will be used to store collected data during the tests
ICT Platform	System	Is the ICT platform of FZJ
HMS	System	Is the home management system, provided by EATON
Riello System	Device	Is the high-power battery system
Tesla System	Device	Is the high-energy battery system
PV system	Device	Is the photovoltaic system
Heat pump	Device	Is one the device related to the thermal domain
HESS operator	Actor	Is the FZJ partner that will coordinate and perform the tests

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
1	Standard	IEC 62559-2 Use Case Methodology	Published	Definition of the presented template	International Electrotechnical Commission	
2	Standard	IEEE2030.5	Published	Provision of possible actors and roles	IEEE	
3	Spreadsheet Document	InterSTORE KPI List		Provision of KPIs to be included	InterSTORE internal document	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**

1	Increased flexibility – Building level	Thanks to the solution developed in InterSTORE, the HMS is used to read data from the system and determine operational setpoint for the HESS. The goal is to be able to operate different HSS by means of the HMS.	HMS	Data collected from the FZJ network	Only assets from the electrical domain can be controlled.	A Single HMS can monitor and operate the multi-domain resources.
2	Increased flexibility – District level	Thanks to the solution developed in InterSTORE, multiple HMSs are used to read data from the system and determine operational setpoint for the HESS. The goal is to be able to coordinate different HMSs.	HMS	Data collected from the FZJ network and from other HMSs	Only one HMS is used to control the multi-domain energy system.	Multiple HMSs can monitor and operate the multi-domain resources.
3	Data sharing via connected data spaces	Operational data collected from the battery systems and the EMS will be shared in the connector interface. This data can be accessed by authorized subscribers. The provision of data is considered as successful deployment.	HMS	Operational data are published in the connected data spaces	Successful deployment of the connector on a server machine where operational data are hosted	Data are successfully shared via the connected data spaces.
4	Unsuccessful increased flexibility – Building level	The HMS is not able to properly handle the data collected from the system, or the provided set points are not feasible.	HMS	Data collected from the FZJ network	Only assets from the electrical domain can be controlled.	The control via the HMS is not effective.
5	Unsuccessful increased flexibility – District level	The HMSs are not able to exchange information and coordinate for the determination of control set points	HMS	Data collected from the FZJ network and from other HMSs	Only one HMS is used to control the multi-domain energy system.	Multiple HMSs cannot operate multi-domain resources
6	Impossible data sharing via connected data spaces	Operational data collected from the battery systems and the EMS cannot be provided or cannot be shared in the connector interface.	HMS	Operational data are not available or cannot be successfully published in the connected data spaces	Unavailability of the operational data or unsuccessful deployment of the connector	Data are not shared via the connected data spaces.

4.2 Steps – Scenarios

Scenario								
Scenario name:		*No. 1 and 2*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1	Voltage profile sent	Voltage measurement is sent to the HMS	The monitoring devices at the PCC of each battery send the voltage value at the PCC at regular intervals	Report	PCC smart meter	HMS	SP-1 (Voltage profile)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
2	Generated power PV sent	Generated Power by the PV measurement is sent to the HMS	The inverters of the PV system send information regarding the generated power to the HMS	Report	PV system	HMS	SP-2 (Generated PV Power)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
3	Thermal Consumption sent	Consumption data from the heat pump	Information on thermal system consumption is sent to the HMS	Report	Heat pump	HMS	SP-3 (Thermal consumption)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

4	Get operation command	Command charge/discharge	Based on the data received from the HESSs, and the PV, the HMS determine that a BESS should be charged/discharged, and/or the thermal storage should be used. In case of District level, this should be coordinated among different HMSs	Execute	HMS	Riello system Tesla system Heat pump HMS	SP-4 (HESS operation schedule)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

Scenario								
Scenario name:		***No. 3***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
1	Operational data available	Data sharing via Data spaces	The server where the operational data of HESSs and HMS s is successfully connected to the Data spaces and operational data are updated regularly.	Change	Server where operational data is stored	Data Space connector	SP-5 (Operational data shared)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

Scenario								
Scenario name:		***No. 4 and 5***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***

1	Get operation command	Command charge/discharge	The HMSs are not able to determine if a HESS should be charged/discharged	Report	HMS	Riello system Tesla system Heat Pumps	SP-6 (HESS operational schedule error)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

Scenario								
Scenario name:		***No. 6***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
1	Operational data not available	Data sharing via Data spaces impossible	Operational data are not properly stored in the Server connected to the data spaces	Report	Server where operational data should be stored	Data Space connector	SP-7 (Operational data shared error)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
2	Operational data not sharable	Data sharing via Data spaces impossible	Server where operational data are stored, cannot be connected to the data spaces	Report	Server where operational data is stored	Data Space connector	SP-7 (Operational data shared error)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
SP-1	Voltage profile	Voltage profile in V, reported every minute	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-2	Generated PV Power	Generated PV power, reported every minute	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-3	Thermal consumption	Thermal consumption, reported regularly	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-4	HESS operation schedule	Scheduling of operations of the HESS (charge/discharge) determined by the HMSs	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-5	Operational data shared	Set of operational data shared with the Data Spaces	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
SP-6	HESS operational schedule error	Unexpected behaviour of the HMSs (erroneous operational schedule determined)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

SP-7	Operational data shared error	Unexpected behaviour when sharing data to Data Spaces	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5 R-SEC.1, R-SEC.2, R-SEC.3, R-SEC.4 R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
CONF	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communication types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable. It includes: - information exchanged with external entities (e.g. service provider, weather data provider, etc.) - information related to the electricity tariff scheme in current use (e.g., variable price and fixed price components). The includes both consumption and generation tariff information. - information related to the weather conditions for the next day/hours to be used by the optimal scheduling methodology to include the local generation. - all the characteristics and configuration parameters related to the use of devices by the HEMS to produce an optimized schedule - all the configuration parameters related to the user preferences in the production of an optimized schedule - the requirements for the information presentation to the end-user - the communication solutions the data models used.

DM	Data Management	Covers both the management of the data exchanges in each use case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions. It should not address database design but should concentrate on the user requirements for the interfaces to databases and other data handling applications. It includes: - all the metering data related with the house consumption and, if applicable, local generation. This information can be obtained by a central metering equipment, like a DSO smart meter or a user electric panel meter. It can also be obtained through distributed meters from electric panel meters, smart plugs or directly from a smart device/system. - the requirements related to the storage of information locally and remotely to the HEMS a structured access to data related to devices and user preferences
SEC	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable. Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors. At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures. Includes all the security related requirements to allow data between devices, systems and entities to be exchanged in a trustworthy way.
Requirement R-ID	**Requirement name**	**Requirement description**
R-CONF.1	Communication access services requirements	Provides access to the HMS platform remotely to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities like the availability of DNS lookup, security credentials, firewall configurations, etc.
R-CONF.2	Data exchange methods	Defines the way data is exchanged between different parties (devices, systems, entities)
R-CONF.3	Existence of legacy systems	Addresses the necessary changes (quantification of the effort) and adaptations necessary to the equipment as related devices to accommodate the integration of legacy systems.

R-CONF.4	Operation mode of Information Receiver	Defines if the target device is operating in manual or automatic mode
R-CONF.5	Operation mode of Information Producer	Defines if the source device is operating in manual or automatic mode
R-SEC.1	Authentication: Masquerade and/or spoofing - Ensuring that data comes from the stated source or goes to authenticated receiver is:	Warrants protected access to the platform locally to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities, security credentials, firewall configurations, etc.
R-SEC.2	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Guarantees the conformity of all the data exchange between the HMS and its service providers
R-SEC.3	Authentication and Access Control mechanisms commonly used with this data exchange	Requires authentication and/or encryption of the data exchanged between the HMS, dataspace connector and additional internal devices as well as with external systems (e.g., from service providers). Key encryption, certificates and other access control mechanisms are necessary.
R-SEC.4	Network security measures commonly used with this data exchange	Establishes communication network separation (including physical one) and the firewall control list to allow external access to the database.
R-DM.1	Correctness of source data	Ensures that the data is correctly interpreted and used for the purpose it was designed to.
R-DM.2	Management of accessing different types of data to be exchanged	Sets the type of data being exchanged and the expected periodic update (asynchronous or every x time). This is applicable to data exchange internally (e.g., with local database) in the HMS, and with other devices and systems on the field.
R-DM.3	Validation of data exchange	Guarantees that data exchanged between parties (devices, systems, entities) is valid. It can provide confirmation to originally sending party.
R-DM.4	Management of data across organizational boundaries	Defines the necessary changes and adaptations to the data exchanges across the assets boundaries, between the HMS and other external systems.

R-DM.5	Data format requirements	Sets specific formats for the data exchange between devices, systems and entities (Data space connector, EMS, FIWARE platform etc). The following formats are required to be supported by the HMS: standard computer formats (e.g., binary, integers and floating pt, files); Serial transfer formats (e.g., DNP, Mobdus, LonTalk, BACnet); Graphics formats; Mark-up based HTML, XML; Human readable CSV and JSON; etc.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
HESS	Hybrid storage system
HMS	Home management system
HP	Heat Pump
PV	Photovoltaic
UC	Use case

HLUC09 – Management of EV charging clusters as HESS

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
HLUC09	Grid users / Industrial	Management of EV charging clusters as HESS

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	13.04.2023	EnelX	Initial definition of the use-case characteristics
1.0	20.06.2023	EnelX	First version delivered

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The main scope of this HLUC can be broken-down as follows: (1) One aspect of the scope is to use the Flexibility platform to allow a set of assets to participate as a portfolio in flexibility market services. This shall leverage the available resources to provide grid services. To enable the energy transition to clean generation, it is important to manage distributed power flexibility and use the flexibility to provide grid services. (2) This Use Case identifies and analyses how different types of storage technologies (Industrial, Residential, EVs) can contribute in a unique cluster to providing Flexibility grid services. Each individual flexibility resource does not hold adequate market value unless aggregated in larger pool with capacity and characteristics that fulfil balancing services and markets' requirements. In this way, each resource can contribute to grid service markets as part of a VPP, despite having different power profiles and capabilities (capacity, time constraints, response and ramp times). This UC will be implemented, tested and validated in Rome XLAB. The assets in the XLAB will ultimately respond to a test signal, to simulate grid responsiveness. Ultimately, this project tests necessary know-how that will enable using HESS (Hybrid Energy Service Systems) to execute a balancing order, but due to the regulations and market requirements, it is not in scope to have this set of assets participate in a live market program.
Objective(s)	(1) Hybridization: we develop a unique environment where different kind of assets are integrated (2) Energy monitoring assets consumption/production making use of IEEE 2030.5, or the protocol appropriate for the asset control reporting to connected dataspace

	(3) Exchange several messages between different distributed assets and the VPP through the Asset Manager (4) Identify the minimum set of information needed to be exchanged between assets and asset Manager and the VPP for flexibility provision
Related business case(s)	HLUC 1: Flexibility Management for grid services HLUC 2: Interoperability of different (large and medium) storage with EV chargers
Prerequisite	The reference program chosen to run the simulation in XLAB refers to concrete market rules to simulate real use case in the laboratory

1.4 Narrative of use case

Narrative of Use Case
Short description
The use case aims to demonstrate how the Flexibility platform (VPP) that aggregates many different DERs into a single operating agent can participate in energy system to provide flexibility services to the network (TSO); customers can take advantage from the services in order to reduce their energy bill or to receive incentives from the BSP (Balancing Service Provider). The UC will be implemented in the test XLab in the Rome to test the possibility of managing a cluster of heterogeneous storage resources E2E so that their capacity can be used seamlessly and without constraints for the services of the flexibility market.
Complete description
The HLUC describes how the flexibility services to the network have been implemented to generate revenue and to fulfil TSO requirements: Transmission system operators (TSO) need balancing services to maintain the balance between generation and consumption in real time and to guarantee reliable grid operation. Balancing Services Providers operate on the market to manage different resources and target customers to provide balancing services to the network: by aggregating distributed flexibility resources, aggregator can participate in balancing service market and profit of it. Following the description how the BSP manage the resources and fulfil TSO requirements to supply flexibility services. Once the BSP is qualified to supply flexservice , the Balancing Service Provider receives the request coming from TSO: VPP operator manages Market communication, Portfolio optimization and events orchestration. The business model depends on type of DER (battery storage, industrial, commercial, EVs, etc.). Flexibility operator refers to a specific contract for buying flexibility from DER, which can be independent from the energy supply contract. Following the description of how the different systems are involved in Flex service implementation: Virtual Power Plant Manager (VPP Manager) is a component of the Flexibility platform that interfaces external Energy Markets (e.g. Grid Operators, Utilities) and each participating vertical business to enable their assets to be registered in VPP programs and to communicates VPP commands and collects business vertical information necessary to run VPP programs and event. It also provides tools to internal operations to enable event performance monitoring and control of event execution and provides an interface with Providers (customers) to enable them to participate in VPP using their specific assets and to monitor their own event performance.

The VPP Manager groups together two major components:

- Flex which is the DR Platform, the foundation layer of the VPP Manager
- Flexible Asset Interface (FAI) which is a set of VPP Integration Standards that defines all interactions with the VPP Manager and the participating flexible assets. The standards consist of a set of APIs, events and protocols

The main responsibilities of the VPP Manager includes:

- Offer management: This includes customer offers as well as market offers.
- Respond and execute Event Dispatches triggered by the Market.
- Manage market specific DR and VPP programs.
- Optimize/rank assets for use during events.
- Orchestrate the execution of assets participation.
- Measure energy usage and/or production of assets during executions.

Energy Services

- Controls physical assets
- Acquires Telemetry
- Forecast asset flexibility available
- Flexibility estimation
- Communicates with the VPP manager using the Flexible Asset Interface (FAI)
- Aggregates/Disaggregates the energy consumption/generation of all physical assets that comprise the VFA (Virtual flexible asset). VFA represents an aggregation of a set of Flexible Assets that have the same behaviour as a Flexible Asset (an asset that can participate in a demand response event or energy management activity requiring energy to be generated or curtailed).

IoT Platform

is the platform which accelerates the delivery times to integrate new components and Enel vertical solutions providing an easy mechanism to integrate third party's systems, services and devices through open and standard protocols

Field Assets

Following the assets list included in the UC:

1) PV: 2x12kWp= 24-29kWp bifacial 3SUN
2) Storage medium (lab 1 small C&I): Pylontech 4X 4,8 kW
3) PV: 102-125kWp Bifacial 3SUN
4) Storage large (lab 5): 274kWh Litium Battery LG
5) PV Small 2X3,7kWp= 7,4-9 kWp Bifacial 3SUN
6) Storage small (lab 3): 1X5,5kW super capacitor energy intensive Greenteche
7) EV charger external lab: EnelX V2G electrical vehicle charger

The UC test regards a combo EV, batteries and solar panels. The test implements (values are just for the description of the example):

Initial state.

1) absorbing from the grid an amount of energy. For instance: Charging station = -1200w, Batteries=-
2) 200W and Solar Panels= 400W (producing energy): the total consumption is 1000W
3) Simulation of Market process where we decide to reduce the consumption (for instance 500W)
4) Dispatch signal is sent (from the VPP to ESv4) in order to curtail the consumption
5) Calculation (on Energy service plt) which devices will we impacted and how much for each of them (Forecast) will be the reduction(flexibility estimation)
6) For the final state we will have a new scenario where each asset/device consumption has changed. For instance Charging station = -1000w,
7) For instance Charging station = -1000W, Batteries=100W (using stored energy) and Solar Panels= 400W (producing energy).
8) Total consumption is now 500W

From End Customer point of view:

Customers sign a contract with BSP in order to allow it to operate on the electricity market using their assets: the customer decides to participate in the flexibility services market and signs the contract to grant the use of the BSP; in return receives a remuneration for the use of the asset.

The customer is informed that the service request has been activated and the asset is part of the aggregate VPP. At the end the customer is notified of the result of the action on his storage.

1.5 Key performance indicators (KPI)

ID(*)	Name	Description	Reference to mentioned use case objectives
KPI11	Data space digitized assets	Amount of digitized storage systems/platforms/hubs assets integrated in the common data space exchanging data	2
KP27	Energy Volume exchanged	Energy volume Exchange kWh between different assets within Enel X test plant	(3),(4)
KP28	Different hybridization configuration	Hybridization scenarios with 2 or more different assets	(1)
KP29	Grid peak avoidance	% of reduction of grid peak power due to flexibility activation	(4)
KP19	Number of assets contributing to the connected data space	From all assets integrated in the use cases we identify how many are connected to the dataspace	(2)
KP19	Number of variables being shared in the connected data space	Combined number of asset variables shared with the connected data space	(2)
KP10	Number of assets integrated with IEEE2030.5	Inverters, Battery management system will be integrated in IEEE20.30.5 environment	(2)
KPI25	Integrated capacity	Integrated power of the HESS within the project demos	2
KPI26	Increase of flexibility	Demand side flexibility potential increase due to hybridization implementation	2

(*) The ID number is based on the project KPI reference list –

1.6 Use case conditions

Use case conditions
Assumptions
• Balancing order simulation is available from VPP flexibility platform • PV generation forecasts are available • Access to single assets consumption and production data • Data production and consumption are loaded form the field in IoT Platform to be elaborated
Prerequisites

- A translation form Modbus to IEEE 20.30.5 should be performed
- A Gateway with protocol converter from Modbus to IEEE2030.5 should be installed
- A flexibility order could be generated to the VPP Flexibility platform
- Power set point signal could be sent to a single asset
- Select a reference flexibility program to run the simulation against, so that this use case complies with realistic, concrete market rules

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Relation to other HLUCs: HLUC 1: Flexibility Management for grid services HLUC 2: Interoperability Large and medium size storage with EV chargers storage
Level of depth
High level use case (HL-UC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution
Prioritisation
High level or priority
Generic, regional or national relation
Generic
Nature of the use case
Business use case
Further keywords for classification
Flexibility, forecast, HEMS, storage, prosumer, interoperability,

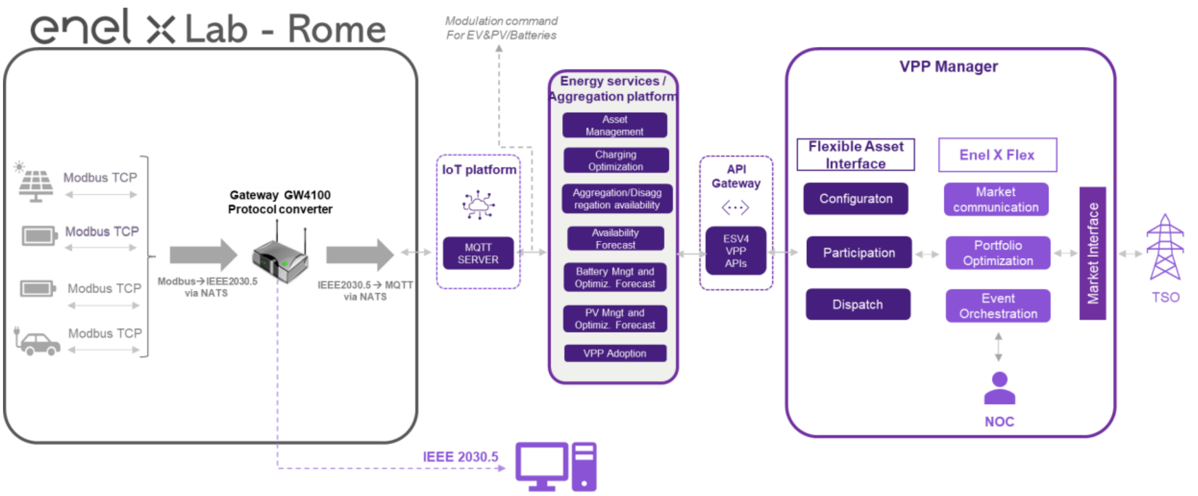
1.8 General Remarks

General Remarks
In the UC service architecture proposed it is important to guarantee a standardized data structure for the information exchange between assets and service platform: to do that a gateway converter (from Modbus to IEEE 2030.5 and from IEEE2030.5 to MQTT) should be provided

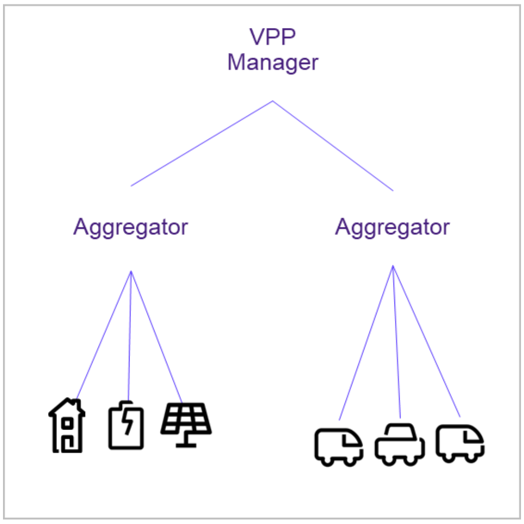
2 Diagrams of use case

Diagram(s) of use case
HLUC-PUC Relation Diagram in two steps implementation: Scenario description: data from asset are received in a gateway GW4100 and protocol messages are converted from Modbus TCP to IEEE 2030.5 and converted again to MQTT to be sent to IoT platform to the centralized platform.

HLUC09 – Management of EV charging clusters as HESS



Actors diagram:



HLUC: Sequence Diagrams:

1) Information exchanged for flexibility provision

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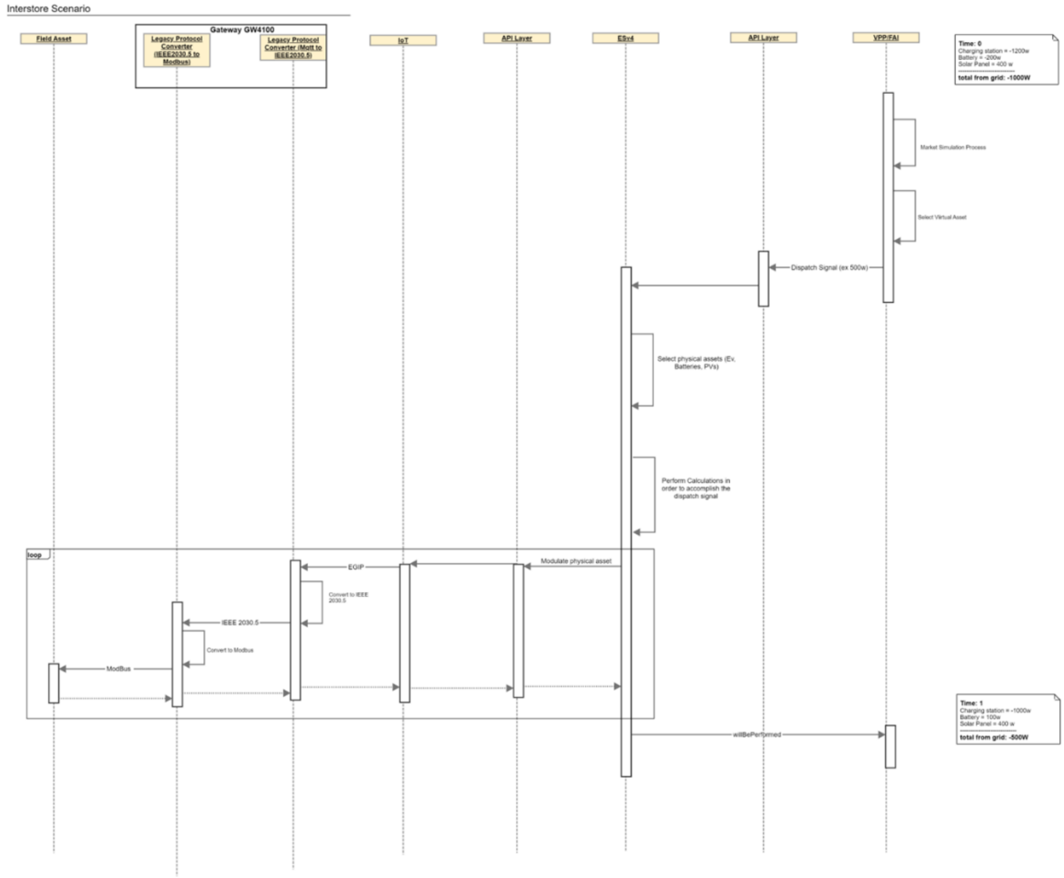

2) Hybridrization & Monitoring collection

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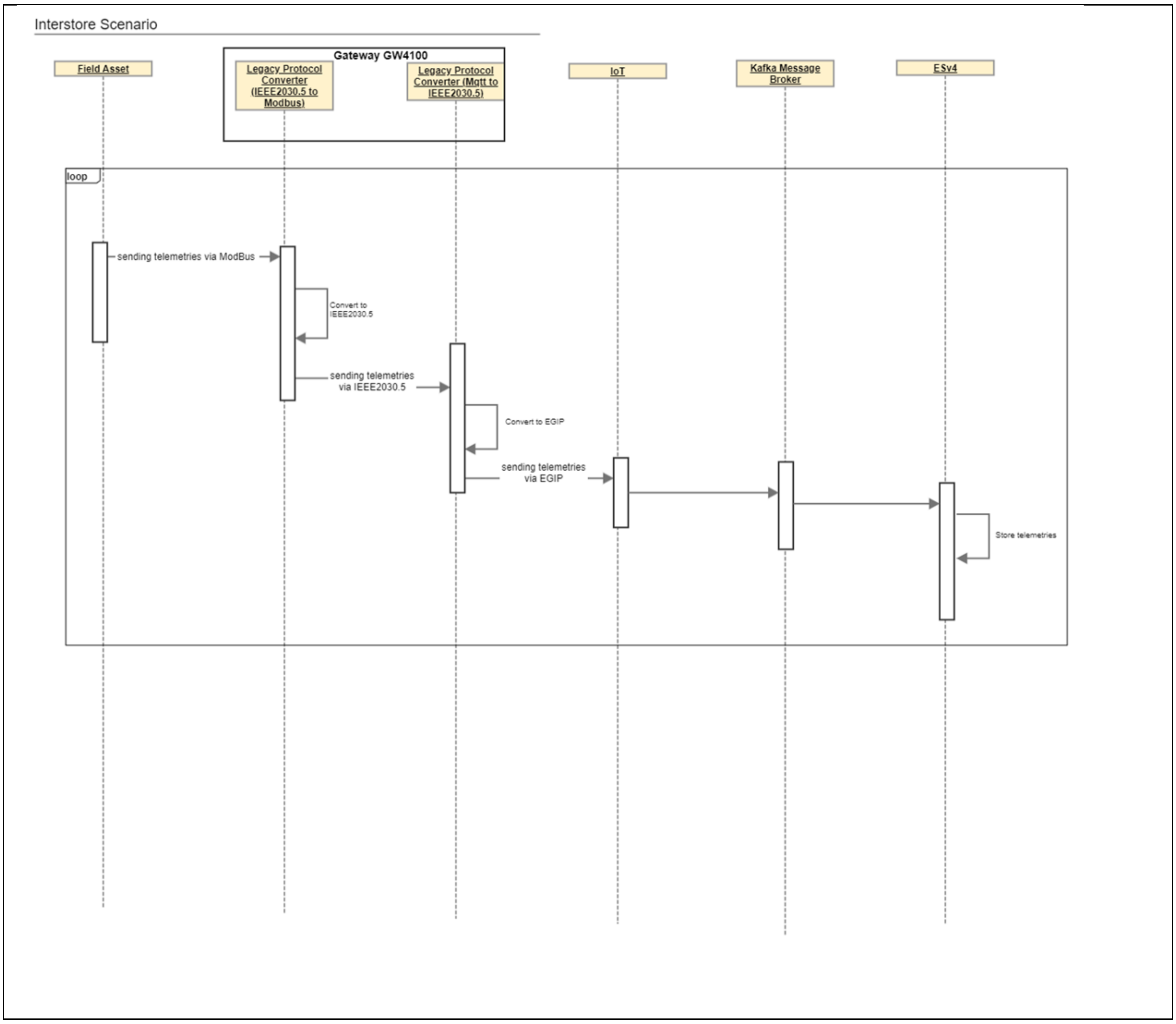

3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
XLAB	Site	The site where the assets are installed, and the activities will be performed
Asset	Device	Object Asset installed in XLAB (see table attached)
Gateway	Device	Gateway converter
PV plant	Device	Device to provide Electrical Energy from sun light (the once to be used are bifacial modules)
Storages	Devices	Large (storage 1) and small size (storage 2) batteries used to store Energy
IoT	System	The software platform and corresponding business to store data from devices (telemetries)
EVs	System	Electrical Vehicle system
Energy services and Asset Management Platform	System	The software platform and corresponding business to manage single devices and perform forecast, availability and site management
VPP Flexibility platform	Platform	The software platform and corresponding business that manages Flexibility services portfolio and interfaces with the TSO
Flex Asset Interface (FAI)	Platform	Interface to translate the request service order in VPP order with VPP manager capabilities

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
1	Spredsheet Document	Assets List definition and specs	released		InterSTORE internal document	
2	Data Communication architecture	Gateway specs	released	Data availability	InterSTORE internal document	
3	Standard	IEEE2030 protocol description	Published		IEEE	
4	Data sharing	Virtual Machine	To be implemented			

4 Step by step analysis of use case

4.1 Overview of scenarios

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Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Flexibility Event Order request	A simulated flexibility order is start from VPP (supposed to come from TSO)	VPP	A flexibility order is simulated from VPP	Forecast and Flexibility estimation available	The flex order is fulfilled: the aggregated assets implement the order received
2	Data Gathering	Collect Data Monitoring from Asset	Energy Service Platform	Data Telemetries request to the assets	The single asset supplies information on data monitoring	The data monitoring are received by ES and used to calculate forecast and Flex estimation

4.2 Steps – Scenarios

4.2.1 Scenario table on flexibility provision

Scenario								
Scenario name:	*No. 1*							
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1	Trigger by the user	Market Simulation	VPP Perform a market simulation request	Execute	VPP	VPP	VPP-1	R-CONF.1, R-CONF.2, R-SEC.1 , R-DM.1, R-DM.2
2	Market simulation event	Select Virtual Asset	Selection of the (Virtual) Assets enrolled on the VPP	GET	VPP	VPP	VPP-2	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2
3	Flex Order	Dispatch Signal	Send a Dispatch signal in order to perform a curtailment load	SET	VPP	ASSET Manager/ESv 4	VPP-3	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2 , R-SEC.3 , R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
4	Dispatch Signal Event	Select Physical assets	Select Batteries, EV and PVs for performing the curtailment	GET	Asset Manager/ESv4	Asset Manager/ESv 4	AM-1	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2, R-DM.5

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5	Selected Field Assets	Perform Calculation	Perform Calculation for choosing the best actions to perform Flex provision	Execute	Asset Manager/ESv4	Asset Manager/ESv 4	AM-2	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2, R-DM.5
6	Optimizatio n Results	Modulate Physical Asset	Execute modulation on each of the physical asset participating	SET	Asset Manager/ESv4	IoT	AM-3	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2 , R-SEC.3 , R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
7	Asset Manager Modulation Message	Modulate Asset	Execute modulation on the asset	SET	IoT	Gateway/Lega cy Protocol Converter	AM-3	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2 , R-SEC.3 , R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
8	IoT message	Protocol Conversion to IEEE 2030.5	Perform message protocol conversion to IEEE 2030.5	Execute	Gateway/Lega cy Protocol Converter	Gateway/Lega cy Protocol Converter	LPC-1	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.3, R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.5
9	IEEE 2030.5 message	Send IEEE 2030.5 message	Send modulation message in IEEE 2030.5 format	SET	Gateway/Lega cy Protocol Converter	Gateway/Lega cy Protocol Converter	LPC-1	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

10	IEEE 2030.5 message reception	Protocol Conversion to ModBus	Perform message protocol conversion to ModBus	Execute	Gateway/Legacy Protocol Converter	Gateway/Legacy Protocol Converter	LPC-2	R-CONF.1, R-CONF.2, R-CONF 3, R-CONF 4, R-CONF.5, R-SEC.3, R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.5
11	ModBus Message	Send ModBus Message	Send modulation message in ModBus format	SET	Gateway/Legacy Protocol Converter	Field Asset	FA-1	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3, R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.5
12	Asset Modulation Performed	Callback Message on For dispatch Signal	Send callback message	Acknowledgement	Asset Manager/ESV4	VPP	AM-4	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2, R-SEC.3, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

4.2.2 Telemetry scenario table

Scenario								
Scenario name:	***No. 1***							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***

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1	Scheduled	Send telemetries via ModBus	Each Asset send telemetries via Modbus	Send	Field Asset	Gateway/Legacy Protocol Converter	FA-1	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
2	Received Telemetry	Convert to IEEE 2030.5	For Each telemetry received perform a message protocol conversion to IEEE 2030.5	Execute	Gateway/Legacy Protocol Converter	Gateway/Legacy Protocol Converter	LPC-3	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
3	Converted Telemetry in IEEE 2030.5 format	Send Telemetries via IEEE2030.5	Send Telemetry message in IEEE2030.5 format	Send	Gateway/Legacy Protocol Converter	Gateway/Legacy Protocol Converter	LPC-3	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
4	Received Telemetry in IEEE 2030.5 format	Convert to EGIP/mqtt	For Each telemetry received in IEEE 2030.5 format, perform a message protocol conversion to EGIP/Mqtt	Execute	Gateway/Legacy Protocol Converter	Gateway/Legacy Protocol Converter	LPC-4	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

5	Converted Telemetry in EGIP/Mqtt format	Send Telemetries via EGIP/Mqtt	Send Telemetry message in EGIP/Mqtt format	Send	Gateway/Legacy Protocol Converter	IoT	LPC-4	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
6	Received Telemetry in EGIP/Mqtt format	Send Telemetries to ESv4	Send Telemetries to ESv4 via message Broker	Send	IoT	ESv4	LPC-4	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2 , R-SEC.3 , R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
7	Received Telemetries from IoT	Store Telemetries	Store Telemetries	Store	ESv4	ESv4	LPC-4	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2, R-DM.5

4.2.3 Failure scenario table on flexibility provision

Scenario								
Scenario name:	*No. 1*							
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1	Trigger by the user	Market Simulation	VPP Perform a market simulation request	Execute	VPP	VPP	VPP-1	R-CONF.1, R-CONF.2, R-SEC.1 , R-DM.1, R-DM.2

2	Market simulation event	Select Virtual Asset	Selection of the (Virtual) Assets enrolled on the VPP	GET	VPP	VPP	VPP-2	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2
3	Flex Order	Dispatch Signal	Send a Dispatch signal in order to perform a curtailment load	SET	VPP	ASSET Manager/ESv 4	VPP-3	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2 , R-SEC.3 , R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
4	Dispatch Signal Event	Select Physical assets	Select Batteries, EV and PVs for performing the curtailment	GET	Asset Manager/ESv4	Asset Manager/ESv 4	AM-1	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2, R-DM.5
5	Selected Field Assets	Perform Calculation with impossible modulation outcome	Perform Calculation for choosing the best actions to perform Flex provision but no modulation can be performed for the current state of the assets	Execute	Asset Manager/ESv4	Asset Manager/ESv 4	AM-2	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2, R-DM.5
12	Performed calculation error event	Callback Message on For dispatch Signal	Send callback message which states the inability to accomplish the dispatch signal	Acknowled gement	Asset Manager/ESV4	VPP	AM-4	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2, R-SEC.3, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

4.2.4 Telemetry Failure scenario table

Scenario								
Scenario name:		*No. 1*						
Step No.	*Event*	*Name of process/ activity*	*Description of process/ activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information Exchanged (IDs)*	*Requirement, R-IDs*
1	Scheduled	Send telemetries via ModBus	Each Asset send telemetries via Modbus	Send	Field Asset	Gateway/Legacy Protocol Converter	FA-1	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
2	Received Telemetry	Error during Conversion to IEEE 2030.5	Error during protocol conversion to IEEE2030.5	Execute	Gateway/Legacy Protocol Converter	Gateway/Legacy Protocol Converter	LPC-3	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
VPP-1	Intra-day flexibility needs	A simulated order is introduced manually in VPP server	R-CONF.1, R-CONF.2, R-SEC.1 , R-DM.1, R-DM.2
VPP-2	Virtual asset information	Aggregate Asset Information visible at VPP level	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2
VPP-3	Curtailment load to perform in a time frame	The amount of electric demand to reduce and the related time frame when it must be done	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2 , R-SEC.3 , R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
AM-1	Physical assets data collection information	Collection of physical asset information related to the aggregated asset exposed to the VPP	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2, R-DM.5
AM-2	Physical assets load configuration	New Physical assets load configuration based on algorithms execution	R-CONF.1, R-CONF.2, ,R-SEC.1 , R-DM.1, R-DM.2, R-DM.5
AM-3	Asset modulation	Physical assets load modulation	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2 , R-SEC.3 , R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
LPC-1	Asset modulation	Physical assets load modulation in IEEE 2030.5 format	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

LPC-2	Asset modulation	Physical assets load modulation in ModBus format	R-CONF.1, R-CONF.2, R-CONF 3, R-CONF 4, R-CONF.5, R-SEC.3, R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.5
AM-4	dispatch signal feedback	Positive/Negative feedback to the VPP on the dispatch signal received	R-CONF.1, R-CONF.2, R-SEC.1, R-SEC.2, R-SEC.3, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
FA-1	Telemetry data	Collection for measurements coming from Physical assets (ex: Batteries Voltage, Temperature, etc...)	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
LPC-3	Telemetry data	Collection for measurements coming from Physical assets (ex: Batteries Voltage, Temperature, etc..) in IEEE 2030.5 format	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5
LPC-4	Telemetry data	Collection for measurements coming from Physical assets (ex: Batteries Voltage, Temperature, etc..) in EGIP format	R-CONF.1, R-CONF.2, R-CONF.3, R-CONF.4, R-CONF.5, R-SEC.1, R-SEC.2 , R-SEC.3 , R-SEC.4, R-DM.1, R-DM.2, R-DM.3, R-DM.4, R-DM.5

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6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
CONF	Configuration	Reflect the typical, probable, or envisioned communication configurations that are relevant to the use case step. These configuration issues include numbers of devices and/or systems, expected growth of the system over time, locations, distances, communication types, network bandwidth, existing protocols, etc., but only from the user's point of view. In some cases, only one of the possible choices is reasonable, while for other situations, more than one choice is reasonable. It includes: - information exchanged with external entities (e.g. service provider, weather data provider, etc.) - information related to the electricity tariff scheme in current use (e.g., variable price and fixed price components). The includes both consumption and generation tariff information. - information related to the weather conditions for the next day/hours to be used by the optimal scheduling methodology to include the local generation. - all the characteristics and configuration parameters related to the use of devices by the HEMS to produce an optimized schedule - all the configuration parameters related to the user preferences in the production of an optimized schedule - the requirements for the information presentation to the end-user - the communication solutions the data models used.

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DM	Data Management	Covers both the management of the data exchanges in each use case step and the management of data at either end if that management is impacted by data exchanges. An example of the first type of data management is the initial setting up and on-going maintenance of what data needs to be exchanged, say between a Geographic Information System and the many different applications that use its data. An example of the second type of data management is the need to backup data or ensure consistency of data whenever it is exchanged, such as if new protection settings are issued to multiple field devices, these settings need to be reflected in Contingency Analysis functions. It should not address database design but should concentrate on the user requirements for the interfaces to databases and other data handling applications. It includes: - all the metering data related with the house consumption and, if applicable, local generation. This information can be obtained by a central metering equipment, like a DSO smart meter or a user electric panel meter. It can also be obtained through distributed meters from electric panel meters, smart plugs or directly from a smart device/system. - the requirements related to the storage of information locally and remotely to the HEMS a structured access to data related to devices and user preferences
SEC	Security	Assess how different security measures applied to different items can potentially interact and either leave security holes or make user interfaces very laborious and possibly unworkable. Security must not only protect against the very harmful but quite rare deliberate attacks, but also against the far more likely inadvertent mistakes, failures, and errors. At the same time, it is necessary to try to identify the requirements and the concerns for implementing security measures. Includes all the security related requirements to allow data between devices, systems and entities to be exchanged in a trustworthy way.
Requirement R-ID	**Requirement name**	**Requirement description**
R-CONF.1	Communication access services requirements	Provides access to the HEMS platform remotely to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities like the availability of DNS lookup, security credentials, firewall configurations, etc.
R-CONF.2	Data exchange methods	Defines the way data is exchanged between different parties (devices, systems, entities)
R-CONF.3	Existence of legacy systems	Addresses the necessary changes (quantification of the effort) and adaptations necessary to the HEMS as related devices to accommodate the integration of legacy systems.

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R-CONF.4	Operation mode of Information Receiver	Defines if the target device is operating in manual or automatic mode
R-CONF.5	Operation mode of Information Producer	Defines if the source device is operating in manual or automatic mode
R-SEC.1	Authentication: Masquerade and/or spoofing - Ensuring that data comes from the stated source or goes to authenticated receiver is:	Warrants protected access to the HEMS platform locally to allow information exchange in a secure way. This includes the necessary communication interfaces and functionalities, security credentials, firewall configurations, etc.
R-SEC.2	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Guarantees the conformity of all the data exchange between the HEMS and its service providers
R-SEC.3	Authentication and Access Control mechanisms commonly used with this data exchange	Requires authentication and encryption of the data exchanged between the HEMS and internal building devices as well as with external systems (e.g., from service providers). Key encryption, certificates and other access control mechanisms are necessary.
R-SEC.4	Network security measures commonly used with this data exchange	Establishes communication network separation (including physical one) and the firewall control list to allow external access to the HEMS.
R-DM.1	Correctness of source data	Ensures that the data is correctly interpreted and used for the purpose it was designed to.
R-DM.2	Management of accessing different types of data to be exchanged	Sets the type of data being exchanged and the expected periodic update (asynchronous or every x time). This is applicable to data exchange internally (e.g., with local database) in the HEMS, with the building devices and with other devices and systems external to the building.
R-DM.3	Validation of data exchange	Guarantees that data exchanged between parties (devices, systems, entities) is valid. It can provide confirmation to originally sending party.

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R-DM.4	Management of data across organizational boundaries	Defines the necessary changes and adaptations to the data exchanges across the building boundaries, between the HEMS and other external systems.
R-DM.5	Data format requirements	Sets specific formats for the data exchange between devices, systems and entities. The following formats are required to be supported by the HEMS: standard computer formats (e.g., binary, integers and floating pt, files); Serial transfer formats (e.g., DNP, Mobdus, LonTalk, BACnet); Graphics formats; Mark-up based HTML, XML; Human readable CSV and JSON; etc.
R-DM.6	SAREF compliant data	The data structures exchanged between systems is SAREF compliant

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
CONF	Configuration
DR	Demand Response
DG	Distributed Generation
DM	Data Management
DER	Distributed Energy Resources
HLUC	High Level Use Case
LV	Low Voltage
BSP	Balancing Service Provider
VPP	Virtual Power Plant
UC	Use Case

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