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Deliverable D1.3

**Pilot Site Surveys results, Use Cases
definition and market needs analysis**

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Deliverable D1.3

Pilot Site Surveys results, Use Cases definition and market needs analysis

Deliverable number	D1.3
Deliverable name	Pilot Site Surveys results, Use Cases definition and market needs analysis
Lead beneficiary	ITG
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ABBREVIATIONS

Abbreviation	Name
AC	Alternating current
API	Application Programming Interface
BACnet	Building Automation and Control Networks
BESS	Battery Energy Storage System
CAN	Controller Area Network
CHP	Combined Heat and Power
CP	Charging Point
DC	Direct current
DER	Distributed Energy Resources
DHO	District Heating Operator
DHW	Domestic Hot Water
DSF	Demand Side Flexibility
DSO	Distribution System Operator
EMS	Energy Management System
ESCO	Energy Service Company
EV	Electric Vehicle
FTP	File Transfer Protocol
H ₂	Hydrogen
HVAC	Heating, Ventilation, and Air Conditioning
HW	Hardware
I ² C	Inter-Integrated Circuit
IoT	Internet of Things
IP	Internet Protocol
IS	Innovative Solutions
KPIs	Key Performance Indicators
LV	Low Voltage
M-Bus	Meter-Bus
MILP	Mixed-Integer Linear Programming
Modbus	Modular Digital Bus
MV	Medium Voltage
OPC	Object Linking and Embedding for Process Control

P2P	Peer-to-Peer
PMS	Power Management System
PS	Pilot Site
PV	Photovoltaic
RE	Renewable Energy
RES	Renewable Energy Sources
REST	Representational State Transfer
RESTful	Representational State Transfer
RS485	Recommended Standard 485
RTO	Research and Technology Organization
SCADA	Supervisory Control and Data Acquisition
SFTP	Secure File Transfer Protocol
SMTP	Simple Mail Transfer Protocol
SOC	State of Charge
SQL	Structured Query Language
SRI	Smart Readiness Indicators
SW	Software
TSO	Transmission System Operator
UC	Use Case
V2G	Vehicle-to-Grid
VC	Voltage Control

EXECUTIVE SUMMARY

Deliverable D1.3 – Pilot Site Surveys results, Use Cases definition and market needs analysis assess the current status in detail and defines the demonstration framework according to the needs of the demonstrated Use Case (UC) scenarios and services.

The methodology followed has been based on (1) the characterization of the pilot sites (PS) from an energy point of view and (2) the definition of use cases and energy services.

Regarding the first aspect, an exhaustive description of the energy context of the PS is carried out, defining their starting point and the expected future situation after the deployment of the solutions and services involved in the EVELIXIA project. In this way, the description of the buildings and energy assets of each PS is addressed, the energy baseline is defined, as well as energy costs, the SRI score, and the energy infrastructure. Special attention is also given to existing and future energy management systems and data communication protocols to be used to make energy assets interoperable with the EVELIXIA platform.

Regarding the second aspect, the definition of each UC for each PS is addressed. For this, the IEC-62559 standard has been followed. For each UC, its scope and objectives, the involved energy assets, the energy services to be demonstrated, and the actors involved are described.

As a result of the work carried out, D1.3 has defined the requirements for each technology and service to be demonstrated by the relevant stakeholders, as well as the range of grid services to be demonstrated, supporting the developments under T5.2. The current state of each PS energy system has been described in detail, which will facilitate the elaboration of the required technical details for EVELIXIA's Innovation Pathways. These pathways will lead to technical and product specifications for all equipment and systems to be engineered and deployed in WP2-WP5.

This deliverable will be updated in month 30 in D1.4, which will focus on refining its context according to the experience acquired from the pilot implementations and preliminary tests (WP5).

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1 INTRODUCTION AND OBJECTIVES

1.1 Scope and objectives

D1.3 is directly linked to the activities foreseen in Task 1.2, considering the definition of the current technical status of the different pilot sites as well as the definition of the relevant use cases in terms of functional and business needs of the engaged pilot site stakeholders.

D1.3 aims to assess Pilot Sites (PS) current status in detail and define the demonstration framework according to the needs of the Use Case (UC) scenarios and services. Specifically, it covers aspects such as:

- Demand/ supply data for establishing an energy baseline.
- Available and future infrastructure state and their characteristics.
- PS requirements for each technology and service to be demonstrated (HW, SW).
- Relevant stakeholders (e.g., system operators, market actors, consumers/prosumers, citizens etc.) roles.
- SRI scores.
- Range of grid services to be demonstrated.

1.2 Structure

The document is structured around each pilot site, covering five sections for each. These are described as follows:

- Section 1. General description of the site
This section introduces the pilot site, its location, and main stakeholders.
- Section 2. Current situation
In this section, a brief description is provided of the most notable buildings and energy assets of the pilot site, including the energy baseline, energy costs, SRI scores, and the grid infrastructure.
- Section 3. Pilot sites future situation
This section describes the energy assets and hardware and software systems to be installed as part of the project, along with the expected situation in terms of energy consumption, generation, and SRI after deployment.
- Section 4. Energy management systems and data communication protocols

This section outlines the existing and future energy management systems and data communication protocols to be used to make energy assets interoperable with the EVELIXIA platform.

- Section 5. Use-cases definition

In this section, the use cases to be carried out at each pilot site are defined. For each use case, its scope and objectives, the involved energy assets, the energy services to be demonstrated, and the actors involved are described.

1.3 Relation to other tasks and deliverables

D1.3 collects the assessment of the pilot sites, including available energy assets, hardware and software systems, use cases, and energy services to be demonstrated, therefore will facilitate the elaboration of required technical details of EVELIXIA's Innovation Pathways, which will derive into technical and product specifications for all equipment and systems to be engineered and deployed in WP2-WP5. At the same time, it will be closely associated with task T1.4, which will define EVELIXIA's architecture based on the use cases outlined in T1.2.

2 PILOT SITE 1. AUSTRIA

2.1 General description of the site

Location: Southern Burgenland, Güssing District, Region of Strem

The pilot area is in the municipality Strem, that lies in the Southeast of Austria, in the province of Burgenland. The municipality is part of the so called ecoEnergyland which is a cooperative of 19 municipalities in the Southern Burgenland and active since more than 20 years in the field of climate protection, renewable energy and energy efficiency. It became a climate and energy model region in Austria, disposing of a huge variety of renewable power plants (biomass & biogas CHP plants, small & large scale PV-plants) and an increased awareness of energy efficiency in the public and private sector based on living lab activities.

Scope: Utilize the existing flexibility sources to tackle the current challenges in the energy sector, improve electric power management, empower associations to actively participate in the market and act as a multifaceted pilot region.



Figure 1. Location. PS#1

2.1.1 Relevant stakeholders

The main goal of the Austrian pilot will be on the one hand to successfully implement the Use Cases and on the other hand to build up a system for a transparent and secure data exchange between energy-sector stakeholders and

the buildings and enabling the use of synergies between them, to open new market and business opportunities.

For the Austrian pilot, it will be important to have all energy related data of the demo area available to allow detailed analytics of the buildings and the overall energy systems, flexibilities, etc.

As relevant stakeholders, there will be different types of stakeholders involved that are represented by internal and external stakeholders. Internal stakeholders within the pilot ecosystem, as we have a DSO and a RES plant operator in the consortium, but also involving the municipality, the building owners, etc. And we will involve external stakeholders like other DSOs, RES plant operators, technology providers, etc. to share and validate results, discuss new business models and to understand drivers and barriers on the market.

Table 1. Relevant stakeholders. PS#1

Stakeholder	Role
European Center for Renewable Energy Güssing	Internal stakeholder – Pilot coordinator, regional energy agency and networking institution, coordinator of the climate and energy model region
Ökoenergie Strem	Internal stakeholder – RES plant and district heating system operator
Biogas Strem	Internal stakeholder – RES plant operator within the pilot area
Energie Güssing	Internal stakeholder – regional small DSO
FB / FHB	Internal stakeholder – technical partners ensuring data communication
Pink	Internal stakeholder - DHW hard and software provider, IS developer & provider
Municipality Strem	Internal stakeholder – participant in the pilot area, public building owner, local stakeholder and decision maker
Private building owners/tenants	Internal stakeholders – participants in the pilot area, building owners or tenants
Social housing company	Internal stakeholder – as owner of the townhouses participating in the pilot area

Nursing home operator	Internal stakeholder – participant in the pilot area as owner of the retirement and care centre
Energy Services	External stakeholder – cloud/API provider, energy data management system operator
EcoEnergyland	External stakeholder – regional association involving 19 municipalities (including Strem) acting in the fields of renewable energy and energy efficiency, important for the dissemination of results, replication and upscaling for the EVELIXIA solution
DSOs and ESCOs	External stakeholders – mainly focused on the provincial DSO and ESCO “Energy Burgenland”
Installation companies	External stakeholders – mainly focused on regional electric and building technology companies, like “Haustechnik Güssing”

2.2 Current situation

2.2.1 Buildings and energy assets

The Austrian pilot covers different private and public buildings, renewable energy plants and a district heating grid as well as a local power grid. Overall, it covers 5 private buildings, 8 identical townhouses and 5 public buildings (retirement & care centre, elementary school, municipality office, mortuary, machine hall). Also, a high number of RES plants is involved, as most of the buildings dispose of a PV-plant and within the pilot there is also RES production based on biomass with a biomass heating plant (1 MW) and a biogas CHP plant (500 kWe/600 kWth).

Table 2. Building 1-8 Townhouses. PS#1

Variable	Description
Name / Type	Townhouse 1-8
Floor Area (m2)	880 m ² (110m ² each)
Year of Construction	2022
N. of Occupants	32 residents



Figure 2. Townhouse 1-8. PS#1

Table 3. Building 9 – PB 1. PS#1

Variable	Description
Name / Type	Public building 1 - Retirement & care centre
Floor Area (m ²)	6.000 m ²
Year of Construction	2004
N. of Occupants	60 residents



Figure 3. Location PB1 – retirement & care centre. PS#1

Table 4. Building 10 – PB2. PS#1

Variable	Description
Name / Type	Public building 2 - Elementary school
Floor Area (m ²)	500 m ²

Year of Construction	1974
N. of Occupants	20



Figure 4. Location – PB2 elementary school. PS#1

Table 5. Building 11 – PB3. PS#1

Variable	Description
Name / Type	Public building 3 - Municipality office
Floor Area (m ²)	199,09
Year of Construction	1970
N. of Occupants	4



Figure 5. Location – PB3 municipality office. PS#1

Table 6. Building 12 – PB4. PS#1

Variable	Description
Name / Type	Public building 4 - Mortuary
Floor Area (m ²)	80 m ²
Year of Construction	1977
N. of Occupants	-



Figure 6. Location – PB4 mortuary. PS#1

Table 7. Building 13 – PB5. PS#1

Variable	Description
Name / Type	Public building 5 - Machine Hall
Floor Area (m ²)	200
Year of Construction	No data available- extensions of the building were made in 1992 – municipality bought it in 2019
N. of Occupants	-



Figure 7. Location – PB5 machine hall. PS#1

Table 8. Building 14 – Priv.B 1. PS#1

Variable	Description
Name / Type	Priv.B 1 - Private building 1 - TRKL
Floor Area (m ²)	350
Year of Construction	Approx. 1925
N. of Occupants	2

Table 9. Building 15 – Priv.B 2. PS#1

Variable	Description
Name / Type	Priv.B 2 - Private building 2 - KCH
Floor Area (m ²)	200
Year of Construction	Approx. 1925
N. of Occupants	3

Table 10. Building 16 – Priv.B 3. PS#1

Variable	Description
Name / Type	Priv.B 3 - Private building 3 - KLVTS 1
Floor Area (m ²)	230
Year of Construction	Ca 1950
N. of Occupants	3

Table 11. Building 17 – Priv.B 4. PS#1

Variable	Description
Name / Type	<i>Priv.B 4 - Private building 4 - KLVTS 2</i>
Floor Area (m ²)	420
Year of Construction	Ca 1950
N. of Occupants	3

Table 12. Building 18 – Priv.B 5. PS#1

Variable	Description
Name / Type	<i>Priv.B 5 - Private building 5 - GSTS</i>
Floor Area (m ²)	225
Year of Construction	Ca 1970
N. of Occupants	2



Figure 8. Private buildings Strem. PS#1

2.2.1.1 Energy Assets

Table 13. Energy assets Building 1-8. PS#1

Energy assets	Description
Heating	8 air-water heat pumps (5kW _{el} each) → 40 kW _e
DHW	hot water tanks (0.35m ³ each) → 2,8 m ³
Lighting	8*15 non-programmable LED lights (15kWh/y/lamp)
Energy Storage	-
On-site RE generation	8 PV-plants (3.3 kW _p each) → 26,4 kW _p
EV Charging	-
Monitoring, Control and Operation	Smart meter monitoring for PV system; energy monitoring with OPT-IN functionality offers the daily load profile (15 min. resolution) accessible for the customers and DSO
Other appliances	-
Planning and Design	Smart meter data (live data)

Table 14. Energy assets Building 9 – PB1 Retirement & care centre. PS#1

Energy assets	Description
Heating	District Heating (200 kW connected load) (supplied by biomass heating & biogas CHP plant)
DHW	District Heating
Lighting	LED
Energy Storage	“Greenrock” saltwater battery storage system 24 kWh (3-phase)
On-site RE generation	4 PV-plants (1x 20 kW _p , 3x 50kW _p) → 170 kW _p (70 kW _p south-oriented, 100 kW _p east-west-oriented)
EV Charging	-
Monitoring, Control and Operation	2 SCADA systems: SCADA 1: Honeywell EXCEL 500, closed system, not expandable controlling functions like: heating/cooling supply, water

	heating (boiler), HVAC kitchen and event area, floor heating/cooling areas north/south SCADA 2: • KNX-system, distributed system • allows single-room control (light, temperature, shading, ventilation) • included weather data Additional smart meter monitoring system – 15 min. granularity.
Other appliances	-
Planning and Design	Smart meter and PV-data available for DSO

Table 15. Energy assets Building 10 – PB2 Elementary school. PS#1

Energy assets	Description
Heating	District Heating (60 kW connected load)
DHW	Electric flow heater (5,7 kW/230 V).
Lighting	Fluorescent tubes
Energy Storage	10 kWh li-ion battery storage system
On-site RE generation	1 PV-plant → 20 kW _p (East-West oriented)
EV Charging	-
Monitoring, Control and Operation	• 9 controllable heating zones, one additional non-controllable zone (zone 10) that represents sanitary, for the zone control, in total 26 valves, 17 valves with thermostatic heads, 12 room temperature sensors with setpoint generators and 32 return medium sensors • A master computer is installed that serves for the visualization of the control devices and the whole control system. • A database is integrated in the new controller (type “WAGO BAC/MOD”).

	- The storage capacity gets configured via SD-cards, the communication is done via BACnet and commands are executed via Python. - The communication to the controller and the database is allowed via FTP access - For the fan coil a heating program can be set, remote control via app possible
Other appliances	-
Planning and Design	Smart meter and PV-data available for DSO

Table 16. Energy assets Building 11 – PB3 Municipality office. PS#1

Energy assets	Description
Heating	District Heating
DHW	Electric boiler
Lighting	Fluorescent and LED lights
Energy Storage	-
On-site RE generation	-
EV Charging	EV charger (KHONS-WB-22-TPSW, AC/AC, output power 22kWe, rated current 32A)
Monitoring, Control and Operation	Monitoring of smart meter data
Other appliances	– 4 cooling units in the old building part of the municipality office building (Mitsubishi split HVAC – Outdoor: MUX-3A63VB, Indoor: MSC-GA35VB & MSC-GA20VB) -controllable by remote control (on/off, temperature) – 1 cooling unit in the new part of the municipality office 1 Daikin, FH45FJ7V1 indoor-unit, R45DC7V1 outdoor-unit, construction year 10/2000, cooling capacity 5,3 kW, controllable by remote control (on/off, temperature)
Planning and Design	Smart meter data available for DSO

Table 17. Energy assets Building 12 – PB4 Mortuary. PS#1

Energy assets	Description
Heating	Infrared (electric) heaters (6 pcs.)
DHW	-
Lighting	inside light bulbs, outside LED
Energy Storage	-
On-site RE generation	PV-plant → 30 kW _p
EV Charging	-
Monitoring, Control and Operation	Room temperature sensors, time scheduling for the 6 infrared heaters
Other appliances	-
Planning and Design	Smart meter and PV-data available for DSO

Table 18. Energy assets Building 13 – PB5 Machine Hall. PS#1

Energy assets	Description
Heating	Air-water heat pump (14 kW _e)
DHW	Electric boiler
Lighting	Fluorescent tubes
Energy Storage	-
On-site RE generation	PV-plant → 25 kW _p
EV Charging	-
Monitoring, Control and Operation	-
Other appliances	Air condition (split unit) – Daikin FH35CVI, ser.no. 2001840, Ventilators in the garages
Planning and Design	Smart meter and PV-data available

Table 19. Energy assets Building 14 – Private building 1- TRKL. PS#1

Energy assets	Description
Heating	District heating
DHW	District heating
Lighting	Mostly LED
Energy Storage	none
On-site RE generation	none
EV Charging	none
Monitoring, Control and Operation	Nopro OPR 0020 (District heating controller)
Other appliances	
Planning and Design	

Table 20. Energy assets Building 15 – Private building 2 – KCH. PS#1

Energy assets	Description
Heating	District heating
DHW	District heating
Lighting	-
Energy Storage	-
On-site RE generation	-
EV Charging	-
Monitoring, Control and Operation	Nopro OPR 0020 (District heating controller)
Other appliances	-
Planning and Design	-

Table 21. Energy assets Building 16 – Private building 3 – KLVTS 1. PS#1

Energy assets	Description
Heating	District heating
DHW	District heating
Lighting	-
Energy Storage	none
On-site RE generation	PV 5 kW
EV Charging	-
Monitoring, Control and Operation	Nopro OPR 0020 (District heating controller)
Other appliances	-
Planning and Design	-

Table 22. Energy assets Building 17 – Private building 4- KLVTS 2. PS#1

Energy assets	Description
Heating	District heating, solar thermal energy
DHW	District heating, solar thermal energy
Lighting	-
Energy Storage	None
On-site RE generation	PV ca 10 kW
EV Charging	-
Monitoring, Control and Operation	TA UVR 16
Other appliances	-
Planning and Design	-

Table 23. Energy assets Building 18 – Private building 5 – GSTS. PS#1

Energy assets	Description
Heating	District heating
DHW	District heating
Lighting	-
Energy Storage	-
On-site RE generation	PV ca 10 kW
EV Charging	-
Monitoring, Control and Operation	Nopro OPR 0020 (District heating controller)
Other appliances	-
Planning and Design	-

2.2.2 Energy baseline

This section gives an overview about the actual energy demand for heat and electricity in the Austrian pilot area and the related annual energy costs.

Table 24. Total energy Consumption (kWh/m²/y). PS#1

Variable	Value
Final energy consumption	59
Primary energy consumption	80

Table 25. Consumption per type (MWh/y). PS#1

Variable	Value
Electricity (from the grid)	98
Electricity (self-generated from RE)	20
District Heating (biomass)	334
Solar Thermal	-
Geothermal	-
TOTAL	452

Table 26. On-Site RE Generation (MWh/y). PS#1

Variable	Value
PV and Wind	4,273
Solar Thermal	-
Geothermal	-
Biomass	-
TOTAL	4,273

2.2.3 Cost of energy

Table 27. Cost of Energy (€/MWh). PS#1

Components	Value
Cost of electricity	300
Cost of heating	200

2.2.4 SRI scores

The SRI scores for the buildings in the Austrian pilot have been calculated for the two different types of buildings involved, that are the residential (private houses and townhouses) and non-residential buildings (public buildings).

Table 28 indicates the SRI scores calculated for the residential buildings are higher than for the public buildings, because the private buildings (mainly the townhouses) are younger and have a higher number of smart or at least controllable devices.

Table 28. SRI scores. PS#1

Building	SRI Score
Residential Buildings (Townhouses + private buildings)	25%
Non-residential buildings (public buildings)	13%

2.2.5 Grid Level. Energy infrastructure

2.2.5.1 Grid topology

At the pilot site of Austria – the municipality Strem – there exists a local power grid operated by the company “Energy Güssing”. This medium-voltage power grid covers different urban districts and can be divided into following areas: Güssing

(urban area), Ludwigshof, Krottendorf, Rosenberg, Neustift bei Güssing, St. Nikolaus, Glasing, Urbersdorf, Sumetendorf, Strem

The system has a length of 182 km in total (71 km with 20 kV and 111 with 0.4 kV voltage). It has 4,136 meter points.

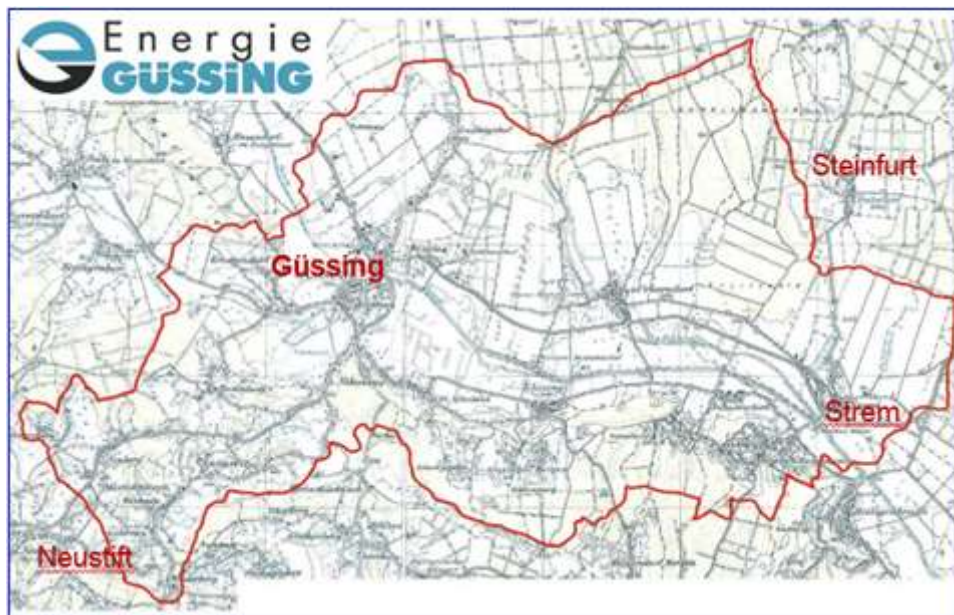


Figure 9. Ruled area of Energy Güssing power grid. PS#1

The voltage levels are 20 kV / 0.4 kV. In the grid there are 67 transformer and 5 switching stations.

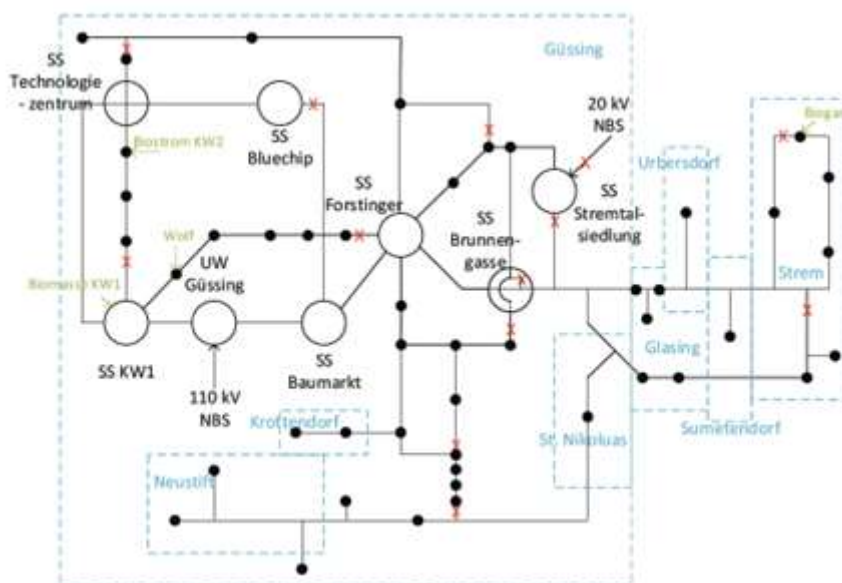


Figure 10. Grid scheme of Energy Güssing power grid. PS#1

In the scheme of the 20kV medium-voltage power grid of Güssing shows the actual status of the grid. The black cycles show the consumer points, the red crosses show the open disconnecting points and the green arrows show the distributed systems. The next figure shows the minimum as well as the maximum knot-voltages at normal operation mode in the grid of Energy Güssing.

Ebene		U	
		%	kV
0,4 kV	max	105,75	0,423
	min	100,25	0,401
20 kV	max	103,65	20,730
	min	102,35	20,470

Figure 11. Minimum and maximum knot-voltages the grid. PS#1

In the grid of Energy Güssing, there are no microgrid activities. But due to the growing numbers of decentralized energy production units, newly arised consumption profiles and declining on dynamic terms of energy prices, the local DSO will have the necessity to undertake microgrid interventions.

2.2.5.2 Grid topology - district heating grid

Öko Energie Strem is a cooperative, whereby approximately 60% of the heat consumers are also members of the cooperative. The heat for the district heating grid derives on from the local biomass district heating plant (based on forestry biomass) as well as from the off-heat form the local biogas CHP plant (based on agricultural biomass). Approximately 2/3 of the heat comes from the biogas CHP. The scheme of the local district heating grid is shown in Figure 12.

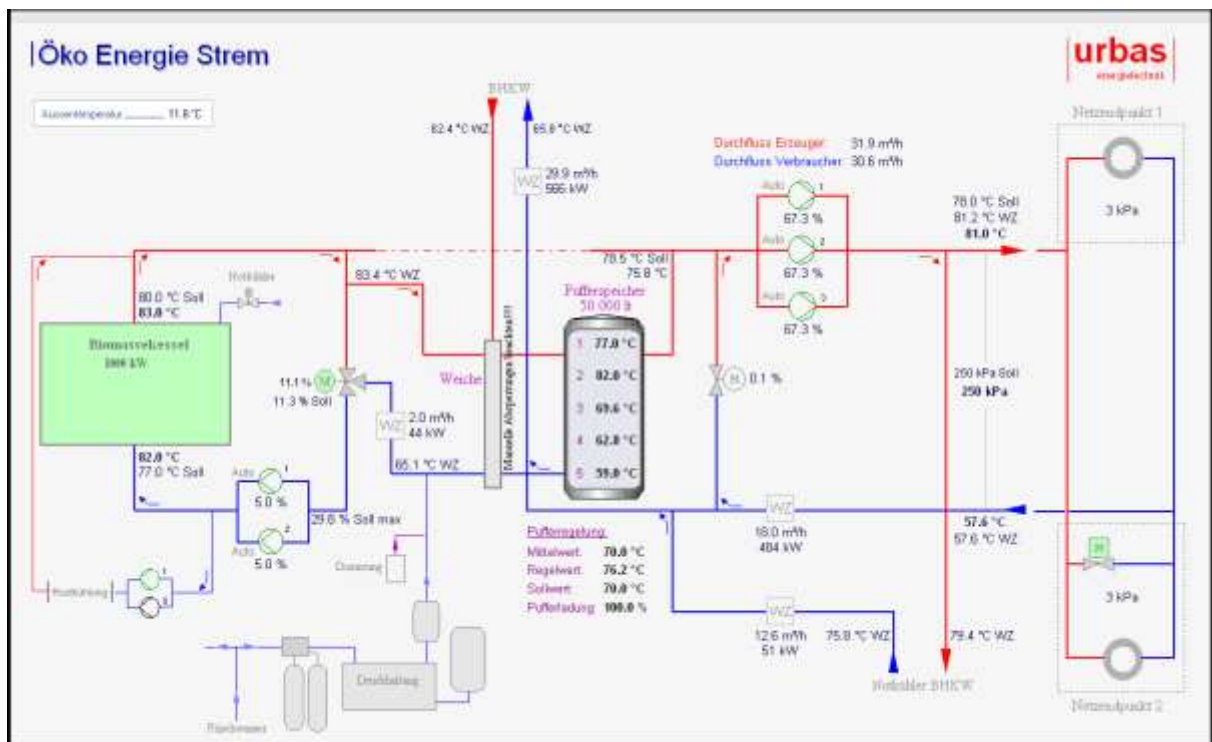


Figure 12. Scheme of the local district heating grid. PS#1

There is a general interest to include the district heating price signals, or just quantification how flattened consumption enabled by the 3Smart energy management platform profile might help the district heating system. During 3Smart is has to be analysed how the district heating system can have benefit from 3Smart approach and how they can contribute to the system. There are 131 heat consumers. Customers' heat consumption is distributed as follows:

Table 29. Customers' heat consumption

Min	1st Qu.	Median	Mean	3rd Qu.	Max	Sum
0	3284	9658	16086	22015	300000	2107279

The biggest consumer is the Retirement & care centre, which uses 14% of the heat sold. Most customers live in apartments where the heating requirement is less than 10 MWh per year. (66 of 131 customers). 26 customers' needs between 10 and 20 MWh. More than 50 MWh only needs the school and an inn and the care centre.

The network itself has a route length of 5600m and was achieved for approx. 50 % of the consumers. The construction of the biogas CHP enabled further supply, although the heat distribution system is reaching its limits. The latest expansion of the heating centre with a 50m³ buffer has further improved the situation.

Additional information on heat network analysis can be found in the annexes.



Figure 13. Overview of the local district heating grid in Strem. PS#1

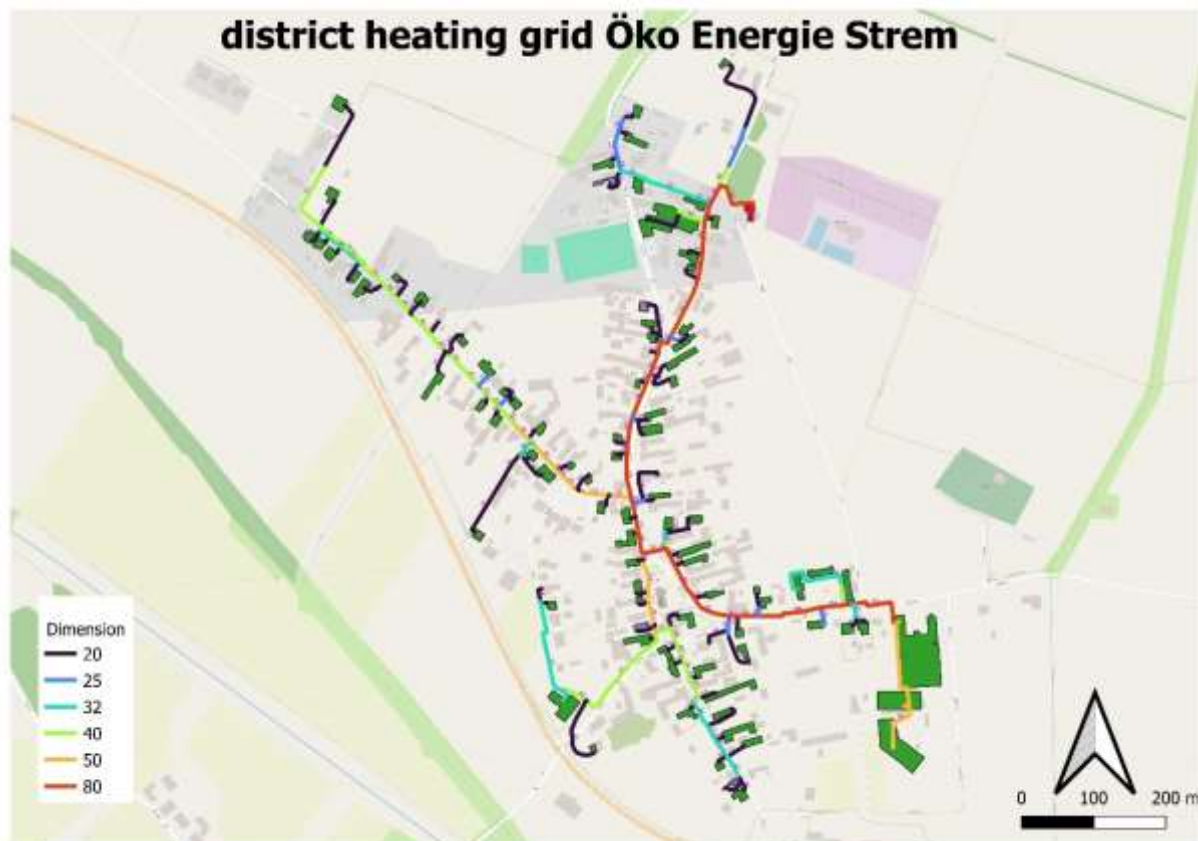


Figure 14. Overview of the local district heating grid in Strem (2). PS#1

2.3 Future situation

2.3.1 New energy assets, hardware and software

Table 30. New technical systems. PS#1

New technical systems	Description
DHW tank	- Domestic hot water tanks with 140 litres - Hybrid charging (thermal & electrical)
Buffer tank	- Buffer tank with 6-10 m³ - Hybrid charging (thermal & electrical) - Prosumer container
Actuators	Switching relays
Controllers	Programmable logic controllers, edge devices
Interfaces	Communication interfaces like modems (if required)

2.3.2 Future Consumption and Generation

Table 31. Total energy Consumption (kWh/m²/y). PS#1

Variable	Value
Final energy consumption	50
Primary energy consumption	69

Table 32. Consumption per type (MWh/y). PS#1

Variable	Value
Electricity (from the grid)	80
Electricity (self-generated from RE)	30
District Heating (biomass)	300
Solar Thermal	-
Geothermal	-
Other (define, e.g. gas, oil)	-
TOTAL	410

Table 33. On-Site RE Generation (MWh/y). PS#1

Variable	Value
PV and Wind	4,298
Solar Thermal	-
Geothermal	-
Biomass	-
TOTAL	4,298

2.3.3 Future SRI scores

Table 34. Future SRI scores. PS#1

Building	SRI Score
Residential Buildings (Townhouses + private buildings)	61%
Non-residential buildings (public buildings)	64%

2.4 Energy management systems and data communication protocols

For the Austrian pilot site, no specific energy management system exists. The pilot site provides the relevant asset infrastructure and within the EVELIXIA project, the communication interfaces for monitoring and control are set up and installed. The interfaces will be connected to EVELIXIA's middle ware platform by the Southbound API connector to allow the EVELIXIA partners a bidirectional data access for monitoring and control. The control signals itself needs to be provided by the innovative solution services participating in EVELIXIA.

Figure 15 depicts the communication architecture covering both energy dimensions, the district heating grid and the electricity grid, as well as the participating buildings as active utility nodes with different energy assets available.

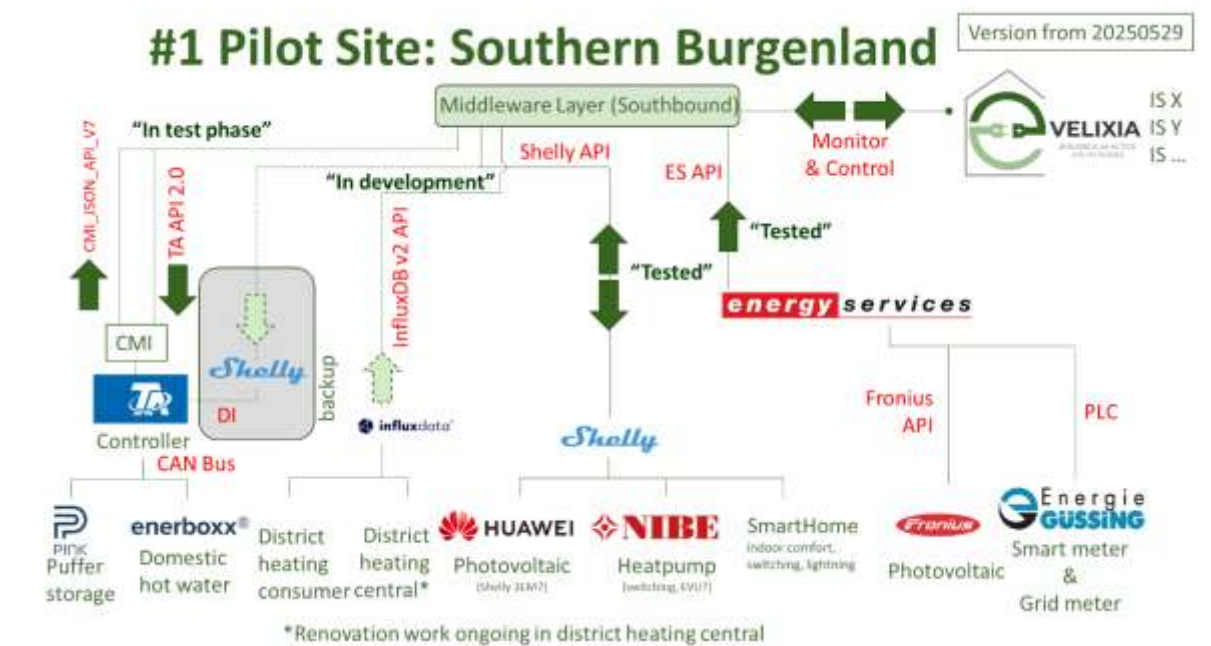


Figure 15. Current status plan of pilot site architecture for monitoring and control communication. PS#1

Table 35. Monitoring and control of energy assets. PS#1

Scope (asset, building, other)	Measurement & Variables	Freq (min)	Monitoring and control	Com. with EVELIXIA
FUTURE				
Electricity grid and individual consumers, producers and prosumers	Electricity consumption, production and residual loads	15	M: energy services API C: none	API REST
Buildings as active utility nodes	Electricity consumption on device level, indoor comfort and operational monitoring as well as actuators	~5 min*	M: Shelly API C: Shelly API	API REST
DHW tank	Operational monitoring and actuators	~5 min*	M: TA API C: TA API 2.0	API REST
Buffer tank	Operational monitoring and actuators	~5 min*	M: TA API C: TA API 2.0	API REST
District heating consumers & central	Operational monitoring	~5 min*	M: InfluxDB API C: none	API REST

*To be confirmed

2.5 Use cases definition

EVELIXIA endeavours to underscore the viability and efficacy of integrating buildings as active utility nodes into the broader energy landscape by showcasing innovative strategies, technologies and services. Central to this initiative are the pilot demonstrations of the proposed solutions through their respective Use Cases.

Table 36. Use Case Summary. PS#1

ID	Use Case	Description
UC-AT#1	Thermal flexibility of district heating	Enhancing thermal flexibility in the district heating grid by decentralized thermal storage solutions at the end-user (DHW storage system Enerboxx) and/or at critical network locations (buffer storages)

UC-AT#2	Local optimization of electricity consumption	Flexible operation of heat pumps, electrical water heaters and/or possibly consuming assets at individual consumer and prosumer level to meet requirements of implicit and explicit demand side flexibility incorporating local production and DSO requirements
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Table below presents the different services encompassed in each Use Case of the Austrian Pilot Site.

Table 37. Energy Services to be demonstrated per Use Case. PS#1

Category	Energy Service	UC-AT#1	UC-AT#2
Behind the meter	DSM Implicit	✓	✓
	Building Investment Planning	-	-
Front of the meter	DER Dispatch	✓	✓
	P2P energy (flexibility) trading	-	-
	Portfolio management services (day-ahead/intra-day)	-	✓
	Network Investment Planning	✓	-

Where:

- DSM Implicit: Adjusting demand fractions (load(s) curtailment or total shifting) by reducing/curtailing or entirely shifting energy-intensive loads during expensive periods to cheaper ones (within the same energy vector or between different sectors -coupling).
- Building Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.
- DER Dispatch: real-time distributed generation and storage (large farms or virtually pooled) dispatch based on grid conditions and financial incentives. Leverage the available local-grid storage farms during peak hours to cover local demand, thereby reducing congestion levels on central power distribution lines
- P2P energy (flexibility) trading: Decentralized synchronized coordination of demand between mutualized/aggregated/community customers (increase-to-decrease demand schemes to provide the same service to the grid)

- Portfolio management services (day-ahead/intra-day): Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading and maximize aggregators' returns, implementing explicit DR schemes in accordance to the upfront market bids. Upfront-selling the potential/estimated result of demand response actions in electricity markets. Based on appropriate predefined contracts (e.g., the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding of large loads is applied in response to incentives provided by aggregators/DR service providers.
- Network Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating, steam, gas) grid needs ensuring reliability, efficiency, and sustainability.

2.5.1 Use case 1. UC-AT#1: Thermal flexibility of district heating

Use Case description

Name

UC-AT#1: Thermal flexibility of district heating

Scope

The scope of UC-AT#1 encompasses various strategies and technologies aimed at optimizing the efficiency, reliability, and sustainability of district heating systems. This use case focuses on several key areas:

- The installation and operation of decentralized buffer tanks play a crucial role in mitigating bottlenecks within the distribution network. These tanks store thermal energy, allowing for a more balanced and continuous energy flow, thereby enhancing the overall efficiency of the system.
- Efficient management of domestic hot water (DHW) energy supply is achieved by balancing the contributions from district heating and on-site photovoltaic systems. This dual approach not only ensures a reliable supply of hot water but also leverages renewable energy sources, reducing dependency on traditional energy supplies and promoting sustainability.
- Integrating the district heating energy domain with the electric grid and decentralized renewable energy sources creates a more resilient and adaptable energy network. This coupling facilitates the efficient use of available energy resources, supports grid stability, and enhances the overall flexibility of the heating system.

Objectives

- Overcome bottlenecks in the distribution network by installation and operation of decentralized buffer tanks
- Balance DHW energy supply between district heating and on-site photovoltaic systems
- Couple district heating energy domain with electric grid and decentralized renewable energy domain

Limitations & Assumptions

It is assumed that the required control signals for the defined objectives of the use case are provided by the integrated solutions of the EVELIXIA platform. There is no pilot specific energy management platform considered for the pilot site. Hence, from pilot side perspective the limitations of the use case mainly relate to the data availability and communication with the EVELIXIA middleware layer (South Bound API connector) and the local stakeholders, occupants and assets.

- Thermal comfort constraints of occupants (e.g. room and domestic hot water temperature levels)
- Adaptability of the existing infrastructure to provide flexibility services
- Data Acquisition limitations due to closed, proprietary systems
- Behaviour of local occupants who are affected by DSF measures
- Reliability of communication infrastructure based on local internet connection and server availability of cloud providers
- Reliability of local edge devices providing bi-directional data interfaces

Assets of the Use Case

- Decentralized puffer tank actuators to define specific charging profiles from the district heating grid
- Electrical water heater actuators to store and provide domestic hot water (actuators to be defined)
- Monitoring equipment (for selected buildings within the use case)
 - Thermal smart meters
 - Thermal comfort evaluation
 - State of Charge evaluation of thermal storage solution
- Communication infrastructure
 - Local sensors and actuators
 - Edge devices for local data handling
 - Cloud providers with API services

Further information

The UC-AT#1 is physically connected to the UC-AT#2 by the applied decentralized domestic hot water thermal storage system “enerboxx” combining the domains of district heating and electricity grid in a single asset.

Grid Services Selection

- Demand Side Flexibility Implicit: Adjusting thermal load consumption patterns by incentives of district heating grid operator or local boundary conditions (local photovoltaic system, thermal constraints)
- Demand Side Flexibility (Load) Shifting: Moving consumption patterns to different time frames as result of puffer tank management at decentralizes grid locations
- DER dispatch: Heat supply district heating: biogas, biomass, electricity via PV power
- System planning: Analysis of thermal network by PINK and derivation of location and dimensioning of buffer tank

Prioritisation of the use case

Obligatory.

Market mechanisms

Use case focuses on thermal district heating grid and is not applicable for electricity market mechanisms.

Use Case Narrative

In the quest to enhance the thermal flexibility of district heating systems, several key strategies are employed to optimize efficiency and sustainability. To optimize district heating systems, decentralized puffer tanks are installed to reduce distribution bottlenecks. Balancing domestic hot water supply between district heating and photovoltaic systems maximizes renewable energy use. Additionally, integrating district heating with the electric grid and decentralized renewable sources boosts system resilience and adaptability, creating a more efficient and sustainable energy network.

Complete description of the use case

Within the use case multiple grid services are addressed for the thermal energy vector of the pilot site.

- The implicit demand side flexibility service involves adjusting the thermal load consumption patterns of consumers based on incentives provided by the district heating grid operator. It also considers local boundary conditions, such as the availability of energy from local photovoltaic systems and existing thermal

constraints. The goal is to optimize energy usage without requiring direct intervention from the consumers.

- The demand side flexibility in terms of load shifting focuses on altering consumption patterns by moving energy use to different time frames. This is achieved through the management of puffer tanks at decentralized grid locations. By storing thermal energy during low-demand periods and releasing it during peak times, this service helps balance the grid, minimises the need for investment in expensive network infrastructure and improves overall efficiency.
- At the district heating central on the pilot site, several renewable energy sources are available to provide the required energy for the district heating network. These sources include biogas, biomass, electricity generated by a local photovoltaic (PV) power plant and electricity provided by multiple small scale PV systems along the district heating grid infrastructure. Therefore, a dispatch between the centralized and distributed energy resources is required to support the operative decision making for an optimal operation of the district heating system.
- System planning entails a comprehensive analysis of the thermal network using district heating grid simulation tools. This analysis helps determine the optimal locations and sizes of buffer tanks needed to improve grid performance. Proper system planning ensures that the district heating grid operates efficiently and meets the thermal demands of its users effectively.

Table 38. Technical details and actors involved. UC-AT#1

Name	Actor Type	Description	Further information specific to this Use Case
EEE*	Research Institute	Pilot coordinator	-
FHB&FB*	University of Applied Sciences	Data interfaces	-
ÖE*	District heating operator	Provides data and operates district heating grid	-
PINK*	Hardware manufacturer and control engineering	Hardware & Innovative solution provider	-
EVELIXIA partners*	Innovative solution provider	Providing control signals for optimal operation of plants	-
Municipally Strem	Building owner & occupants	User	-

Private building owners			-
Energy Services	Cloud/API provider	Data storage, management and interface provider	-
SHELLY EUROPE LTD.			-
Technische Alternative			-
RES plant owners	DER operator (Biogas)	Energy provider	-
Haustechnik Güssing	Installation company	Required conversion and installation	-

* Part of EVELIXIA consortium

Table 39. Step by step analysis. UC-AT#1

No	Scenario name	Scenario description	
1	Demand Side Flexibility Implicit	Adjusting thermal load consumption patterns by incentives of district heating grid operator or local boundary conditions (local photovoltaic system, thermal constraints)	
		Primary actor	Noval storage solution for domestic hot water
		Triggering event	Availability of local photovoltaic surplus energy, low-cost thermal energy input in the district heating grid or regional surplus of renewable energy within energy communities and/or occurrence of off-peak periods; present or future triggering events by forecasts
		Pre-condition	Multiple, e.g. potential for hot water supply is available
		Post-condition	Commands for thermal or electric hot water heating; Immediate or predictive command nature
2	Demand Side Flexibility (Load) Shifting	Moving consumption patterns to different time frames as result of puffer tank management at decentralizes grid locations	
		Primary actor	Decentralized puffer storage tanks placed at critical branches within the thermal district grid
		Triggering event	Local undersupply in district heating network, proactive identified by forecasts or live data
		Pre-condition	Puffer storage potential available and customer-energy consumption given

		Post-condition	Puffer storage charge or discharge commands; live signals or optimized operation plans for the near future
3	DER dispatch	Dynamic selection of central and distributed heat supply for district heating.	
		Primary actor	District heating grid operator
		Triggering event	Availability, operative costs and/or emission factors of central and distributed renewable energy sources, current and future power requirements of district heating grid
		Pre-condition	Among others, data availability
		Post-condition	Optimal predicted dispatch plan to support decision making
4	System planning	Analysis of thermal network and derivation of location and dimensioning of buffer tank	
		Primary actor	PINK
		Triggering event	Local shortages in the thermal power supply at critical branches of the district heating network
		Pre-condition	Historical data at grid and customer level
		Post-condition	Location and dimension of puffer tank

2.5.2 Use Case 2. UC-AT#2: Local optimization of electricity consumption

Use Case description
Name UC-AT#2: Local optimization of electricity consumption
Scope UC-AT#2 aims to optimise the electricity consumption pattern of individual consumers. The primary scope is to focus on single assets that cause most of the electricity consumption behind a specific metering point like heat pumps and electrical heaters. Because of its energy intensive nature, these assets refer mainly to power-to-heat applications. Additionally, further electricity consuming assets like laundry devices (washer/dryer) or other individual household consumers may be integrated in the use case.
Objectives

- Minimizing electricity costs for end-users through active load shifting and demand side flexibility by utilizing time variable energy and/or grid tariffs and maximizing self-consumption of (behind the meter, local) photovoltaic assets
- Optimizing electricity self-consumption within local energy communities (virtual sub-grid connecting multiple consumers and producers) with a high proportion of photovoltaic generation
- Counteract overloads on local transformer stations due to simultaneities in the consumption patterns of connected consumers by the distribution system operator (DSO) through direct and indirect influence on the end-users behaviour.
- Counteract overloads on local transformer stations due to simultaneities in the production patterns of connected producers (photovoltaic systems) through specific signals.

Limitations & Assumptions

It is assumed that the required control signals for the defined objectives of the use case are provided by the integrated solutions of the EVELIXIA platform. There is no pilot specific energy management platform considered for the pilot site. Hence, from pilot side perspective the limitations of the use case mainly relate to the data availability and communication with the EVELIXIA middleware layer (South Bound API connector) and the local occupants and assets.

- Thermal comfort constraints of occupants (e.g. room and domestic hot water temperature levels)
- Adaptability of the existing infrastructure to provide flexibility services
- Data Acquisition limitations due to closed, proprietary systems
- Behaviour of local occupants who are affected by DSF measures
- Reliability of communication infrastructure based on local internet connection and server availability of cloud providers
- Reliability of local edge devices providing bi-directional data interfaces

Assets of the Use Case

- Smart meters operated by the DSO for production and consumption for single and accumulated metering points
 - Electrical consumptions and production patterns on metering point level
- Heat-pump actuators to block or enable heat pump operation or initiate set point increases
- Electrical water heater actuators to store and provide domestic hot water (actuators to be defined)
- Monitoring equipment (for selected buildings within the use case)
 - Electrical consumptions and production patterns on asset level

- Thermal comfort evaluation
- Communication infrastructure
 - Local sensors and actuators
 - Edge devices for local data handling
 - Cloud providers with API services

Further information

The UC-AT#1 is physically connected to the UC-AT#2 by the applied decentralized domestic hot water thermal storage system “enerboxx” combining the domains of district heating and electricity grid in a single asset.

Grid Services Selection

- **Demand Side Flexibility Implicit:** Adjusting electricity consumption patterns by incentives of grid operator, energy retailer, energy community or local boundary conditions (local photovoltaic system)
- **Demand Side Flexibility Explicit:** Adjusting electricity consumption patterns by direct control signals of grid operator or possibly other stakeholders
- **Demand Side Flexibility (Load) Shifting:** Moving consumption patterns to different time frames as result of implicit or explicit DSF
- **Demand Side Flexibility (Load) Shedding:** Switch-off defined consumption assets as result of implicit or explicit DSF
- **Portfolio management services (day-ahead/intra-day):** In terms of the possibility of using the historical consumption and generation data for asset-specific forecasts providing insights for day-ahead and intra-day portfolio management.

Prioritisation of the use case

Obligatory.

According to the energy service structure, the implicit demand side flexibility has the highest priority since it inherent covers multiple other energy services and take local constraints of the specific assets into account. It is therefore seen as obligatory for the use case.

Explicit demand side flexibility is optional, supports critical DSO requirements and should not be the standard operation case but still available for critical operational situations.

Services for portfolio management like forecasts are classified as nice to have and not crucial for the use case itself.

Market mechanisms

Hourly electricity spot prices can be incorporated in the implicit DSF application

Use Case Narrative

The objective of UC-AT#2 is to optimize the electricity consumption patterns of individual consumers. The primary scope encompasses single assets that contribute most significantly to electricity consumption behind a specific metering point, such as heat pumps and electric heaters. Due to their energy-intensive nature, these assets are primarily associated with power-to-heat applications. Additionally, other electricity-consuming devices, such as laundry appliances (washers and dryers) and various household electronics, may also be incorporated into this use case to achieve comprehensive energy optimization.

Complete description of the use case.

Within the use case multiple grid services are addressed for the electric energy vector of the pilot site to meet the defined objectives of the use case.

- The implicit demand side management strategies will adjust electricity consumption patterns based on incentives provided by grid operators, energy retailers, energy communities, or influenced by local boundary conditions, such as the availability of energy from local photovoltaic systems.
- The explicit demand side management will directly control and influence the consumption patterns by signals addressing consumption and production appliances behind the meter.
- The portfolio management services involve using historical consumption and generation data to create asset-specific forecasts, offering insights for day-ahead and intra-day portfolio management.

Table 40. Technical details and actors involved. UC-AT#2

Name	Actor Type	Description	Further information specific to this Use Case
EEE*	Research institute	Pilot coordinator	-
FHB&FB*	University of Applied Sciences	Data interfaces	-
EG*	DSO	Provides access and data to distribution grid	-
PINK*	Hardware manufacturer	DHW hardware provider	-

EVELIXIA partners*	Innovative solution providers	Provide control signals for electric appliances	-
Municipally Strem	Building owner & occupants	User	-
Private building owners			-
Energy Services	Cloud/API provider	Data storage, management and interface provider	-
SHELLY EUROPE LTD.			-
Technische Alternative			-
RES plant owners	DER operator (Photovoltaic)	Renewable energy supply	-
Haustechnik Güssing	Installation company	Required conversion and installation	-

Table 41. Step by step analysis. UC-AT#2

No	Scenario name	Scenario description	
1	Demand Side Flexibility Implicit	Adjusting electricity consumption patterns by incentives of grid operator, energy retailer, energy community or local boundary conditions (local photovoltaic system)	
		Primary actor	Consumption and production appliance behind the meter
		Triggering event	Incentives by the grid operator, energy retailer, energy community or local surplus photovoltaic energy
		Pre-condition	Shut-on/Shut-off potential of the devices
		Post-condition	Live control signal or future operation plan
2	Demand Side Flexibility Explicit	Adjusting electricity consumption patterns by direct control signals of grid operator or possibly other stakeholders	
		Primary actor	Consumption and production appliance behind the meter
		Triggering event	Critical operation conditions in the local distribution grid due to simultaneities in the

			consumption or production patterns of connected appliances behind the meter.
		Pre-condition	Shut-on/Shut-off potential of the devices
		Post-condition	Live control signal or future operation plan
3	Portfolio management services (day-ahead/intra-day)	Providing historic, present or possibly future consumption and production patterns of residual load at meter level to support portfolio management of local grid operation.	
		Primary actor	DSO
		Triggering event	Among others, critical operation states in distribution grid
		Pre-condition	Available data and developed methods
		Post-condition	Specific processed information to support decision making within addressed grid level

3 PILOT SITE 2. ROMANIA

3.1 General description of the site

Location: Location: Cluj-Napoca, which is the second most populated city in Romania, in the north-western part of the country. The climate of Cluj-Napoca can be described as temperate continental climate, characterized by warm, dry summers and cold winters.

Scope: Technical University of Cluj-Napoca (TUCN), being a public higher education and research institution, pays an increased attention to the energy efficiency of its own blocks of buildings, as the annual cost of utilities is currently around 5% of total annual incomes. From all the buildings belonging to TUCN, the Campus “Marasti” (two dormitories and one restaurant) has been chosen to take part as a pilot in EVELIXIA project implementation. The dormitories are 11 floors high with 20 rooms in each floor. Each room can accommodate 4 students, and some only 2 students on each floor. The energy use intensity is 319.5 kWh/m² year, although the buildings’ envelopes are insulated.

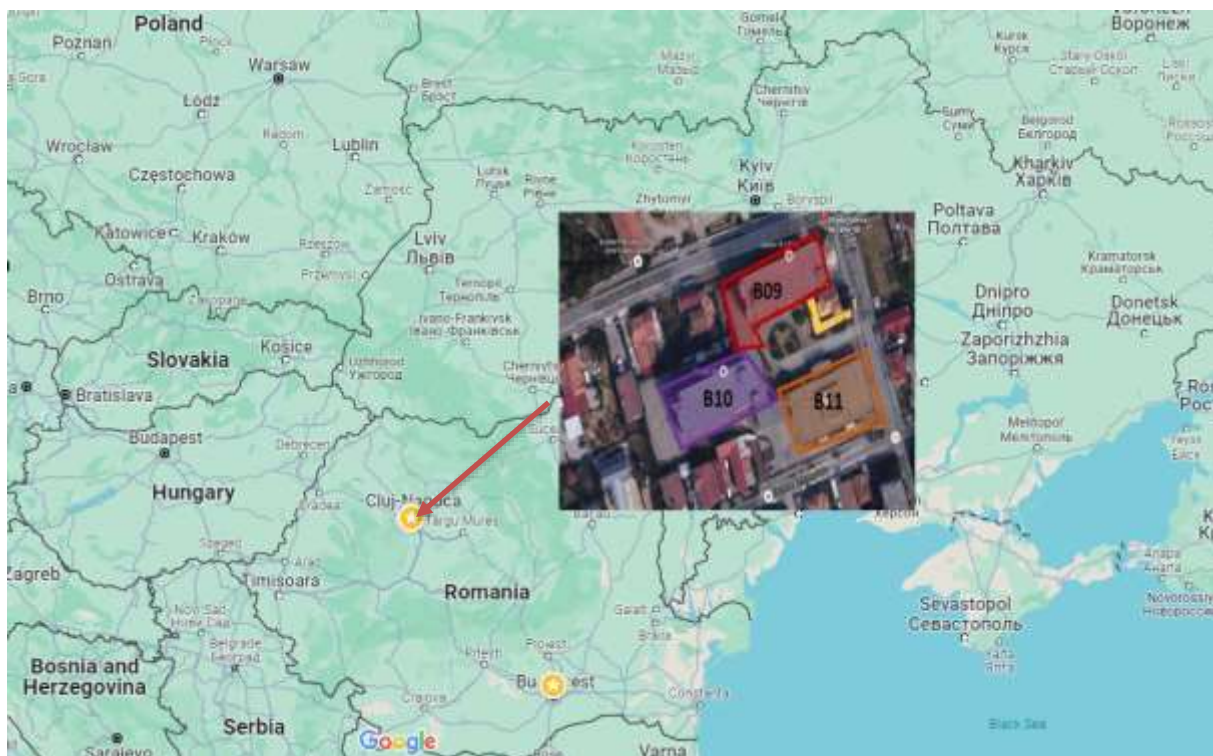


Figure 16. Geographical location of the TUCN pilot site in Romania. PS#2

Table 42. Description of the buildings. PS#2

Variable	Description
Name / Type	Campus “Marasti” Student Dormitories (two buildings)/Residential – 11 floors high Campus restaurant – Non-residential (Tertiary)
Floor Area (m2)	17,376 m ² – total floor area of the Campus
Year of Construction	1978
No. of Occupants	1,846 students



(a)



(b)



(c)



(d)

(a) the East side of the campus, (b) the top view, (c) the main entrance of the examined building, and (d) the centre of the campus.

Figure 17. Photographs of the examined buildings. PS#2

3.1.1 Relevant stakeholders

Table 43. Relevant stakeholders. PS#2

Stakeholder	Role
TUCN	Pilot site coordinator, implementation and evaluation of EVELIXIA solutions
Building Owner/Building Manager TUCN	Should be trained to understand the benefits of the proposed technologies, as well as to use them efficiently. Following the commissioning of the solutions, it is necessary to foresee a comprehensive training
Technology providers TUCN	The technologies developed should be able to communicate and work seamlessly with the building management system and other devices that are installed in the building. - Security: Given the increasing connectivity and the potential for cyber threats, security is a critical concern. - Scalability: The technologies are developed in such a way that can easily be scalable. - Energy Efficiency: Buildings should be equipped with technologies that optimize energy usage, reduce waste, and contribute to sustainability goals. - User-Friendly Interfaces: Intuitive and user-friendly interfaces for building occupants and administrators enhance the overall experience and usability of the technology. - Integration with Smart Grids: Technology providers may require compatibility with smart grid systems for optimized energy distribution and management.
Occupants	The occupants of the building must participate in the implementation process of the proposed technologies, especially those directly impacted, and thus, whose activities will be influenced by the implementation. Occupants of the pilot site should be informed about the project objectives, the key results expected, and their role in the implementation. In addition to engagement, user education should be planned to ensure that users understand the benefits and potential

impact on their daily activities. Moreover, this activity contributes to raising awareness regarding concepts such as smart buildings and BAUNs. The occupants in the Romanian pilot site are students at the Technical University, enabling their education more technically.

3.2 Current situation

3.2.1 Buildings and energy assets

The two dormitories' buildings are identical, consisting of a basement, a ground floor, and 10 floors, with a total of 240 rooms in each building. The total useful area of one building is 8,054 m², covering a total volume of 21,689 m³.

The main heating needs of the occupants are satisfied by a central heating system based on natural gas-powered boilers connected to radiators in each student's room. The temperature setpoint for the heating period is 20°C.

3.2.1.1 Energy Assets

Table 44. Energy assets at site/district level. PS#2

Energy assets	Description
Heating	Two natural gas boilers with a capacity of 1750 kW _{th} each
DHW	Gas boilers (1120 kW _{th})
Lighting	There are four types of lamps: - Type 1: 2 X 8W (T5) fluorescent lamps, powered from the grid. In case of power loss, the lamps are fitted with accumulators, with 90 minutes autonomy. - Type 2: 2 X 36W (T8) fluorescent lamp, electronic ballast, powered from the grid. These lamps are installed in the rooms, the kitchen, the cleaning room and on corridors. - Type 3: 1 X 36W (T8) fluorescent lamp, electronic ballast, powered from the grid. These lamps are installed on corridors. - Type 4: 1 X 18W (T8) fluorescent lamp, electronic ballast, powered from the grid. These lamps are installed in the ironing room and the storage rooms.

	Power/floor: 8*22W=176W lamps type 1 + 29*84W=2436W lamps type 2 + 3*36W=102W lamps type 3 + 3*22W=66W lamps type 4
Energy Storage	-
On-site RE generation	-
EV Charging	-
Monitoring, Control and Operation	A BEMS monitors the total consumption of all campus buildings. In 11 rooms there are smart meters for electrical and NG consumption, indoor air quality and conditions sensors (measuring temperature, RH, CO2).
Other appliances	22 washing machines, 22 drying machines, 44 electric stoves, fridge in each room, computers etc.
Planning and Design	Panning of the building in .dwg format and on the paper, Energetic audit of the buildings (only for the dormitories)

3.2.1.2 Other characteristics

3.2.2 Energy baseline

Table 45. Total energy Consumption (kWh/m2/y). PS#2

Variable	Value
Final energy consumption	215
Primary energy consumption	308

Table 46. Consumption per type (MWh/y). PS#2

Variable	Value
Electricity (from the grid)	650
Electricity (self-generated from RE)	0
District Heating (natural gas)	-
Solar Thermal	-
Geothermal	-

Natural gas	3,308
TOTAL	3,958

Table 47. On-Site RE Generation (MWh/y). PS#2

Variable	Value
PV and Wind	-
Solar Thermal	-
Geothermal	-
Biomass	-
TOTAL	0

3.2.3 Cost of energy

Table 48. Cost of Energy (€/MWh). PS#2

Components	Value
Cost of electricity	256
Cost of heating	131

3.2.4 SRI scores

Table 49. SRI scores. PS#2

Building	SRI Score
Student Dormitories buildings	18% - G class
Campus Restaurant	20% - G class

3.2.5 Grid Level. Energy infrastructure

3.2.5.1 Grid topology

Distribution Network: The pilot site is supplied at low voltage level through a MV – LV transformer.

3.3 Future situation

3.3.1 New energy assets, hardware and software

Table 50. New technical systems. PS#2

New technical systems	Description
BIPVs	Module of 60 cells of 1.7 m length and $P_i \sim 350/400$ W $100/1.7=58$ panelx2 rows=116 ~ 40 kW _p
GeoWall	- Part of the underground wall of the dorm facing South Facade will be thermally activated. - FOCUS on the scalability and optimization of the system - Heat pump system connected - Distribution system to be installed in some of the Dorm Rooms (1 or 2 rooms)
V2G charging	22kW bidirectional charging system
IoT devices (sensors, gateways, data logger, upgrade of the monitoring system BEMS)	1 local server, 1 data logger, gateways, indoor multifunctional wireless air quality sensors (e.g., temperature, humidity, CO ₂)

3.3.2 Future Consumption and Generation

Table 51. Total energy Consumption (kWh/m²/y). PS#2

Variable	Value
Final energy consumption	202
Primary energy consumption	267

Table 52. Consumption per type (MWh/y). PS#2

Variable	Value
Electricity (from the grid)	615
Electricity (self-generated from RE)	40
District Heating (natural gas)	-
Solar Thermal	-

Geothermal	~ 14
Natural gas	3,030
TOTAL	3,699

Table 53. On-Site RE Generation (MWh/y). PS#2

Variable	Value
PV and Wind	40
Solar Thermal	-
Geothermal	~ 14
Biomass	-
TOTAL	54

3.3.3 Future SRI scores

Table 54. SRI scores. PS#2

Building	SRI Score
Student Dormitories buildings	49%
Campus Restaurant	52%

3.4 Energy management systems and data communication protocols

Table 55. Energy management, monitoring and control systems. PS#2

System	Description
POSTGRES Database	Scope: BIPVs production, V2G charger, Heat pump consumption, building consumption, indoor temperatures in the rooms where the GeoWall will be installed API: Yes, but not yet available Protocol: SQL

Table 56. Monitoring and control of energy assets. PS#2

Scope (asset, building, other)	Measurement & Variables	Freq (min)	Monitoring and control	Com. with EVELIXIA
CURRENT				
Building consumption	Energy, voltage, power, etc.	15	M: BMS C: none	
FUTURE				
V2G charger	Energy meter: voltage, power, energy, current; charging monitoring statistics; daily consumption monitoring	*	M: daily consumption, charging statistics C: programmable charging/discharging rates	API SQL
GeoWall	Temperatures of the primary energy system inlet, outlet and performance per meter of wall Performance/temperature of secondary system (heating and cooling of the room) Thermo-mechanical stresses due to thermal activation of the wall	30	M: Room temperatures	API SQL
Heat Pump	Energy performance of the Heat Pump (Seasonal Factors)	*	M: Energy consumption of the Heat Pump	API SQL
BIPV production	BIPV production, Solar radiation factor	10	BIPV production forecasting	API SQL

* Depending on data type. Can be adapted accordingly; depends on the sensing capacity and attributes of the devices

Where:

- Scope (asset, building, other): energy asset, building or environment (electricity market, weather...) where monitoring and control is carried out
- Measurement & Variables: measuring equipment and monitored and control variables
- Frequency: monitoring frequency
- Monitoring and control: system responsible for managing monitoring and control and that will communicate with the EVELIXIA platform
- Communication with EVELIXIA: existence of API and protocol to use to communicate with the EVELIXIA platform

In Figure 18, the current assets and systems are shown, as well as those to be deployed in the future.

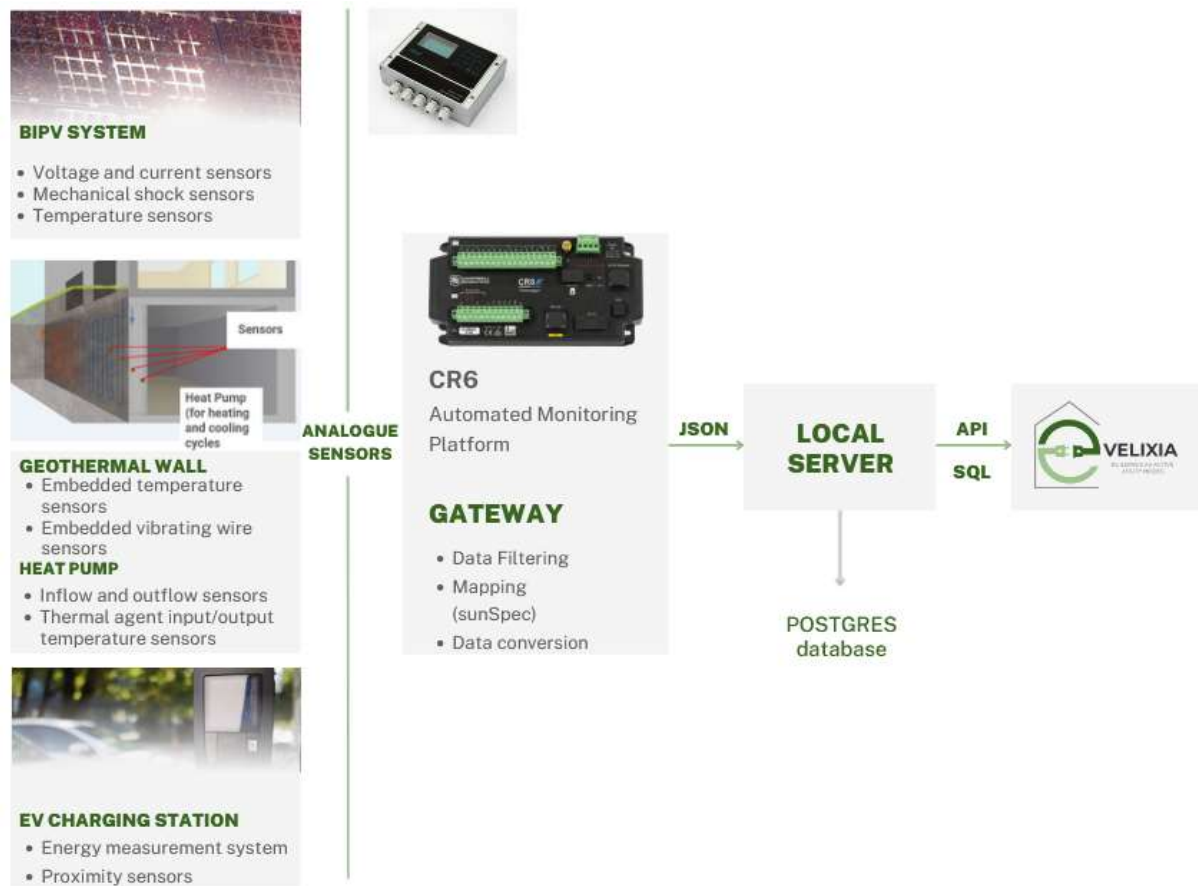


Figure 18. Future assets and systems at the pilot level. PS#2

3.5 Use cases definition

EVELIXIA endeavours to underscore the viability and efficacy of integrating buildings as active utility nodes into the broader energy landscape by showcasing innovative strategies, technologies and services. Central to this initiative are the pilot demonstrations of the proposed solutions through their respective Use Cases.

Table 57. Use Case Summary. PS#2

ID	Use Case	Description
UC-RO#1	Implicit Demand Response	Demonstrate Demand Side Adaptability as inherent response to time of day tariffs
UC-RO#2	Explicit Demand Response	Demonstrate Demand Side Flexibility in response to external DSO signals and requests

Table 58 presents the different services encompassed in each Use Case of the Romanian Pilot Site.

Table 58. Energy Services to be demonstrated per Use Case. PS#2

Category	Energy Service	UC-RO#1	UC-RO#2
Behind the meter	DSM Implicit	✓	-
	Building Investment Planning	✓	-
Front of the meter	DER Dispatch	-	✓
	P2P energy (flexibility) trading	-	-
	Portfolio management services (day-ahead/intra-day)	-	✓
	Network Investment Planning	-	-

Where:

- DSM Implicit: Adjusting demand fractions (load(s) curtailment or total shifting) by reducing/curtailing or entirely shifting energy-intensive loads during expensive periods to cheaper ones (within the same energy vector or between different sectors -coupling).
- Building Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.
- DER Dispatch: real-time distributed generation and storage (large farms or virtually pooled) dispatch based on grid conditions and financial incentives. Leverage the available local-grid storage farms during peak hours to cover local demand, thereby reducing congestion levels on central power distribution lines
- P2P energy (flexibility) trading: Decentralized synchronized coordination of demand between mutualized/aggregated/community customers (increase-to-decrease demand schemes to provide the same service to the grid)
- Portfolio management services (day-ahead/intra-day): Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading and maximize aggregators' returns, implementing explicit DR schemes in accordance to the upfront market bids. Upfront-selling the potential/estimated result of demand response actions in electricity markets. Based on appropriate predefined contracts (e.g., the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding

of large loads is applied in response to incentives provided by aggregators/DR service providers.

- Network Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating, steam, gas) grid needs ensuring reliability, efficiency, and sustainability.

3.5.1 Use case 1. UC-RO#1 Implicit Demand Response

Use Case description
Name UC-RO#1 Implicit Demand Response
Scope UC-RO#1 focuses in adapting the consumption pattern of the student campus (the Romanian pilot site) to a time of use tariff scheme by shifting and/or rescheduling electricity consumption in order to reduce/minimize costs related to the total energy consumption of the pilot site while responding also to occupants needs (thermal comfort, consumption behaviour, daily schedule, etc.). The scope encompasses a comprehensive list of actions: • Establish a robust communication framework between pilot site manager, building manager, staff, facility and system operators, campus occupants. • Explore strategies to seamlessly integrate onsite renewable energy generation, geothermal wall operation and adjustable electricity loads in a long-term consumption demand planning and scheduling to maximize cost reductions according to time of use tariff schemes (implicit demand response). • Capitalize on the existing monitoring systems to track the performance of long-term load scheduling and implicit demand response initiatives. • Cost-benefit analysis to evaluate the economic viability of implicit demand-side adaptability to time of use tariffs. • Document the methodologies, findings, and practices during the pilot activities.
Objectives Key Objectives for UC-RO#1: • Analyse current demand patterns and historical data in electricity consumption data to identify daily consumption profiles. • Evaluate the variability of electricity demand across different time scales (hourly, daily, and seasonal). • Survey and classify potential demand-side resources: loads that could be rescheduled on a long-term basis to meet time of use tariff scheme's low electricity price time intervals.

-
- Assess the feasibility of leveraging local renewable energy resources.
 - Align and coordinate the use of long-term reschedulable power loads with time of use tariff schemes low electricity price time intervals.
 - Explore strategies to seamlessly integrate onsite renewable energy generation, geothermal wall operation and adjustable electricity loads in a long-term consumption demand planning and scheduling to maximize cost reductions according to time of use tariff schemes.
 - Actively manage geothermal wall operation to meet occupant thermal comfort need and avoid operation in peak electricity price periods in accordance with time of use tariff schemes.
 - Strategically schedule off work (resting) periods of washing, drying machines and high-power load equipment to meet peak electricity price periods in accordance with time of use tariff schemes.
 - Coordinate V2G charging and discharging periods with time of use tariff schemes electricity price time intervals (charging during low electricity price time periods and discharging during high electricity price period if possible).
 - Capitalize on the existing monitoring systems to track the performance of long-term load scheduling and implicit demand response initiatives.
 - Cost-benefit analysis to evaluate the economic viability of implicit demand-side adaptability to time of use tariffs.
-

Limitations & Assumptions

- **Data Acquisition:** The effectiveness of the activities and the accuracy of the results rely heavily on the availability of data pertaining to energy consumption, demand patterns, and other relevant variables. Inaccuracies or gaps in the data may introduce uncertainties.
 - **Occupant Behaviour:** Demand-side planning assumes a certain level of responsiveness from end-users. Given the primary use of the campus buildings (dormitories) students behaviour and activity schedules may lead to potential discrepancies between planned consumption profiles and actual real time energy consumption.
 - **Technological Reliability:** The employed technologies function reliably without any technical failures or inconsistencies throughout the pilot activities.
 - **External Factors:** Weather conditions could introduce a certain level of unpredictability into the resulting related outcomes such as PV generation or heating and cooling demand in the pilot dormitory room.
-

Assets of the Use Case

- 116 recycled/repaired PV modules with 60 cells each, 1.7m long, representing a total of ~40kW_p.
 - GeoWall system.
-

- 22 washing machines, 22 drying machines, 44 electric stoves, fridge in each room, computers, etc.
- V2G charger – 22kW.

Further information

n/a

Grid Services Selection

Several grid services will be implemented in UC-RO#1 to address specific needs related to Implicit Demand Response actions:

- **DSM Implicit (price-based shifting):** Adjusting demand fractions (load(s) curtailment or total shifting) by reducing/curtailing or entirely shifting energy-intensive loads during expensive periods to cheaper ones (within the same energy vector or between different sectors (coupling)).

Included Sub-Service:

- **DSF Shifting:** Adjusting a portion of the demand for electricity consumption in the system by moving electricity-intensive equipment work load to different time-frames.
- **Building Investment Planning:** Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.

Prioritisation of the use case

Obligatory.

Market mechanisms

Time of use tariffs

Use Case Narrative

Implicit Demand Response involves the adjustment of energy consumption based on price signals rather than direct instructions from the utility or grid operator. This use case describes a scenario where the Romanian pilot site, the student campus, adjusts its energy usage in response to fluctuating electricity prices. The goal is to optimize energy costs while maintaining occupant comfort and convenience.

Complete description of the use case.

The implementation of the scenario includes:

- **Load Shifting:** Postponing non-essential energy-consuming activities such as running washing machines, computers, dimming non-essential lights and high-power load equipment, in order to meet peak electricity price periods in accordance with time of use tariff schemes.
- **Avoid operation in peak electricity price periods of the GeoWall,** adjusting the heating or cooling systems (the temperature setpoint) to run slightly earlier or later to avoid high-cost periods while maintaining thermal comfort.
- **Coordinate V2G charging and discharging periods** with time of use tariff schemes electricity price time intervals (charging during low electricity price time periods and discharging during high electricity price period if possible).

The success of the use case implementation depends on the availability of energy-consuming activities that can be shifted or rescheduled without significant impact on campus operations and on willingness of occupants to tolerate minor, temporary changes in their environment

Table 59. Technical details and actors involved. UC-RO#1

Name	Actor Type	Description	Further information specific to this Use Case
TUCN	Pilot manager		Responsible for UC implementation in the Romanian Pilot.
TUCN	Building manager		Supportive role in UC implementation.
TUCN	Technology Provider	Integration, testing, of the technology development	Monitoring and controlling capabilities

Table 60. Step by step analysis. UC-RO#1

No	Scenario name	Scenario description	
1	Detection of operating anomalies	The BEMS installed will provide information about the voltage, current and total electric consumption of the building. Thus, through the platform, pilot site manager is informed of any malfunctions or damage to the electricity system and also could analyse the demand pattern	
		Primary actor	BEMS
		Triggering event	Abnormal operating value
		Pre-condition	Correct operating condition
		Post-condition	Abnormal operating status
		Postponing non-essential energy-consuming activities	

2	Load Shifting	Primary actor	EVELIXIA platform, washing machines, computers, heat pump
		Triggering event	Time of uses tariffs, schedules
		Pre-condition	Current operation plan
		Post-condition	New operation plan
3	Adjusting the heating or cooling systems	Avoid operation in peak electricity price periods of the GeoWall, to avoid high-cost periods while maintaining thermal comfort.	
		Primary actor	GeoWall – temperature setpoint control
		Triggering event	Time, temperatures
		Pre-condition	Current operation plan
		Post-condition	New operation plan
4	V2G charging and discharging periods	Coordinate V2G charging and discharging periods with time of use tariff schemes electricity price time intervals	
		Primary actor	V2G charger
		Triggering event	VE connection
		Pre-condition	Current charging plan
		Post-condition	New charging plan

3.5.2 Use case 2. UC-RO#2 Explicit Demand Response

Use Case description	
Name	
UC-RO#2 Explicit Demand Response	
Scope	
UC-RO#2 deals with leveraging the demand side flexibility of the Romanian pilot site in adapting its energy consumption to external day ahead or hour ahead signals and request from the local DSO while ensuring also the fulfilment of occupants needs (thermal comfort, daily activity schedule, etc.) This scope will be achieved by short-term shifting/rescheduling and/or shedding electricity consumption and heating system workload. The scope encompasses a comprehensive list of actions: • Establish a robust communication framework for real-time information exchange between grid operators, pilot site operators, build manager, and demand-side resources. • Establish a communication framework between pilot site manager and dormitory occupants for voluntary active involvement in explicit demand response actions. • Align and coordinate the use of voluntary and mandatory active power flexibility for the process of consumption shedding and short-term rescheduling.	

- Day ahead planning and short-term re-dispatch of flexible consumption units to meet DSO and explicit DR signal requirements.
- Cost-benefit analysis to evaluate the economic viability of explicit demand-side flexibility measures.
- Document the methodologies, findings, and practices during the pilot activities.

Objectives

Key Objectives for UC-RO#2:

- Analyse current demand patterns and historical data in electricity consumption data to identify peak demand periods.
- Analyse historical distribution network load flow profiles to identify DSO level peak load periods.
- Survey and classify potential demand-side resources: loads that could be temporarily stopped or short-term rescheduled at a voluntary and/or mandatory basis with the corresponding flexibility level and periods.
- Align and coordinate the use of voluntary and mandatory power load flexibility for the process of consumption re-dispatch.
- Explore strategies to seamlessly reschedule adjustable power loads to meet day ahead or hour ahead DSO initiated DR signals and requests.
- Actively manage geothermal wall operation to meet occupant thermal comfort need and avoid operation in DR signals request periods.
- Coordinate V2G charging and discharging periods with DR signals request periods. (charging outside of DR request period and if possible, discharging during DR request period).
- Cost-benefit analysis to evaluate the economic viability of explicit demand-side flexibility measures.

Limitations & Assumptions

- **Data Acquisition:** The effectiveness of the activities and the accuracy of the results rely heavily on the availability of data pertaining to energy consumption, demand patterns, and other relevant variables. Inaccuracies or gaps in the data may introduce uncertainties.
- **Occupant Behaviour:** Demand-side flexibility assumes a certain level of responsiveness and volunteering from end-users. Given the primary use of the campus buildings (dormitories) students behaviour and activity schedules may lead to potential discrepancies between planned load reduction and actual real time energy consumption.
- **Technological Reliability:** The employed technologies function reliably without any technical failures or inconsistencies throughout the pilot activities.
- **External Factors:** Weather conditions could introduce a certain level of unpredictability into the resulting related outcomes such as PV generation or heating and cooling demand in the pilot dormitory room.

Assets of the Use Case

- 116 recycled/repared PV modules with 60 cells each, 1.7m long, representing a total of ~40 kW_p.
- 22 washing machines, 22 drying machines, 44 electric stoves, fridge in each room, computers etc.
- GeoWall system
- V2G charging system of 22 kW
- Lightning

Further information

n/a

Grid Services Selection

Several grid services will be implemented in UC-RO#2 to address specific needs related to Explicit Demand Response actions:

- **DER Dispatch (congestion management):** Real-time local generation and consumption dispatch based on grid conditions and financial incentives. Leverage the available local-grid flexibility during peak hours to reduce congestion levels on central power distribution lines.
- **Portfolio management services (day-ahead/intra-day):** Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading and maximize returns, implementing explicit DR schemes in accordance to the upfront market bids. Upfront selling the potential/estimated result of demand response actions in electricity markets.

Included Sub-Services:

- **DSF Explicit:** Adjusting electricity consumption patterns in direct response to external signals, commands, or incentives provided by grid operators, energy management systems, or market mechanisms.
- **DSF Shedding:** Active control of electricity consumption in response to specific signals or commands from the grid operator or the energy management systems.
- **Network Investment Planning:** Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating, steam, gas) grid needs ensuring reliability, efficiency, and sustainability

Prioritisation of the use case

Obligatory.

Market mechanisms

Out of scope

Use Case Narrative

Explicit Demand Response is a strategy used to balance the supply and demand of electricity by directly influencing the consumption patterns of end users. This use case describes a scenario in which the Romanian pilot site leverages to adapt its energy consumption in response to external signals from the local DSO, while ensuring the comfort and convenience of the occupants.

The objective will be achieved through short-term shifting, rescheduling, and/or shedding of electricity consumption and heating system workload.

Complete description of the use case.

- The local DSO sends a day-ahead or hour ahead signal to the Romanian pilot site, indicating the need for demand response actions during a specific time window.
 - Upon receiving the day-or hour ahead signal, the Pilot manager of the pilot site analyses the current energy consumption patterns, thermal comfort requirements, and daily activity schedules of the occupants, based on the data recorded to BEMS. Then, identifies potential flexibility in energy usage that can be leveraged to respond to the DSO's request.
 - Pilot manager together with the building manager devises a plan to adjust the building's energy consumption:
 - Shifting Non-Essential Loads: Rescheduling the operation of non-essential assets such as washing machines, dishwashers, computers, and EV charging to times outside the peak demand window.
 - Optimizing Heating/Cooling Systems: Pre-cooling or pre-heating the rooms during off-peak hours to reduce the peak demand period, ensuring that thermal comfort is maintained.
 - Shedding Loads: Temporarily reducing or turning off non-critical systems and appliances that can withstand short periods of reduced operation without impacting occupant comfort or safety.
 - If an hour-ahead signal is received, indicating a need for further adjustments due to unexpected changes in grid conditions, then the pilot manager quickly reassesses the situation, through BEMS. Real-time modifications to the ongoing demand response actions are made, such as further delaying the operation of certain appliances or making finer adjustments to temperature setpoint.
 - Once the demand response period ends, the normal operation of all systems and appliances are gradually restored, any postponed activities are completed, and the building's energy consumption returns to its typical pattern. The energy savings obtained from the demand response event are recorded by the local BEMS and the feedback to the DSO and EVELIXIA platform will be sent.
-

- The successful implementation of the use case depends on:
 - Availability of flexible loads within the building and the ability to adjust them without compromising essential services
 - Communication Infrastructure
 - Occupant Cooperation: The willingness of occupants to participate in demand response programs, facilitated by minimal impact on their comfort and schedules, is essential for the long-term success.

Table 61. Technical details and actors involved. UC-RO#2

Name	Actor Type	Description	Further information specific to this Use Case
TUCN	Pilot manager	-	Responsible for UC implementation in the Romanian Pilot.
TUCN	Building manager	-	Supportive role in UC implementation.
DEER	DSO	-	In charge of managing the measurement and collection of network characteristic data and conducting network impact studies
TUCN	Technology Provider	Integration, testing, of the technology development	Monitoring and controlling capabilities

Table 62. Step by step analysis. UC-RO#2

No	Scenario name	Scenario description	
1	Solar DHW production	Adaptation of energy consumption in response to external signals from the local DSO, while ensuring the comfort and convenience of the occupant's through short-term shifting, rescheduling, and/or shedding of electricity consumption and heating system workload.	
		Primary actor	EVELIXIA Platform, BMS, manageable assets
		Triggering event	External day ahead or hour ahead signals and request received from the local DSO in adapting the energy consumption.
		Pre-condition	Current assets operation plan and setpoints
		Post-condition	New assets operation plan and setpoints

4 PILOT SITE 3. FRANCE

Operational since March 2021, the E-Factory is the headquarters of Entech smart energies. The E-Factory building aims to demonstrate that an industrial and tertiary activity, beyond consuming as little energy as possible and producing renewable one, can also provide services to the electricity network and reduce infrastructure and operating costs through conversion and storage technologies as well as artificial intelligence.



Figure 19. PS#3: E-FACTORY, ENTECH, FRANCE

While renewable solar powered production plants, EV chargers, battery electricity storage systems and energy management solution are already installed, further developments, aiming to integrate a long-term storage system using hydrogen technologies aiming at increasing optimum self-consumption, also on a community level, and orchestration of the different elements, still need to be implemented.

A challenge is to maximise the self-consumption in the building and district of the electricity produced on site, while respecting the regulatory framework and grid constraints. The pilot ambitions to maximise the global self-consumption by implementing two different operations, i.e. a) a collective self-consumption operation gathering through a legal person, different consumers of the neighbourhood and b) an individual self-consumption operation making an optimum use of the site flexibility potential and storage capacities at all times using an energy management system, interacting and exchanging data flows with the corresponding inter-connected DNOs.

4.1 General description of the site

Location: Quimper (France). The demonstration building is located in the economic zone of Menez-prat in the city of Quimper (France).

Scope: Optimum self-consumption through energy storage in industrial and tertiary activity.



Figure 20. Location PS#3

4.1.1 Relevant stakeholders

Table 63. Relevant stakeholders. PS#3

Stakeholder	Role
ENTECH	Buildings' owner, building manager, technology provider
SDEF	DSO owner
CEA	Support demonstration, develops services

4.2 Current situation

4.2.1 Buildings and energy assets

Below, the buildings involved in the project and the main energy assets of the site are described.

Table 64. Building 1. PS#3

Variable	Description
Name / Type	E-Factory / industrial
Floor Area (m2)	4133 m2 (1172 m ² of Office Areas (OA) and 2962 m ² of Workshops Areas (WA))
Year of Construction	2021
N. of Occupants	160

The building is certified as Passivhaus Premium. It was designed using bioclimatic architecture to maximize summer and winter comfort while minimizing energy consumption. The building envelope consists of metal cladding with numerous openings including recessed windows and photovoltaic sunshades to maximize natural light penetration into the building. The building's rooftop terrace is partially covered with photovoltaic panels.



Figure 21. Photographs of the building envelope. PS#2

4.2.1.1 Energy Assets

Energy assets	Description
Heating	Office area: - Extensive heat panels with smart piloting sometimes associated with destratification fans. - Total installed capacity: 30,75 kWth Workshop area: - Fan heater (8 units) (48 kWe)

	- Air handling unit with an electric battery (30 kWe) - Extensive heat panels with smart piloting sometimes associated with destratification fans (4kWth)
DHW	4 controllable electric water heaters of a total electricity power of 8,8 kWe (3,7 MWh/a)
Lighting	Total lighting power: 10,9 kW, 17,6 MWh/a
Energy Storage	There are 2 Battery Energy Storage System (BESS) on site. They are both directly connected to the grid to provide services to the system (primary frequency setting and capacity mechanism). - BESS n°1, (outdoor equipment): - o Beginning of Life Usable Energy: 1490,8 kWh - o Type of batteries: Li-ion CATL, (4 outdoor liquid cooling racks (4 x 372,7kWh) Conversion: Power electronics - o Application: primary frequency setting, capacity mechanism - BESS n°2, (integrated in a container): - o Beginning of Life Usable Energy: 1360 kWh - o Type of batterie: li-ion SAMSUNG, (14 racks) - o Conversion: Danfoss - o Application: primary frequency setting, capacity mechanism  
On-site RE generation	Total installed PV capacity: 394 kW_p. 1257 panels – sunpower – CS Wismar LONGI (with 44 kW_p PV parking canopies and 350 kW_p PV roofing systems) - 244 kW_p used for the individual self-consumption operation - 150 kW_p destined for use in the collective self-consumption operation under development

	 
EV Charging	There are 18 EV charging points on site: - 4 charging stations with 1 charging point AC 22 kWmax and 1 charging point DC 100 kWmax - 1 charging station with 4 charging points AC 7kW max - 3 charging stations with 2 charging points AC 7 kW max The EV charging stations are connected to the main LV board and contribute to the self-consumption operation on site.  
Monitoring, Control and Operation	- Energy monitoring Measuring stations are deployed across the building to monitor precisely the electricity consumption units (lighting, air handling units, hot water generators, workshop) - Energy management An Energy Management System (EMS) integrated into an industrial computer deployed at the main LV board level controls the balance between PV generation and consumption. The solar-generated electricity is preferentially used to supply the EV charging stations and then supply the building's electrical needs. Any surplus is used to heat the water tanks. The programming languages used are Python, C and C++. The data communication protocol used are Modbus, CAN, RS485, I2C, SMTP, FTP, SFTP, RESTfull. The cycle times are between 1ms and 20 ms.

	The EMS also monitors the connection to the grid (state of connection, response to requests). An PMS (ESEreg) controls and optimizes in real time the BESS performance according to frequency instructions. ESEreg processes the data collected from the storage system (Power load, frequency, alarms, temperature) and from external setpoint (Power, frequency instructions) to control and monitor the system. ESEview visualizes in real-time all key indicators (external setpoint, SOC, number of cycles, system availability, defaults and alarms, temperature). ESEview also provides a dynamic visualisation of EVs connected and load sharing, and processes data collected from CPs.
Other	- Ventilation - o Double-flow ventilation system (12,5 MWh/an) - o Air handling unit 1: 11,8 kW - o Air handling unit 2: 6,7 kW - Test bench: experimental environment for the testing of solutions, from both an energy performance and control performance point of views. Its main equipment is: - o 410kW connection to the main DSO grid through 2 DC buses for independent frequency/voltage operation - o 2 AC connection points to the μ-grid with emulators: 440kVA and 110kVA - o 2 DC connection points with DC-DC to the μ-grid: 500kW and 110kW - o 2 DC connection points without DC-DC: 400kW and 130kW - o 425kW AC resistive load bank

4.2.1.2 Other characteristics

The pilot site offers the possibility of operating independently from the network and functioning as a microgrid in case of a network outage, as to carry out tests on Entech products. The site is connected to the medium voltage distribution network with a maximum power consumption and injection limit set at 2500 kW. Additionally, the site is connected to the local low-voltage distribution network for

injecting a portion of the solar electricity produced for use in a collective self-consumption operation with two neighbouring industrial sites.

4.2.2 Energy baseline

The building's energy consumption is solely composed of electricity.

Table 65. Total energy Consumption (kWh/m²/y). PS#3

Variable	Value
Final energy consumption	59
Primary energy consumption	104

Table 66. Consumption per type (MWh/y). PS#3

Variable	Value
Electricity (from the grid)	144
Electricity (self-generated from RE)	100
District Heating (biomass)	-
Solar Thermal	-
Geothermal	-
Other (define, e.g. gas, oil)	-
TOTAL	244

Table 67. On-Site RE Generation (MWh/y). PS#3

Variable	Value
PV and Wind	243
Solar Thermal	-
Geothermal	-
Biomass	-
TOTAL	243

4.2.3 Cost of energy

The building's energy consumption is solely composed of electricity. Entech has entered into an expert contract with an electricity supplier. The average electricity price equals 230 €/MWh.

Table 68. Cost of Energy (€/MWh). PS#3

Components	Value
Cost of electricity	230

4.2.4 SRI scores

Table 69 shows the values of SRI index for the two buildings as calculated according to the European Commission's calculation method/standard.

Table 69. SRI scores. PS#3

Building	SRI Score
E-factory	22%

4.2.5 Grid Level. Energy infrastructure

4.2.5.1 Grid topology

The distribution electrical network in the area is composed of medium and low voltage overhead and underground lines connected to a substation ensuring the link with the electricity transmission network.

The building is connected to the medium voltage distribution network (MV) (voltage 20 kV) via a medium voltage delivery substation.

A transformer inside the building allows the supply of low voltage current (400V) to the building.



	Innovative components will comprise a 30 kWe electrolyser combined with a 10 kWe fuel cell and coupled with a Battery Energy Storage System (BESS). Innovative bidirectional AC/DC converters designed for EV charging station application will be used to fit the electrolysers and fuel cell low levels of voltage, to reduce the cost and increase stability and efficiency by up to 5%. A system-dedicated controller will ensure interoperability between all components of the system and optimal system control.
Hypervisor – ESEsoft platform	Entech will upgrade existing ESEsoft software to develop a new hypervisor solution in a secure cloud computing environment for managing and overseeing the entire operation of the whole system ESEsoft platform will include ESEdiag (the diagnostic and prognostic module and ESEmanage (the Energy Management System module) ESEdiag will supervise the operation of the hybrid system, providing the necessary control inputs to operate the system safely and efficiently. ESEmanage will consider both day-ahead and seasonal scheduling to maximize the annual self-consumption ratio. Optimal energy disptach will be calculated every 10' based on PV production and consumption forecast.

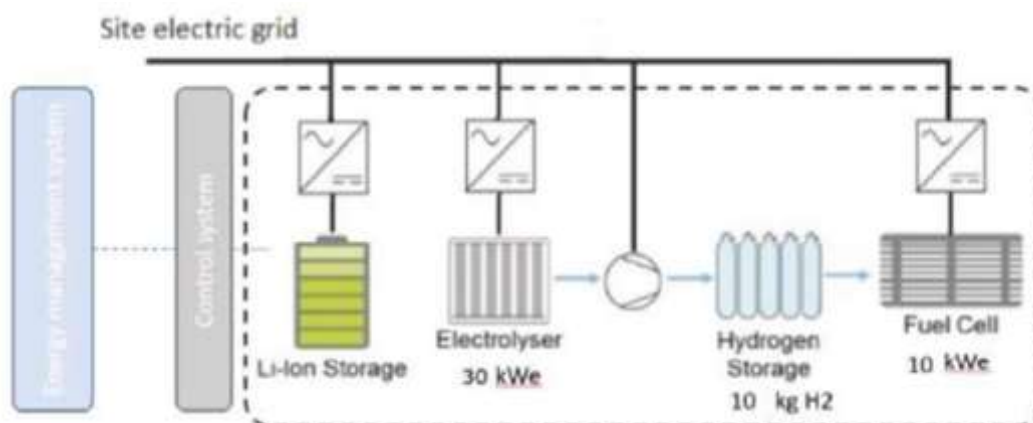


Figure 23 : schematic of the hybrid storage system. PS#3

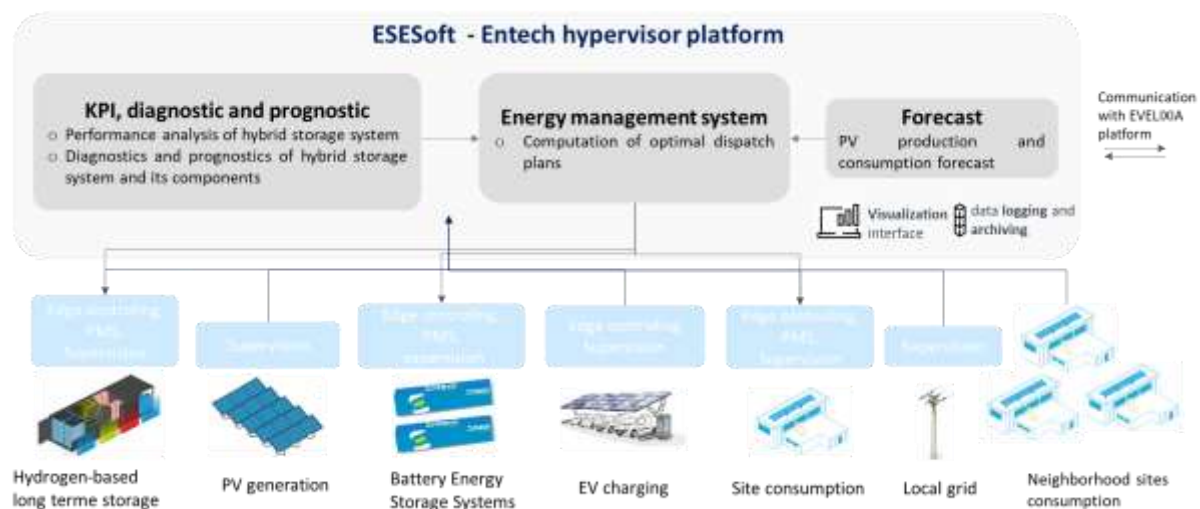


Figure 24 : Hypervisor platform. PS#3

4.3.2 Future Consumption and Generation

The demonstrator aims to optimize the use of flexibilities and storage systems on-site to maximize the self-consumption of photovoltaic energy production at both the building and neighbourhood scales. The expected monthly energy productions and consumptions on the site remain the same as the existing balance, while the self-consumption rate should increase significantly, with a target of 70% compared to the current 40%.

Table 71. Total energy Consumption (kWh/m²/y). PS#3

Variable	Value
Final energy consumption	59
Primary energy consumption	83

Table 72. Consumption per type (MWh/y). PS#3

Variable	Value
Electricity (from the grid)	74
Electricity (self-generated from RE)	170
District Heating (biomass)	-
Solar Thermal	-
Geothermal	-
TOTAL	244

Table 73. On-Site RE Generation (MWh/y). PS#3

Variable	Value
PV and Wind	243
Solar Thermal	-
Geothermal	-
Biomass	-
TOTAL	243

4.3.3 Future SRI score

The target set for increasing the smart readiness indicator (SRI) is presented in Table 74.

Table 74. SRI scores. PS#3

Building	SRI Score
E-factory	72%

4.4 Energy management systems and data communication protocols

The management, monitoring, and control systems that will be available at the pilot sites and how they will be integrated into the EVELIXIA platform are presented in Table 75.

Table 75. Energy management, monitoring and control systems. PS#3

System	Description
Hypervisor platform	Scope: PV production, electric vehicle charger, battery energy storage, building consumption, test bench, and hydrogen storage system API: Yes Protocol: REST

Table 76. Monitoring and control of energy assets. PS#3

Scope (asset, building, other)	Measurement & Variables	Freq (s, min)	Monitoring and control	Com. with EVELIXIA
CURRENT				
Battery energy storage	BMS: voltage, power, energy, amperage, SOC, SOH, temperature	10s	Edge Control: Power set point	
PV	Energy meter: voltage, power, energy, current, power limitation	1s	Edge Control: PV bridge	
EV charger	Energy meter: voltage, power, energy, current, power limitation	1s	Monitoring	
Building loads	Energy meter: voltage, power, energy, current	1s	Monitoring	
FUTURE				
EV charger	Energy meter: voltage, power, energy, current	1 min	EMS cloud – edge control: Power set point	ESEAPI
Electric heaters	Energy meter: voltage, power, energy, current	1 min	EMS cloud edge control: on-off signal	ESEAPI
Other building loads	Energy meter: voltage, power, energy, current	1 min	monitoring	ESEAPI
Test bench	Energy meter: voltage, power, energy, current	1 min	monitoring	ESEAPI
Hybrid battery-Hydrogen storage system	Energy meter: voltage, power, energy, current, pressure, power limit of charge, power limit of discharge	1 min	EMS cloud - Control: Power setpoint	ESEAPI
PV production	Irradiance forecast, PV production forecast	10 min	EMS cloud: PV production forecasting	ESEAPI

Where:

- Scope (asset, building, other): energy asset, building or environment (electricity market, weather...) where monitoring and control is carried out

- Measurement & Variables: measuring equipment and monitored and control variables
- Frequency: monitoring frequency is 1 min for mostly signals
- Monitoring and control: system responsible for managing monitoring and control and that will communicate with the EVELIXIA platform
- Communication with EVELIXIA: extension of ESEapi to communicate with the EVELIXIA platform

Figure 25 presents the current assets and systems are shown, as well as those to be deployed in the future.

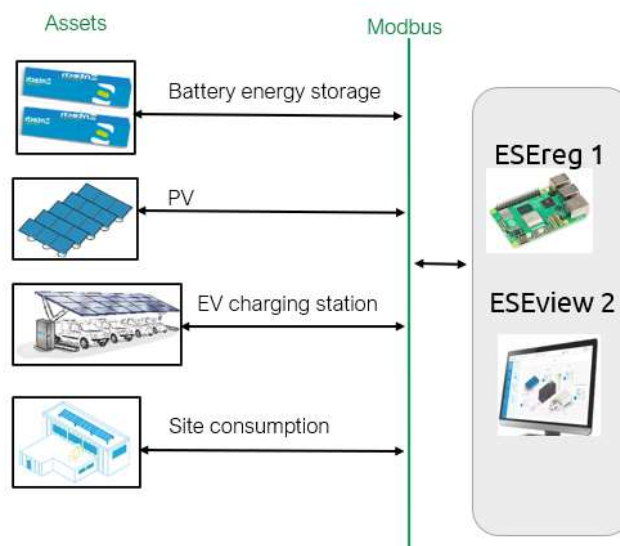


Figure 25. Current assets and systems involved at the pilot site level. PS#3

Figure 26 shows the details of the systems and equipment to be deployed during the project.

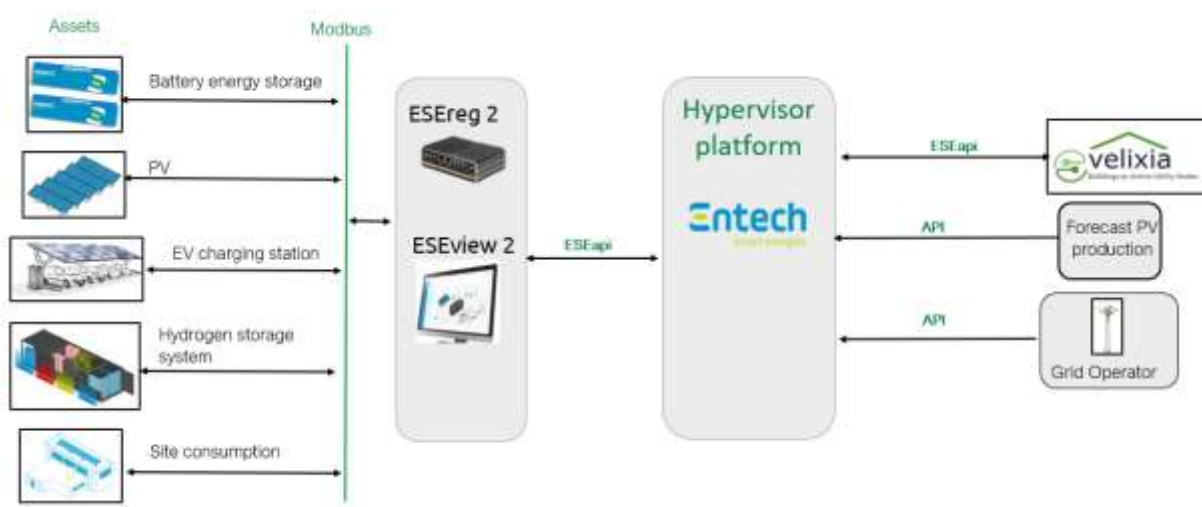


Figure 26 : future assets and systems at the pilot level. PS#3

4.5 Use cases definition

EVELIXIA endeavours to underscore the viability and efficacy of integrating buildings as active utility nodes into the broader energy landscape by showcasing innovative strategies, technologies and services. Central to this initiative are the pilot demonstrations of the proposed solutions through their respective Use Cases.

Table 77. Use Case Summary. PS#3

ID	Use Case	Description
UC-FR#1	Maximize self-consumption	Maximize self-consumption using a multi-time scale energy management strategy. The use case includes 1 main scenario and 2 simulated variant scenarios.
UC-FR#2	Provision of Ancillary grid services	Provision of Ancillary grid services: primary frequency setting and capacity mechanism

Table 78 presents the different services encompassed in each Use Case of the French Pilot Site.

Table 78. Energy Services to be demonstrated per Use Case. PS#3

Category	Energy Service	UC-FR#1	UC-FR#2
Behind the meter	DSM Implicit	✓	-
	Building Investment Planning	✓	-
Front of the meter	DER Dispatch	✓	-
	P2P energy (flexibility) trading	-	-
	Portfolio management services (day-ahead/intra-day)	✓	✓
	Network Investment Planning	-	-

Where:

- DSM Implicit: Adjusting demand fractions (load(s) curtailment or total shifting) by reducing/curtailing or entirely shifting energy-intensive loads during expensive periods to cheaper ones (within the same energy vector or between different sectors -coupling).
- Building Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.

- DER Dispatch: real-time distributed generation and storage (large farms or virtually pooled) dispatch based on grid conditions and financial incentives. Leverage the available local-grid storage farms during peak hours to cover local demand, thereby reducing congestion levels on central power distribution lines
- P2P energy (flexibility) trading: Decentralized synchronized coordination of demand between mutualized/aggregated/community customers (increase-to-decrease demand schemes to provide the same service to the grid)
- Portfolio management services (day-ahead/intra-day): Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading and maximize aggregators' returns, implementing explicit DR schemes in accordance to the upfront market bids. Upfront-selling the potential/estimated result of demand response actions in electricity markets. Based on appropriate predefined contracts (e.g., the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding of large loads is applied in response to incentives provided by aggregators/DR service providers.
- Network Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating, steam, gas) grid needs ensuring reliability, efficiency, and sustainability.

4.5.1 Use Case 01. UC-FR#1 Maximize self-consumption

Use Case description
Name UC-FR#1 Maximize self-consumption using a multi-time scale energy management strategy
Scope
Main scenario This use-case deals with the implementation of an advanced energy management strategy in a cloud hypervisor to optimize the real-time operation of on-site flexibilities (EV charging, manageable appliance, storage systems) in order to maximize the annual self-consumption ratio while achieving the most profitable scenario.

The energy management strategy will aim, in particular, to reduce demand peaks by shifting flexible energy consumption and storing excess energy generated on-site during low-demand periods for use during peak demand times. Lithium battery storage will be used for intraday storage, while hydrogen storage will be used for longer periods (multi-day, multi-week, multi-month).

The energy management system will calculate an optimal energy dispatch plan and send setpoints via a robust communication framework to the controllable assets every 10 minutes, considering both day-ahead, week-ahead, and seasonal scheduling.

The tailored control systems for each asset will use these setpoints together with multiple data collected from different sensors deployed within the systems to: i) regulate the system power, taking into account the fluctuation of the system itself, ii) manage the dispatch, and iii) send control orders to each device.

A human-machine interface will allow visualization of data, parameterization, and manual controls. It will collect all relevant indicators, display real-time information, record data, and send information to the cloud-based platform.

The implemented energy management strategy will take into account the following variables:

- PV generation forecast using the forecast tool;
- Demand forecast (probabilistic model of EV consumption, forecast of building consumption based on historical data);
- Hourly energy prices;
- Modelling the behaviour of operational assets (PV systems, H2 energy storage system, EV charging station, building consumption) using a Mixed-Integer Linear Programming (MILP) method.
- Diagnostic and prognosis of H2 system behaviour: a model predictive control strategy for the H2 storage system will be implemented to i) ensure the system operates safely, ii) maximize the efficiency and lifetime of the various components and the system as a whole.
- Limits on injection and consumption from the grid.

Data on local characteristics of the distribution network (frequency, voltage) will be collected every 15 minutes and used to analyse the impact of the operation on the electrical network and to mitigate physical congestion.

A comprehensive analysis aimed at evaluating the economic and environmental viability of the operation and storage systems will be conducted.

Variant Scenario 1

Variant Scenario 1 corresponds to a simulated variation of the main scenario in which the considered hydrogen-based hybrid long-term storage system would have a larger storage capacity.

The other elements of the scope are identical.

This scenario aims to implement more advanced seasonal management strategies for the utilization of the storage system. The surplus PV production during summer months will be stored for consumption during months with low demand.

Variant Scenario 2

Variant Scenario 2 corresponds to a simulated variation of the main scenario in which the considered hydrogen-based hybrid long-term storage system would have a larger storage capacity, and the self-consumption operation considered would not only involve the E-factory building but also the two neighbouring sites participating in a collective self-consumption operation with associated PV production and electrical consumption.

This scenario aims to evaluate the economic viability in the case of an energy community with multiple buildings.

Objectives

- Maximization of the annual self-consumption on site
The deployment of an advanced energy management strategy in a cloud hypervisor to optimize the real-time operation of on-site flexibilities (EV charging, manageable appliances, storage systems) aims to maximize self-consumption on-site by shifting consumption during peak hours and storing electricity during periods of excess PV production.
- Cost optimisation without compromising comfort or care standards.
The hypervisor solution will analyse electricity prices from the grid and strategically manage flexible assets to consume grid electricity when prices are lower, while relying on solar PV and storage injection during peak demand.
- Optimization of the usage of the hydrogen-based hybrid long-term storage system
The diagnostic and prognostic service of the hydrogen-based storage system will aim to ensure optimal utilization of the system, ensuring that the system operates safely, and maximizing the efficiency and lifetime of the various components and the system as a whole.
- Study of the economic and environmental viability of the operation through various scenarios (main scenario implemented in real-life simulation, variant scenario 1 with simulation of the use of a system with larger capacity storage, variant 2 with simulation of an energy community).
- Sustainability Benefits: By maximizing the use of renewable energy sources, the facility will enhance its sustainability efforts.
- Advanced energy management and monitoring
On-site deployment of an advanced cloud-based solution for controlling and supervising energy systems, allowing parameterization, manual control, and visualization of indicators.
- Analysis of the impact on the distribution network
The impact of the operation on the electrical network will be studied to evaluate the potential for replicating the operation to mitigate physical congestion and enable the widespread integration of distributed renewable energy into the network.

Limitations & Assumptions

- **Uncertainties in PV production and building energy consumption forecasts**
The PV production and consumption forecasts to be used are based on historical data, probabilistic insights, and weather forecasts. Weather phenomena, changes in building users' behaviour, and in the utilization of building assets can alter the accuracy of forecasts, thus modifying the relevance of the deployed energy management strategy.
 - **Computational Power and Time Constraint**
The advanced energy management strategy to be deployed involves intricate real-time calculations considering various parameters. Constraints on computational power and time may result in decreased precision of the deployed model.
 - **Data acquisition**
The operation of the energy management system to be deployed relies heavily on the collection of multiple data from the assets of the operation. Malfunction or inaccuracies in the data collection could lead to imprecisions and operational errors.
 - **Technological Reliability:**
The employed technologies, such as smart meters, actuators and automation systems, function reliably without any technical failures or inconsistencies throughout the pilot activities.
 - **Reliability and behaviour of the H2-based storage system under operational conditions**
The behaviour and operational performance of the H2-based storage system are expected to correspond to the models created based on the theoretical characteristics of the system.
 - **Scalability**
The transition to a larger scale could result in an exponential increase in computational time
 - **External Factors:**
Economic conditions, electricity prices, weather conditions may not be relatively stable throughout the pilot period.
-

Assets of the Use Case

Existing equipment

- On site PV generation used for individual self-consumption operation: 244 kW_p with 44 kW_p PV parking canopies and 200 kW_p roofing systems
 - On site PV generation used for collective self-consumption operation: 150 kW_p roofing systems (used only in the simulated variant scenario 1)
 - EV charging station. 18 EV charging points:
-

- 4 charging stations with 1 charging point AC 22 kWmax and 1 charging point DC 100 kWmax
- 1 charging station with 4 charging points AC 7kW max
- 3 charging stations with 2 charging points AC 7 kW max
- Heating assets:
 - Office area:
 - Extensive heat panels with smart piloting sometimes associated with destratification fans.
 - Total installed capacity: 30,75 kWth
 - Workshop area:
 - Fan heater (8 units) (48 kWe)
 - Air handling unit with an electric battery (30 kWe)
- DHW: controllable electric water heaters of a total electricity demand of 8,8 KWe (3,7 MWh/a)
- Lighting. Total lighting power 10,9 kW, 17,6 MWh/y
- Ventilation:
 - Double-flow ventilation system (12,5 MWh/y)
 - Air handling unit 1: 11,8 kW
 - Air handling unit 2: 6,7 kW
- Energy monitoring. Existing measuring stations are deployed across the building to monitor precisely the electricity consumption units (lighting, air handling units, hot water generators, workshop)

Planned installation (EVELIXIA)

- Hydrogen-based hybrid long-term storage optimized hybrid storage system comprising
 - 30 kWe electrolyser
 - 10 kg H2 compressed gas storage
 - 10 kWe fuel cell
 - Battery Energy Storage System (BESS)
- Scenarios variant 1 and 2 will simulate using an identical system with the following characteristics:
 - 100 kWe electrolyzer
 - 550 kg H2 compressed gas storage
 - 50 kWe fuel cell
 - identical Battery Energy Storage System (BESS).

Monitoring, control, and communication systems (see section 4.4)

Further information

No relation with other Use Cases

Grid Services Selection

Services implemented in the use case:

- **Load Shifting:** A portion of electricity demand (EV charging, DHW systems) during peak periods will be shifted to times when renewable energy generation is abundant or during periods of low demand.
- **Demand side flexibility implicit:** Program and control the operation of storage devices and flexible load in response to price signal.
- **Demand side flexibility explicit:** Program and control the operation of storage devices and flexible load using energy management strategy.
- **Demand side flexibility shedding:** Active storage charging and discharging for peak load management.
- **Demand side flexibility modulation:** Modulation consumption from the grid using active storage charging and discharging.
- **Maximizing self-consumption** and **reducing peak demand** through storage and energy management strategy.
- **DER dispatch:** Activate / deactivate photovoltaic plants
- **Portfolio management services:** Optimize flexible loads (battery, EV, DHW) based on forecasted generation, demand, diagnostic and prognostic of storage performances.
- **System planning:** Design, development, and optimization of energy storage infrastructure.
- **Collective self-consumption** operation.

Prioritisation of the use case

Obligatory

Market mechanisms

Out of scope

Use Case Narrative

UC-FR#1 ambition to maximise the global self-consumption operation on-site while achieving the most profitable scenario by making an optimum use of the site flexibility potential and storage capacities at all times using an advanced energy management system.

The use case includes 1 main scenario corresponding to the scenario implemented in the real-life demonstration and 2 simulated variant scenarios allowing for the study of implementing more advanced seasonal management strategies and evaluating the technical and economic viability in the case of an energy community with multiple buildings.

Complete description of the use case.

Entech sizes, designs, develops, and installs the H₂-based hybrid storage system. Entech tests the operation of the H₂ storage system and ensures that it functions correctly.

Entech develops and deploys the ESEsoft hypervisor platform on the demonstrator including the energy management system (with the participation of CEA for the domestic hot water tank management part), the diagnostic and prognostic service of the battery-H₂ storage system, the visualization interface, data storage, and communication with the EVELIXIA platform.

Entech establishes connections with control interfaces for controlling the hybrid battery-H₂ storage system, PV plants, DHW, EV charger, and for monitoring other loads.

For each scenario, at the start of the demonstration, an annual optimization plan is generated (corresponding to the power setpoints of controllable systems at 10-minute time intervals) by implementing a comprehensive optimization strategy aimed at maximizing self-consumption under the best economic conditions and considering:

- Hourly forecasts of PV production.
- Hourly site consumption forecasts.
- Behaviour modelling of controllable components (ESS, EV charging station, PV, hot water tanks).
- Diagnosis and prognosis of lithium-H₂ storage system performance.
- Parameters associated with these components.
- Cost of grid electricity.
- Injection constraints and withdrawals from the grid.

The generated energy management strategy aims to reduce demand peaks by shifting flexible energy consumption (EV, DHW) and storing excess energy generated on-site during low-demand periods for use during peak demand times. Lithium battery storage is used for intraday storage, while hydrogen storage will be used for longer periods (multi-day, multi-week, multi-month).

This optimization plan is generated in about ten hours in the cloud hypervisor platform runner and is then transmitted to the master via an API connection and stored in the SQL database.

During the demonstration, the optimization plan is updated several times a day each time a new electric vehicle connects to the site. Each update takes into account 10-minute PV production and consumption forecasts, component modelling, updated diagnosis and prognosis of storage system performance, updated parameters, electricity costs, and network constraints.

For scenario 1 (real-life demonstration), the plan generated by the cloud platform runner in about 1 second is transmitted via API to the central Power Management System (PMS), ESEreg, and stored in the local database, which then generates a dispatch and control plan at 1-minute intervals for each component using the EMS setpoints together with multiple data collected from different sensors deployed within the systems and considering system fluctuations.

The dispatch setpoints from the PMS are communicated to the systems via Modbus communication.

The operating data of the systems (PV plants, EV charging stations, battery-H2 storage system, building consumption, battery storage systems) are sent to the central PMS and then to the cloud platform and stored in the timeseries database.

The monitoring of network characteristic data at the level of a digital meter installed at the building's delivery point at 15-minute intervals is transmitted via API to the cloud platform and the data is stored in the SQL database.

The optimization plans, system operating data, and network characteristic data are transmitted to the EVELIXIA platform via the API connection.

System operating data are used for calculating various KPIs and conducting technical and economic performance analysis studies of scenarios.

Network characteristic data are used for conducting distribution network impact studies by SDEF in collaboration with the DSO.

Table 79. Technical details and actors involved. UC-FR#1

Name	Actor Type	Description	Further information specific to this Use Case
Entech Smart Energies	Building Operator Technology provider	Company specialized in energy conversion, storage and management as well as in the realization of PV plants	Responsible for UC implementation in the French Pilot.
SDEF	Local authority	Public institution in charge of organizing the electricity distribution in the Finistère area of Brittany	In charge of managing the measurement and collection of network characteristic data and conducting network impact studies
CEA	RTO		Contribute to the EMS development. Support demonstration activities

Table 80. Step by step analysis. UC-FR#1

No	Scenario name	Scenario description
1		Optimize the real-time operation of on-site flexibilities (EV charging, manageable appliance, storage systems) in order to maximize the annual self-consumption ratio while achieving the most profitable scenario.

Maximize self-consumption	The energy management strategy will aim, in particular, to reduce demand peaks by shifting flexible energy consumption and storing excess energy generated on-site during low-demand periods for use during peak demand times. Lithium battery storage will be used for intraday storage, while hydrogen storage will be used for longer periods	
	Primary actor	EVELIXIA Platform, Hypervisor platform, EV charging, manageable appliance and storage systems
	Triggering event	Optimal energy dispatch plan every 10 minutes
	Pre-condition	Current energy dispatch plan and setpoints
	Post-condition	Same/new energy dispatch plan and setpoints

4.5.2 Use Case 02. UC-FR#2 Provision of Ancillary grid services and capacity market services

Use Case description	
Name	UC-FR#2 Provision of Ancillary grid services: and capacity market services
Scope	This use case focuses on the provision of Ancillary Grid Services (primary frequency setting) and capacity market services by two existing Battery Energy Storage Systems on the site. This service is already in place and operates independently of the self-consumption operation. The use case aims to enhance the service by implementing a maintenance prediction and fault detection service on the BESS cooling systems developed by CEA.
Objectives	- Provision of Ancillary grid services (primary frequency setting) and capacity market services 2 Battery Energy Storage System (BESS) on site (1490 kWh, 1360 kWh) are both directly connected to the grid to provide services to the system (primary frequency setting and capacity mechanism) according to the instruction of an aggregator. - Optimization of BESS Performance The implementation of a maintenance prediction and fault detection service on the BESS cooling systems aims to reduce downtime due to cooling system faults and improve efficiency. - Analysis of the impact on the distribution network The impact of the operation on the electrical network will be studied to evaluate the potential for replicating the operation to mitigate physical congestion and

enable the widespread integration of distributed renewable energy into the network.

Limitations & Assumptions

- Data acquisition
The operation of the maintenance prediction and fault detection service for the cooling systems of BESS to be deployed relies heavily on the collection of multiple data from the assets of the operation. Malfunction or inaccuracies in the data collection could lead to imprecisions and operational errors.
 - Technological Reliability:
The employed technologies, such as smart meters, sensors and communication devices, function reliably without any technical failures or inconsistencies throughout the pilot activities.
 - External Factors:
The requests from the systems for grid services, weather conditions may not be relatively stable throughout the pilot period.
-

Assets of the Use Case

Existing equipment

Energy storage

The two existing Battery Energy Storage Systems (BESS) are both directly connected to the grid to provide services to the system (primary frequency regulation and capacity mechanism). They will not be used to store surplus solar energy in order to maximize self-consumption, but their operation will be monitored and considered as a constraint for the limits of withdrawal and injection into the grid.

- BESS n°1, (outdoor equipment):
 - Beginning of Life Usable Energy: 1490,8 kWh
 - Type of batteries: Li-ion CATL, (4 outdoor liquid cooling racks (4 x 372,7kWh) Conversion: Power electronics
 - Application: primary frequency setting, capacity mechanism
 - BESS n°2, (integrated in a container):
 - Beginning of Life Usable Energy: 1360 kWh
 - Type of batterie: li-ion SAMSUNG, (14 racks)
 - Conversion: Danfoss
 - Application: primary frequency setting, capacity mechanism
-

Further information

No relation to other Use Cases

Grid Services Selection

Ancillary grid services: Primary frequency setting

Capacity market

Existing Battery Energy Storage Systems provide ancillary grid services: primary frequency setting and capacity mechanism

Prioritisation of the use case

Obligatory.

Market mechanisms

Services include primary frequency setting and capacity mechanism

Use Case Narrative

UC-FR#2 aims to enhance the provision of Ancillary Grid Services (primary frequency setting) and capacity market services by 2 Battery Energy Storage Systems by implementing a maintenance prediction and fault detection service on the BESS cooling systems.

Complete description of the use case.

CEA develops a maintenance prediction and fault detection service for the cooling systems of BESS using the operational data history of the systems operated by Entech.

This service is hosted on the EVELIXIA platform.

During the demonstration the operating data of the 2 BESS at a time step of 1 minute are sent to the central PMS and then to the cloud platform and stored in the timeseries database.

The maintenance prediction and fault detection service for the cooling systems of BESS utilizes this data to assess the availability and fault risk of the system components. This information is transmitted from the EVELIXIA platform to the cloud platform at a time step of 15 minutes and stored in the SQL database.

The monitoring of network characteristic data at the level of a digital meter installed at the building's delivery point at 15-minute intervals is transmitted via API to the cloud platform and the data is stored in the SQL database.

System operating data are used for calculating various KPIs

Network characteristic data are used for conducting distribution network impact studies by SDEF in collaboration with the DSO.

Table 81. Technical details and actors involved. UC-FR#2

Name	Actor Type	Description	Further information specific to this Use Case
Entech Smart Energies	Building Operator Technology provider	Company specialized in energy conversion, storage and management as well as in the realization of PV plants	Responsible for UC implementation in the French Pilot.
SDEF	Local authority	Public institution in charge of organizing the electricity distribution in the Finistère area of Brittany	In charge of managing the measurement and collection of network characteristic data and conducting network impact studies
CEA	RTO		Development of the maintenance prediction and fault detection service for the cooling systems of BESS

Table 82. Step by step analysis. UC-FR#2

No	Scenario name	Scenario description	
1	Primary frequency setting	Provide ancillary services (primary frequency setting)	
		Primary actor	BESS n°1 & n°2
		Triggering event	Signal from aggregator
		Pre-condition	Current set point
		Post-condition	New set point
2	Capacity market	Provide capacity market services	
		Primary actor	BESS n°1 & n°2
		Triggering event	Signal from aggregator
		Pre-condition	Current set point
		Post-condition	New set point
3	Maintenance prediction and fault detection service of the BESS cooling system	The EVELIXIA platform will inform about the availability and fault risk of the system components	
		Primary actor	EVELIXIA platform
		Triggering event	Fault risk, unavailability of components
		Pre-condition	Monitoring the functioning of the system components
		Post-condition	Consideration of default risk in the EMS

5 PILOT SITE 4. DENMARK

The Danish pilot site is part of the Kolstrup housing association. The aim of the pilot site is to ensure tenants better usage of locally produced electricity. The pilot site will use batteries, PV panels, and hot water buffer tanks to contribute to provide flexibility to both the electricity grid and the local district heating system.

5.1 General description of the site

Location: City of Aabenraa, South of Denmark.

Scope: In Denmark, Energinet buys balancing services from aggregators establishing a market for balancing services. However, today these services are provided only by core plants and at local level there are no existing models for aggregators. The Pilot Sites buildings are typical examples of the Danish housing associations build in the '70s', renovated in 2015, and aim to demonstrate the provision of grid services.



Figure 27. Location of PS#4, DK

5.1.1 Relevant stakeholders

At Aabenraa six stakeholder groups were participating.

Table 83. Relevant stakeholders. PS#4

Stakeholder	Role
Kolstrup Housing Association	Building Owner
N1	DSO Owner
Sustain	ESCO Company / Technical Advisor
SALUS	Building Manager
Neogrid	Technology Provider
Aabenraa Fjernvarme	District Heating
European Green Cities	PS Leader / Stakeholder Involvement

5.2 Current situation

5.2.1 Buildings and energy assets

Each building has a heating system connected directly to the DH. Every building has PV-panels together with a battery package. The electricity grid in the buildings is established as a behind the meter system so each building is connected to the grid. The pilot site is 9 building blocks. The buildings have the same specifications.

Table 84. Building 1 – 9. PS#4

Variable	Description
Name / Type	Housing blocks
Floor Area (m2)	28.629 m ² in total, 3.181 m ² per building
Year of Construction	1973
N. of Occupants	283 apartments, approx. 700 residents in total

The building has the energy certificate B and the general building envelope has been updated within the last 10 years.

5.2.1.1 Energy Assets

Table 85. Energy assets, Hørgård section. PS#4

Energy assets	Description
Heating	- Hørgård 6-28: Direct heat in each apartment - Hørgård 30-40: ECL 310 controlled heat exchanger
DHW	- Hørgård 6-28: substation per apartment - Hørgård 30-40: ECL 310 controlled DHW exchanger
Lighting	- Hørgård 6-28, all exterior light is controlled from Hørgård 20 technical rooms, there are LED lamps in parks, and stairwells, and on facades. - Hørgård 30-40 is controlled from the technical room in no. 38, there are LED lamps (rebuilt) in the park. on façade and in stairwells it is PLC pipe, g23 or g24d. - Old municipality style between Hørgård and Lergård is connected to technical room in 38 and runs all the way up to behind Hørgård 6 from 40.
Energy Storage	- 180 kWh Huawei FLUNA2000-5KW-C0, 5 battery.
On-site RE generation	PV 15 kW _p
Monitoring, Control and Operation	17 pcs. Huawei 10KTL inverter online by WLAN
Ventilation	- Hørgård 6-28: Decentralized units with heat recovery per apartment - Hørgård 30-40: Centralized pressure-controlled unit without heat recovery for extractor hood and bath

Table 86. Energy assets, Uglekaer section (2 buildings). PS#4

Energy assets	Description
Heating	ECL 310 controlled heat exchanger
DHW	750 l tank ECL 310 controlled
Lighting	Uglekær 2-16. - Technical room in no. 6 takes lighting on block in stairwell and exterior.

	- Technical room in no. 14 takes light on block and in stairwell. - There are g24d-2 plc in the lamps on the façade, there are T5 Ho tubes in the stairwells, and in the park, we have a variation of E27 LED, and PLC tubes in the floor lamps. Lady's Loop: - Frueløkke 10-16 is the technical room in no. 14, it takes all the lighting, in the park, façade and stairwell, and it is all joints. - Townhouses Frueløkke are all link, they are controlled from a main board that sits in a "tombstone" on the side of the bicycle shed Frueløkke 1E.
Energy Storage	- 105 kWh Huawei FLUNA2000-5KW-C0, 5 battery
On-site RE generation	PV 15 kW _p
Monitoring, Control and Operation	12 pcs. Huawei 10KTL inverter online by WLAN
Ventilation	Centralized pressure-controlled unit without heat recovery for extractor hood and bath

Table 87. Energy assets, Fruelykke section. PS#4

Energy assets	Description
Heating	Direct heat in each apartment
DHW	Substation per apartment
Lighting	N/A
Energy Storage	- 95 kWh Huawei FLUNA2000-5KW-C0, 5 battery
On-site RE generation	PV 15 kW _p
Monitoring, Control and Operation	10 pcs. Huawei 10KTL inverter online by WLAN
Ventilation	Decentralized units with heat recovery per apartment

5.2.1.2 Other characteristics

The main characteristic of this pilot site is the homogenic buildings. The buildings are a part of Kolstrup Housing Associations. This means that it will be the residents that decide if any investments will be implemented in the project.

5.2.2 Energy baseline

Table 88. Total energy Consumption (kWh/m²/y). PS#4

Variable	Value
Final energy consumption	140
Primary energy consumption	174

Table 89. Consumption per type (MWh/y). PS#4

Variable	Value
Electricity (from the grid)	538
Electricity (self-generated from RE)	-
District Heating (biomass)	4,386
Solar Thermal	-
Geothermal	-
Other (define, e.g. gas, oil)	-
TOTAL	4,924

Table 90. On-Site RE Generation (MWh/y). PS#4

Variable	Value
PV and Wind*	390
Solar Thermal	-
Geothermal	-
Biomass	-
TOTAL	390

* PV in operation after project start

5.2.3 Cost of energy

Table 91. Cost of Energy (€/MWh). PS#4

Components	Value
Cost of electricity	48,7
Cost of heating	70

5.2.4 SRI scores

Table 92. SRI scores. PS#4

Building	SRI Score
Building 1-9	19% G

5.2.5 Grid Level. Energy infrastructure

5.2.5.1 Grid topology

Figure 28 presents the maps of the grid level:



Figure 28. Grid topology. PS#4

5.2.5.2 Other characteristics

The energy system has been quite stable during the last years.

5.3 Future situation

As a measure to heighten the usage of the PV production and to investigate the possibility to make peak shaving in electricity demand there will be installed 600 smart plugs along with 300 sensors to monitor and steer electrical appliances in the departments.

5.3.1 New energy assets, hardware and software

Table 93. New technical systems. PS#4

New technical systems	Description
Electric heater DHW	DHW tank at Uglekær is planned to be upgraded with electric heater
Accumulative Tank	DHW tank at Uglekær is planned to be installed whit electric heater
Two-way heat meter	Sensors to measure the heat and comfort level in apartment level

5.3.2 Future Consumption and Generation

Table 94. Total energy Consumption (kWh/m2/y). PS#4

Variable	Value
Final energy consumption	140
Primary energy consumption	154

Table 95. Consumption per type (MWh/y). PS#4

Variable	Value
Electricity (from the grid)	285
Electricity (self-generated from RE)	253
District Heating (biomass)	3,424
Solar Thermal	-
Geothermal	-
Other (define, e.g. gas, oil)	-
TOTAL	3,962

Table 96. On-Site RE Generation (MWh/y). PS#4

Variable	Value
PV and Wind	390
Solar Thermal	-
Geothermal	-
Biomass	-
TOTAL	390

There is not planned any expansion of the PV-panels in the project.

5.3.3 Future SRI scores

Table 97. SRI scores. PS#4

Building	SRI Score
Residential (9 building blocks)	Target: 68%

5.4 Energy management systems and data communication protocols

Table 98. Energy management, monitoring and control systems. PS#4

System	Description
Neogrid platform	Scope: Data + contextual information for all connected assets, see Table 99 API: Yes Protocol: JSON/REST or DomOS WoT/SAREF4* based

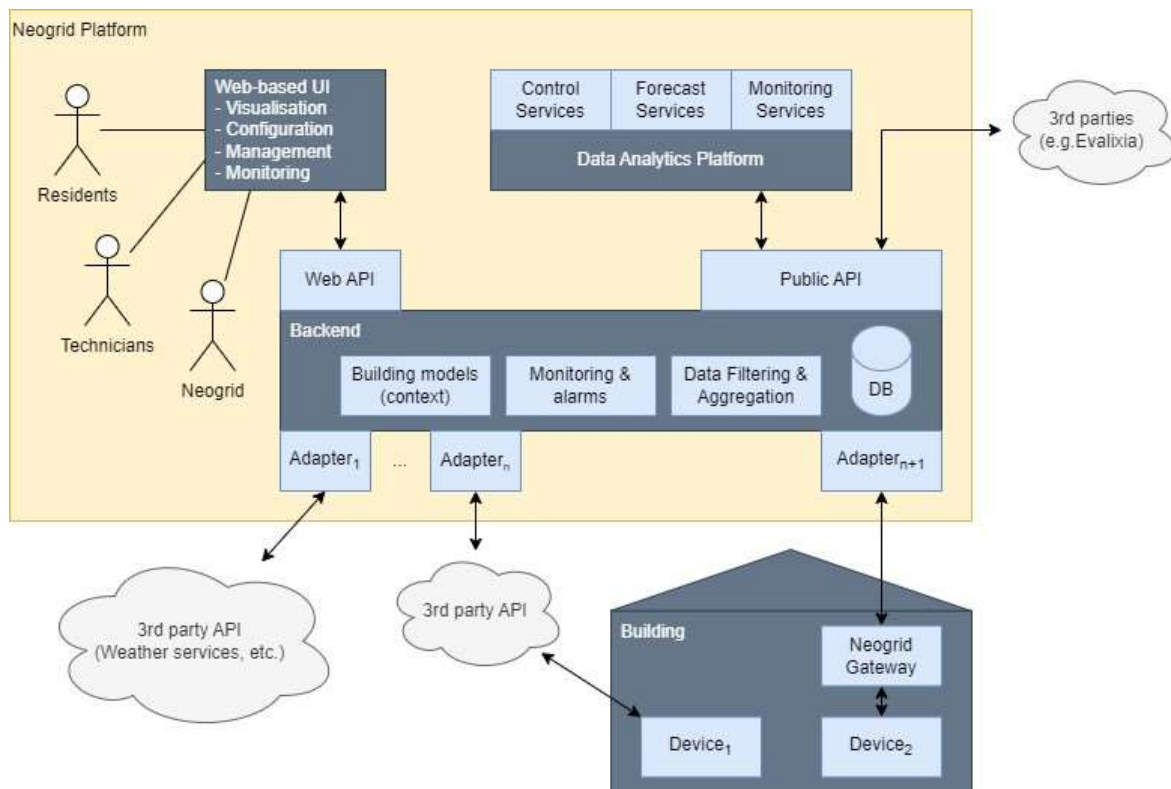


Figure 29. Conceptual diagram over Neogrid Platform. PS#4

Table 99. Monitoring and control of energy assets. PS#4

Scope (asset, building, other)	Measurement & Variables	Freq (min)	Monitoring and control	Com. with EVELIXIA
CURRENT				
Danfoss ECL comfort controller	Pipe temperatures, setpoint, motor position etc	1	M/C	Neogrid API
Energy meters	DH meters measuring energy, volume and temperatures at key points in building	1	C	Neogrid API
Electricity meters	Building meters and apartment meters delivers AC energy	1	C	Neogrid API
Huawei PV, inverter and battery	Various information on PV production, energy flow and battery SOC	60	M/C	Neogrid API
Ventilation units	Supply-, outdoor-, extract- and exhaust temperature including set points	5	M	Neogrid API
FUTURE				

DHW tank	Tank temperature, DH valve position, Electric heater activation	5	M&C	Neogrid API
DH accumulation tank	Tank temperature, Electric heater activation	5	M&C	Neogrid API

Raw data, in highest resolution, is only available for a limited period of time (14 days). However, aggregated data in 5-minute and lower resolutions are kept beyond 14 days.

5.5 Use cases definition

EVELIXIA endeavours to underscore the viability and efficacy of integrating buildings as active utility nodes into the broader energy landscape by showcasing innovative strategies, technologies and services. Central to this initiative are the pilot demonstrations of the proposed solutions through their respective Use Cases

Table 100. Use Case Summary. PS#4

ID	Use Case	Description
UC-DK#1	Electricity Optimisation on Building Level	Optimised operation of inverter, battery, and possibly consuming assets, to minimize cost of electricity.
UC-DK#2	Optimisation of District Heating Consumption and Production	Optimised operation of district heating assets, including conversion of surplus electricity to energy for district heating network.

Table 101 presents the different services encompassed in each Use Case of the Danish Pilot Site.

Table 101. Energy Services to be demonstrated per Use Case. PS#4

Category	Energy Service	UC-DK#1	UC-DK#2
Behind the meter	DSM Implicit	✓	✓
	Building Investment Planning	-	-
Front of the meter	DER Dispatch	✓	✓
	P2P energy (flexibility) trading		✓
	Portfolio management services (day-ahead/intra-day)	✓	✓
	Network Investment Planning	-	✓

Where:

- DSM Implicit: Adjusting demand fractions (load(s) curtailment or total shifting) by reducing/curtailing or entirely shifting energy-intensive loads during expensive periods to cheaper ones (within the same energy vector or between different sectors -coupling).
- Building Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.
- DER Dispatch: real-time distributed generation and storage (large farms or virtually pooled) dispatch based on grid conditions and financial incentives. Leverage the available local-grid storage farms during peak hours to cover local demand, thereby reducing congestion levels on central power distribution lines
- P2P energy (flexibility) trading: Decentralized synchronized coordination of demand between mutualized/aggregated/community customers (increase-to-decrease demand schemes to provide the same service to the grid)
- Portfolio management services (day-ahead/intra-day): Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading and maximize aggregators' returns, implementing explicit DR schemes in accordance to the upfront market bids. Upfront-selling the potential/estimated result of demand response actions in electricity markets. Based on appropriate predefined contracts (e.g., the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding of large loads is applied in response to incentives provided by aggregators/DR service providers.
- Network Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating, steam, gas) grid needs ensuring reliability, efficiency, and sustainability.

5.5.1 Use case 01. UC-DK#1: Electricity Optimisation on Building Level

Use Case description

Name

UC-DK#1: Electricity Optimisation on Building Level

Scope

UC-DK#1 covers control and optimisation of electricity assets on a building and appartement level.

The primary scope is to optimise operation of PV, inverter, and battery storage, according to the (expected) consumption in buildings/apartments and development of electricity and grid transportation prices.

Additionally, electricity consuming assets might be included in a second iteration of this use case, or an additional use-case later.

Objectives

Primary objectives:

- Minimise cost of importing electricity from the grid, while utilising local PV production as much as possible by controlling battery charge levels.
- Assess whether consuming assets (listed below) can be included in the control – e.g. has accessible interfaces for control, and has enough potential for flexibility to significantly impact the other objectives.

Secondary objectives:

- Include consuming assets where possible and potential exist.
- Reduce the amount of consumed electricity
- Maximise profits of selling surplus electricity to the grid.

Limitations & Assumptions

The housing association is regulated strictly regarding activities beside housing tenants. This can be an obstacle in utilizing the business cases.

Assets of the Use Case

Primary assets used:

- PV
- Battery

Additional consuming assets, that may be included:

- Lightning

- EV
- Smart Plugs (handouts to residents)
- Ventilation

Further information

UC-DK#1 will be expanded by UC-DK#2 that will add a layer of district heating optimization on top of this.

Grid Services Selection

Related services to enhance the grid's stability, reliability, resilience, efficiency, and adaptability to fluctuations by actively managing the electricity demand:

- **RES Harnessing:** UC-DK#1 will prioritize using this solar PVs for local consumption. The housing association is one energy community and the energy bill is settled by one energy meter measuring energy flow in and out from the community. The flexibility in local consumption comes from installed battery storage.
- **Cost Optimization:** UC-DK#1 will create a model of PV power generation and local consumption. Input will be historical production and consumption data and historical weather data. A daily optimization of energy flow in/out of community and battery usage takes place. Inputs are the created models, weather forecast and actual spot prices on electricity and dynamic tariffs on transmission and distribution. This will give the lowest electricity operation cost for the housing association.
- **Sustainability Benefits:** Using electricity at lowest cost typically means reducing electricity power plants carbon footprint and dependence on fossil fuel-based grid electricity.
- **Load Shifting:** UC-DK#1 supports grid load shifting by dynamically controlling the usage of the battery. It's done implicit by generating the daily optimized operation schedule.
- **Portfolio management services (day-ahead/intra-day):** UC-DK#1 implements Day-ahead portfolio management as an operation plan for energy flow and battery usage for coming day is generated every afternoon.

Prioritisation of the use case

Battery optimisations are mandatory, optimisation of consuming assets is optional (dependent on both availability of control interfaces and how much flexibility they can provide).

Market mechanisms

Hourly electricity spot prices and tariffs on the electricity market.

Use Case Narrative

Utilizing the usage of local produced electricity while maximizing the tenant's business case of the installed batteries regarding electricity and grid transportation prices. Furthermore, providing the possibility to store electricity as domestic hot water to provide grid flexibility.

Complete description of the use case.

1. Ensure that electricity installations are physically completed.
2. Establish data collection from primary assets – and start gathering baseline data. These are the minimum desired parameters; list is still to be finalised:
 - a. Electricity consumption of buildings.
 - b. Electricity spot prices and ideally additional tariffs¹.
 - c. Battery levels.
 - d. PV energy production.
 - e. Weather.
3. Establish connections with control interfaces for controlling battery charge levels.
4. Evaluate model predictions of building consumption (develop/improve where necessary).
5. Evaluate model predictions of PV production (develop/improve where necessary).
6. Develop and deploy control service for battery level optimisation.
 - a. Ongoing evaluation and improvement.
 - b. Collection of KPIs for evaluation.
7. Data analysis / evaluation for project.

Plus, possibly additional steps to include the consuming energy assets, if this is deemed possible.

¹ In Denmark, some additional tariffs vary hourly and thus impact which hours are the cheapest/most expensive during a day.

Table 102. Technical details. UC-DK#1

Name	Actor Type	Description	Further information specific to this Use Case
Kolstrup Housing Association	Building Owner		
N1	DSO Owner		
Sustain	ESCO Company / Technical Advisor		Ensures that installations are completed, and assets are maintained during the pilot.
SALUS	Building Manager		Ensures that installations are completed, and assets are maintained during the pilot.
Neogrid	Technology Provider		Development and deployment of all software components.
Aabenraa Fjernvarme	District Heating		
European Green Cities	PS Leader / Stakeholder Involvement		Coordinates the effort.

Table 103. Step by step analysis. UC-DK#1

No	Scenario name	Scenario description	
1	Solar DHW production	Optimisation of the operation of PV, inverter, and battery storage, according to the (expected) consumption in buildings/apartments and energy prices.	
		Primary actor	EVELIXIA Platform, Neogrid platform, manageable appliances and storage systems
		Triggering event	Continuous control
		Pre-condition	Current energy dispatch plan and setpoints
		Post-condition	Same/new energy dispatch plan and setpoints

5.5.2 Use case 02. UC-DK#2: Optimisation of District Heating Consumption and Production

Use Case description

Name

UC-DK#2: Optimisation of District Heating Consumption and Production

Scope

UC-DK#2 cover optimisation of district heating assets alone, as well as in combination with electricity optimisation in UC-DK#1.

The primary scope is to convert surplus electricity into heating, either for use in the buildings, or for selling the heat to the district heating supply through their network.

Additionally, this is ideally to be combined with Neogrid's existing PreHEAT solution, which reduces the total energy consumption of the building by optimising flow temperatures in the building mixing loop.

Objectives

Primary objectives:

- Convert surplus electricity to district heating, not exceeding temperature limits of the grid.
- Optimise district heating consumption/production according to prices of both district heating and electricity, to determine the optimal way of using the surplus electricity, e.g.: Sell as electricity? Sell as district heating?

Additional objectives:

- Reduce the overall consumption of heating in the building (and cost hereof).

Limitations & Assumptions

The housing association is regulated strictly regarding activities beside housing tenants. This can be an obstacle in utilizing the business cases.

Assets of the Use Case

- Building mixing loop
- Pipe / tank temperatures
- Electric heater in tank

Further information

Adds a layer of district heating on top of UC-DK#1

Grid Services Selection

UC-DK#2 is an extension to UC-DK#1 where electricity also can be used in the district heating (**DH**) system for energy storage, export to DH grid and domestic hot water production.

Related services to enhance the grid's stability, reliability, resilience, efficiency, and adaptability to fluctuations by actively managing the electricity demand:

- **RES Harnessing:** UC-DK#2 will prioritize using this solar PVs for local consumption. The housing association is one energy community and the energy bill is settled by one energy meter measuring energy flow in and out from the community.
- **Cost Optimization:** UC-DK#2 will optimize the combined cost of electricity and district heating for the housing association by cross sector optimization. Beside flexibility in the batteries as explained in UC-DK#1 flexibility is also available now in the storage tank with electric heater and DHW tank with electric heater. A dynamic price on DH energy will be included as inputs together with the parameters from UC-DK#1.
- **Sustainability Benefits:** Using electricity at lowest cost typically means reducing electricity power plants carbon footprint and dependence on fossil fuel-based grid electricity.
- **Load Shifting:** UC-DK#2 supports grid load shifting by dynamically controlling the usage of the battery. It's done implicit by generating the daily optimized operation schedule.
- **Load Shedding:** UC-DK#2 with its energy management supports Load Shedding. The plan is to have it tested together with the local DSO N1. This will be on a test basis as there is no commercial setup for this yet.
- **Modulation:** UC-DK#2 can align adaptable electricity consumption patterns of end-users with the dynamically varying needs and conditions of the grid. The plan is to have it tested together with the Danish TSO Energinet by participating in the existing markets for ancillary services.
- **Distributed Energy Resources (DERs) dispatch:** UC-DK#2 plan to participate in the markets for ancillary services. This also includes the market for regulating power intra-day. Here DER dispatch might take place if bids are activated.
- **Portfolio management services (day-ahead/intra-day):** UC-DK#2 will support Day-ahead and intra-day portfolio management for the existing markets in Denmark.

Prioritisation of the use case

- Some production of heating through the electric heater in the tank is mandatory for the success of this use-case. Ideally, excess heating will also be delivered back into the district heating network.
- Combining this solution with Neogrid PreHEAT is optional, but certainly nice to have.

Market mechanisms

Hourly electricity spot prices and tariffs on the electricity market.

District heating prices for both buying and selling are likely to be included as well. The later might have to be simulated in the project. Other market mechanisms might also come into play as we evaluate best approaches to determine the needs of the district heating network.

Use Case Narrative

Utilizing surplus electricity production to provide hot water for the building or selling it to the District Heating company thus providing a layer of flexibility to bought the electricity grid and the district heating.

Complete description of the use case.

1. Ensure that district heating installations are physically completed.
2. Establish data collection from primary assets – and start gathering baseline data. These are the minimum desired parameters; list is still to be finalised:
 - a. Mixing loop temperatures.
 - b. Electric heater consumption or production.
3. Establish connections with control interfaces for controlling the electric heater, and preferably flow temperatures of the mixing loop.
4. Evaluate model predictions of building heating consumption (develop/improve where necessary).
5. Develop and deploy control service for optimisation of district heating production.
 - a. Ongoing evaluation and improvement.
 - b. Collection of KPIs for evaluation.

(Optional) combine production of district heating with optimisation of overall heating consumption (PreHEAT)

Table 104. Technical details. UC-DK#2

Name	Actor Type	Description	Further information specific to this Use Case
Kolstrup Housing Association	Building Owner		
N1	DSO Owner		
Sustain	ESCO Company / Technical Advisor		Ensures that installations are completed, and assets are maintained during the pilot.

SALUS	Building Manager		Ensures that installations are completed, and assets are maintained during the pilot.
Neogrid	Technology Provider		Development and deployment of all software components.
Aabenraa Fjernvarme	District Heating		Helps decide the best mechanism for knowing when to produce heating into their network. Monitors the network and evaluates the pilot from their perspective.
European Green Cities	PS Leader / Stakeholder Involvement		Coordinates the effort.

Table 105. Step by step analysis. UC-DK#2

No	Scenario name	Scenario description	
1	Solar DHW production	Optimisation of the operation of PV, inverter, and battery storage, according to the (expected) consumption in buildings/apartments and energy prices.	
		Primary actor	EVELIXIA Platform, Neogrid platform, manageable appliances and storage systems
		Triggering event	Continuous control. Production could possibly be triggered based on signals from the district heating supplier (AF).
		Pre-condition	Current energy dispatch plan and setpoints
		Post-condition	Same/new energy dispatch plan and setpoints

6 PILOT SITE 5. GREECE

6.1 General description of the site

Location: Northwestern part of Ptolemaida city, Greece (4Km N.Road Ptolemaidas-Mpodosakeio Hospital area)

Scope: Existing power plants (using fossil fuels) located in Ptolemais (about 1530MW installed capacity, units of Agios Dimitrios III & IV, Meliti I, new Ptolemaida V) are about to be decommissioned fully until 2028. The Region of Western Macedonia (RWM) is one of the four pilot projects within the Platform on Coal Regions in Transition. The meta-lignite area requires exploitation of B2G strategies with collective self-consumption and DR schemes.

Table 106. Buildings of Pilot Site 5 (Greece)

Variable	Description	
Name / Type	CERTH/CPERI Building // Tertiary	Mpodosakeio Hospital // Tertiary
Floor Area (m ²)	1895	19,089.25
Year of Construction	2007 (Phase A) – 2022 (Phase B~3.9M€) - 2027 (Phase C~3M€, expected 2027)	1992- current building (new section-2022)
N. of Occupants	40 (mainly researchers)	300 patients & medical staff



Figure 30.CERTH/CPERI. PS#5



Figure 31.Mpodosakeio Hospital. PS#5



Figure 32. Top View of the Greek Pilot Site (Google Maps). PS#5

6.1.1 Relevant stakeholders

Table 107. Relevant stakeholders. PS#5

Stakeholder	Role
DHCP	District heating operation of Ptolemaida city, also partner of the EVELIXIA project (https://tpt.gr/d-h-c-p-en/)
HEDNO	Hellenic Electricity Distribution Network Operator S.A, also partner of the EVELIXIA project (https://deddie.gr/en/deddie/i-etaireia/profil/)

Municipality of Eordaia	Municipality under transition to new energy model with minimum carbon footprint.
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6.2 Current situation

6.2.1 Buildings and energy assets

The Greek pilot project will be based on 2 buildings, the Mpodosakeio Hospital and the CERTH/CPERI building.

Regarding the energy facilities, both buildings use district heating to cover the required thermal loads, however, in Mpodosakeio a system of installed solar thermals of total power 625kW_{th} is used (for solar cooling), while in CERTH, photovoltaic panels with a power of 10 kW is utilized and an additional system of 38 kW is planned to be installed (for covering own electric loads).

Below, the buildings involved in the project and the main energy assets of the site are described.

Table 108. Building 1 – CERTH/CPERI. PS#5

Variable	Description
Name / Type	CERTH/CPERI Building // Tertiary
Floor Area (m2)	1895
Year of Construction	2007 (Phase A) – 2022 (Phase B~3.9M€) - 2027 (Phase C~3M€, expected 2027)
N. of Occupants	40 (mainly researchers)

Table 109. Building 2 – Mpodosakeio Hospital. PS#5

Variable	Description
Name / Type	Mpodosakeio Hospital // Tertiary
Floor Area (m2)	19,089.25
Year of Construction	1992- current building (new section-2022)
N. of Occupants	300 patients & medical staff

The two buildings of Pilot Case 5 have been erected in different periods and different technologies and materials have been used in their construction.

6.2.1.1 Energy Assets

The pilot case contains two buildings, the CERTH/CPERI building and the Mpodosakeio Hospital building. *Table 110* presents information regarding existing controllable building assets for CERTH/CPERI, while the corresponding data for Mpodosakeio are presented in *Table 111*.

Table 110. Energy assets Building 1 CERTH/CPERI. PS#5

Energy assets	Description
Heating	DH connection with heat exchanger (175 kW) 2 backup oil boilers (482 kW _{th})
Cooling	Central HVAC (268 kW _c)
DHW	2 electric water heaters (8 kW _e)
Ventilation	HVACs covering needs of the building (offices, laboratories, open spaces etc) Mechanical ventilation for offices (3m ³ /h/m ²)
Lighting	LED (18,5 kW)
Energy Storage	Battery (5 kWh) coupled with roof PV (10 kW _p)
On-site RE generation	Monocrystalline (6 kW _p) and polycrystalline (4 kW _p) PV system coupled with 5 kWh battery
EV Charging	There is no EV charging infrastructure
Monitoring, Control and Operation	A Building Energy Management System (BEMS-Platform of Pragma IoT) with monitoring equipment consisting of 14 temperature and humidity sensors, 10 occupancy sensors, 14 air quality sensors, 10 window opening sensors, 25 smart electricity (3-phase) meters, 40 smart plugs and a Weather station-1 on the roof (measuring wind speed, direction, pressure, humidity, temperature, solar radiation etc). The devices have open APIs and support BACnet over IP, Lonworks, Modbus, Panelbus. The above sensors are in the interior of offices whereas the energy meters are installed in the current electric panels of the building.

	There is also another BEMS from Honeywell (central line) for basic operations of heating (DH) and cooling system of the building.
Other appliances	A second weather station-2 is located on the roof of the building (mobile) able to measure and monitor in a separate platform (Delta Ohm Cloud), the following parameters: air quality PM1, PM2.5, PM10, CO, CO ₂ , NO ₂ , SO ₂ , O ₃ , wind direction and speed, rain (mm), pressure, humidity, solar radiation, dew point etc.
Planning and Design	A new section-new building is currently under study to host offices and laboratories of about 900 m ² .

Table 111. Energy assets Building 2 Mpodosakeio Hospital. PS#5

Energy assets	Description
Heating	- Connected to DH - Thermal substation 3.5 MW_{th} (~97% efficiency) - A plate heat exchanger (539.3 kW_{th}) supports extra heating needs
Cooling	- 1 water-cooled chiller (500 kW_c) covering cooling loads (80.9 kW_e) - An absorption chiller (264 kW_c) - A cooling tower (408 kW_{ct}) driven by a solar thermal field
DHW	- 1 diesel-fired boiler room (1276 kW_{th}), Burners and Pumps (6.6 kW_e) - 320 solar thermal collectors (456 MWh annual production - 236.7 MWh_{th} hot water, 109.7 MWh_{th} space heating, 106.7 MWh space cooling) - Diesel fired steam boiler to serve sterilization needs. - For the 6 bar high-pressure steam there are 2 installed boilers (one in reserve) with a power of 1.4 MW_{th} and a rated production of 3.25 tn/h of steam.

	- For the low-pressure steam of 0.5 bar there are 2 boilers installed (one in reserve) with a power of 0.84 MW_{th} and a rated production of 1.25 tn/h of steam
Ventilation	Central Cooling Unit (HVAC) for surgery rooms, intensive care units etc (106.055 m ³ /h)
Lighting	- Fluorescence (190kW) - LED (1.7 kW) - Na (15 kW) - PL (6.6 kW)
Energy Storage	- Hot water tanks (10m³) (coupled with the solar thermal system) - DHW boilers (12m³)
On-site RE generation	320 vacuum solar thermal collectors (625kW _{th})
EV Charging	There is no EV charging infrastructure
Monitoring, Control and Operation	- A BEMS (by Siemens Desigo) monitors the RES installed systems (solar vacuum collectors). - Metering Systems record and monitor the operational performance of the solar thermal system and assess the impact of interventions on energy consumption and CO₂ emissions. - A pyranometer is installed in the solar collector support system; a heat meter is installed in the primary solar energy system circuit, measuring the solar energy converted into heat energy; 4 heat meters (M-Bus) are installed to measure the consumption and the distribution of thermal energy across the whole hospital building facilities, at any time, with a 1-minute time granularity. - The system consists of automation stations, signal collection cards, Desigo CC workstations and Green

	Building Monitor energy consumption statistics display system (time step: ~1').
Planning and Design	The current BEMS will be extended in the framework of EVELIXIA project in order to monitor also other parameters of the building (heating and electric production and consumption) along with existing solar thermal system for cooling.

6.2.1.2 Other characteristics

Other Characteristics of the Greek Pilot:

- The useful life for all the assets described above is expected to be up to 25 years.
- In case of a blackout, Mpodosakeio Hospital and CERTH's building have oil power generators to cover emergency needs.

6.2.2 Energy baseline

The main indicators related to energy consumption and production are presented below.

Table 112. Total energy Consumption (kWh/m²/y). PS#5

Variable	Value
Final energy consumption	324
Primary energy consumption	490

Table 113. Consumption per type (MWh/y). PS#5

Variable	Value
Electricity (from the grid)	2,875
Electricity (self-generated from RE)	14
District Heating*	2,704
Solar Thermal	1,212
Geothermal	-
Other (define, e.g. gas, oil)	-
TOTAL	6,805

* PS#5: Lignite based

Table 114. On-Site RE Generation (MWh/y). PS#5

Variable	Value
PV and Wind	14
Solar Thermal	1,212
Geothermal	-
Biomass	-
TOTAL	1,226

6.2.3 Cost of energy

Both buildings of Pilot Case 5 cover their electricity demands through their connection with the PPC grid and their thermal needs through their connection with the city's district heating network.

The average electricity price equals 165 €/MWh, while the corresponding thermal price equals 63 €/MWh.

Table 115. Cost of Energy (€/MWh). PS#5

Components	Value	Units
Cost of electricity	165	€/MWh
Cost of heating	63	€/MWh

6.2.4 SRI scores

Both in CERTH and in Hospital buildings, major automations and smart devices that could significantly increase the Smart Readiness Indicator have not yet been installed.

Table 116 shows the values of SRI index for the two buildings as calculated according to the European Commission's calculation method/standard.

Table 116. SRI scores. PS#5

Building	SRI Score
CERTH/CPERI	8%
Mpodosakeio Hospital	8%

6.2.5 Grid Level. Energy infrastructure

6.2.5.1 Grid topology

CERTH's building has its own MV (medium voltage) electric substation.

Mpodosakeio building has also its own MV electric substation, outside of the building.

6.2.5.2 Other characteristics

Nothing significant has happened in relation to power line congestion in the last 15 years. The energy system has been quite stable during the last decade.

6.3 Future situation

For Pilot Case 5, the main goal has been to install and utilize innovative technologies and systems that will contribute to the development of the wider area, the greening of energy sector and the increase of the buildings functionality. In this framework, both CERTH and Mpodosakeio will make use of own funds or EVELIXIA funds (according to proposal) in order to extend operation and function of monitoring and control systems and upgrade their SRI score.

6.3.1 New energy assets, hardware and software

Table 117 shows the new energy assets that will be installed in CERTH's building, while Table 118 shows the systems that will be installed in Hospital. Also, assets related to their monitoring and control are reported.

Table 117. New energy assets in CERTH/CPERI building. PS#5

New energy assets	Description	Funding
Heating & Cooling	4 heat-pumps (14.65 kW, nominal power) supporting heating and cooling of open spaces, Heating 13.5kWth; Cooling (12.1 kWth), EER~6.41	Own
Energy Storage	1 BESS (2 - 3kWh) for extra PVs	Own
EV Charging	2 EV chargers (22kW _e) in the Solar Car Parking (pergolas) 1 V2G charger (11kW _e) in the Car Parking	Own

On-site RE generation	Roof mono crystalline PVs (38 kW _p) / Vertical axis Wind Turbine (1.5 kW _e) on roof Solar pergola in the parking (~ 10 kW _p)	Own
Energy Storage	A new small-scale power-to-hydrogen-to-power system "MOSE" will be designed, and included in an ATEX container, provided from BER (partner in the EVELIXIA project)	EVE
Monitoring, Control and Operation	Novel human thermal sensation control & IoT smart meters to be connected to current BEMS from Pragma IoT (14 monitoring sensors, 10 window sensors, 10 motion sensors, 14 air quality sensors, 25 smart energy meters, 40 smart plugs)	Own
Monitoring, Control and Operation	A fully automated monitoring and control system will be developed for the MOSE system based on a proprietary predictive approach to allow for remote control and operation of the system, defining the operational time-schedule of the system and load controls- it will be connected also to platform from Pragma IoT.	EVE
Monitoring, Control and Operation	Eight (8) Smart actuators for controlling fancoils in offices (heating-cooling)- KNX system for Lightning control in offices. Ten (10) smart magnets, 5 smart plugs, 8 sensors (motion, CO2, temperature, moisture), 4 WiFi repeaters for enhancing communication. Two (2) heat meters for heating/cooling and HVAC in foyer. Extra batteries (2-3 KWh) for increasing energy storage capacity from installed PVs	EVE

Table 118. New energy assets in Mpodosakeio Hospital. PS#5

New energy assets	Description	Funding
On-site RE generation	1MWp PV park	Own*
Energy Storage	batteries (500 kWh), an electrolyzer (275 kWe) and a Fuel Cell (500 kWe) to cover part of the electricity/thermal needs of 3 neighbouring buildings: 1) Mpodosakeio Hospital, 2) Day care centre for the disabled in the Municipality of Eordaia.	Own*
Monitoring, Control and Operation	A cutting-edge BEMS system (Siemens desigo updated version 7.0) will cover the hospital's five (5) operating rooms and will be significantly improved with predictive and operation scheduling algorithms to realize significant energy savings, promote the RES uptake in buildings, lower electricity costs, and reduce CO ₂ emissions. This will enhance the current BMS which monitors only the operation of solar thermal system.	EVE
Monitoring, Control and Operation	Energy flow monitoring platform (BMS) for optimizing energy flows between the PV park, the electrolyzer, the fuel cells, batteries, and final users (buildings). The optimization will be based on prediction scenarios according to weather conditions, buildings electric loads during day and night, energy tariffs etc	EVE**
Monitoring, Control and Operation	Four (4) meters (M-bus) (to be installed) measuring and controlling a) central power supply, b) system energy consumption, and c) back-up system energy consumption	EVE
Monitoring, Control and Operation	Three (3) meters (M-bus) (to be installed) measuring the thermal energy used in the building coming from the solar thermal system, the actual thermal energy	EVE

	consumption of the building, and the cooling energy consumption of the building	
--	--	--

* The foreseen own funded solutions are currently encountering significant delays and cannot be expected by 2025 (study not launched yet)

** The foreseen EVELIXIA-funded solutions are currently encountering significant delays and cannot be expected by 2025 (study not launched yet)

6.3.2 Future Consumption and Generation

The primary expected indicators of energy consumption and production are presented below.

Table 119. Total energy Consumption (kWh/m²/y). PS#5

Variable	Value
Final energy consumption	266
Primary energy consumption	390

Table 120. Consumption per type (MWh/y). PS#5

Variable	Value
Electricity (from the grid)	2,363
Electricity (self-generated from RE)	128
District Heating	1,893
Solar Thermal	1,212
TOTAL	5,596

Table 121. On-Site RE Generation (MWh/y). PS#5

Variable	Value
PV and Wind	128
Solar Thermal	1,212
TOTAL	1,340

6.3.3 Future SRI scores

The target set for increasing the Smart Readiness Indicator (SRI) is presented in *Table 122*. The targets for increasing the SRI score have been set based on the supply and installation of monitoring and automation systems (for cooling & heating systems, for domestic hot water, electricity and EV-charges) which will be determined during the progress of the project.

Table 122. SRI scores. PS#5

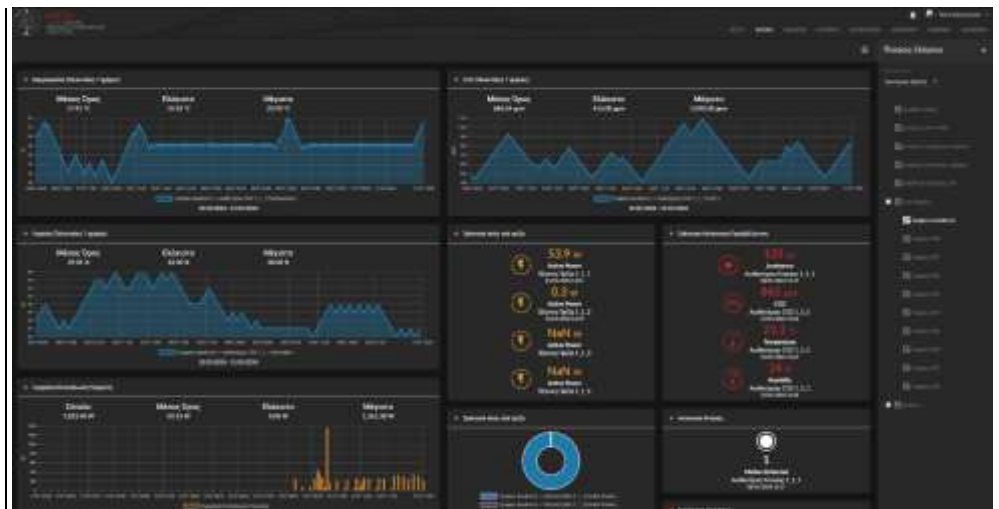
Building	SRI Score
CERTH/CPERI	71%
Mpodosakeio Hospital	67%

6.4 Energy management systems and data communication protocols

Each of the buildings of Pilot Case 5 has a BEM system installed to monitor some basic functions. *Table 123* describes the two systems of CERTH and Mpodosakeio. Actually, CERTH can monitor energy consumption through installed energy meters (platform of Pragma IoT) but Mpodosakeio can only monitor (Siemens Desigo platform) operation of solar thermal system (solar cooling and supporting DH needs and hot water needs).

Table 123. Energy management, monitoring and control systems. PS#5

System	Description
Building Energy Management System (BEMS) in CERTH/CPERI	Scope: Integrated energy monitoring and management system, with simultaneous monitoring of temperature, humidity, pressure, indoor air quality, electric consumption, energy production from roof PV, parameters from roof weather station etc. API: Yes Protocol: MQTT and HTTP REST



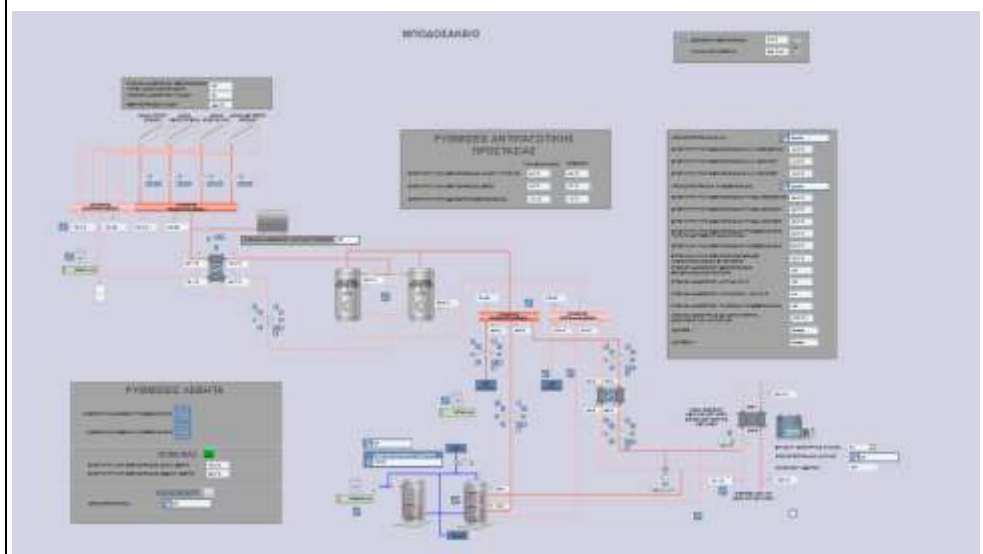
Temp, CO₂, humidity, plugs consumption in office 1

Scope: Monitors only the RES installed systems (solar vacuum collectors, production and consumption)

API: Yes

Protocol: HTTP REST

BEMS in
Mpodosakeio
Hospital



Current monitoring system (BEMS) in Hospital (solar thermal system and interconnection with DHW buffer, main DH system for heating etc)

The proper and efficient operation of BEM systems described above requires the supporting operation of various assets which are presented in *Table 124*.

Table 124. Current monitoring and control of energy assets. PS#5

Scope (asset, building, other)	Measurement & Variables	Freq (min)	Monitoring and control	Com. with EVELIXIA
14 sensors	Temperature and humidity	1	BEM of CERTH/CPERI	API*
10 occupancy sensors	Human presence	1	BEM of CERTH/CPERI	
10 window opening sensors	Window open or closed	1	BEM of CERTH/CPERI	
25 smart electricity meters	Energy consumption	1	BEM of CERTH/CPERI	
40 smart plugs	Energy consumption	1	BEM of CERTH/CPERI	
Weather station	Weather and climatic conditions	1	BEM of CERTH/CPERI	
Pyranometer	Solar radiation	1	BEM of Mpodosakeio Hospital	
5 heat meters (M-BUS) for solar thermal system- (calorimeters) for Consumption and the distribution of thermal energy across the whole hospital building facilities	Installed in different points (outlet of solar thermal system, inlet and outlet of adsorption chiller, DH water buffer tank) of solar thermal system • Water temperature • Water supply • Thermal energy	1	BEM of Mpodosakeio Hospital	
18 temperature sensors	Immersed in various points of the grid (solar fields, exchangers,	1	BEM of Mpodosakeio Hospital	

	collectors), monitor the temperature of system			
1 environmental temperature sensor	Environmental temperature	1	BEM of Mpodosakeio Hospital	
4 analog pressure sensors	Water pressure in different points of grid	1	BEM of Mpodosakeio Hospital	

* The devices have open APIs and support BACnet over IP, Lonworks, Modbus, Panelbus

Figure 33 & Figure 34 present the measurement equipment (sensors and monitoring assets) in the building of CERTH/CPERI and Mpodosakeio hospital respectively.



Figure 33. Measurement equipment in the building of CERTH/CPERI. PS#5

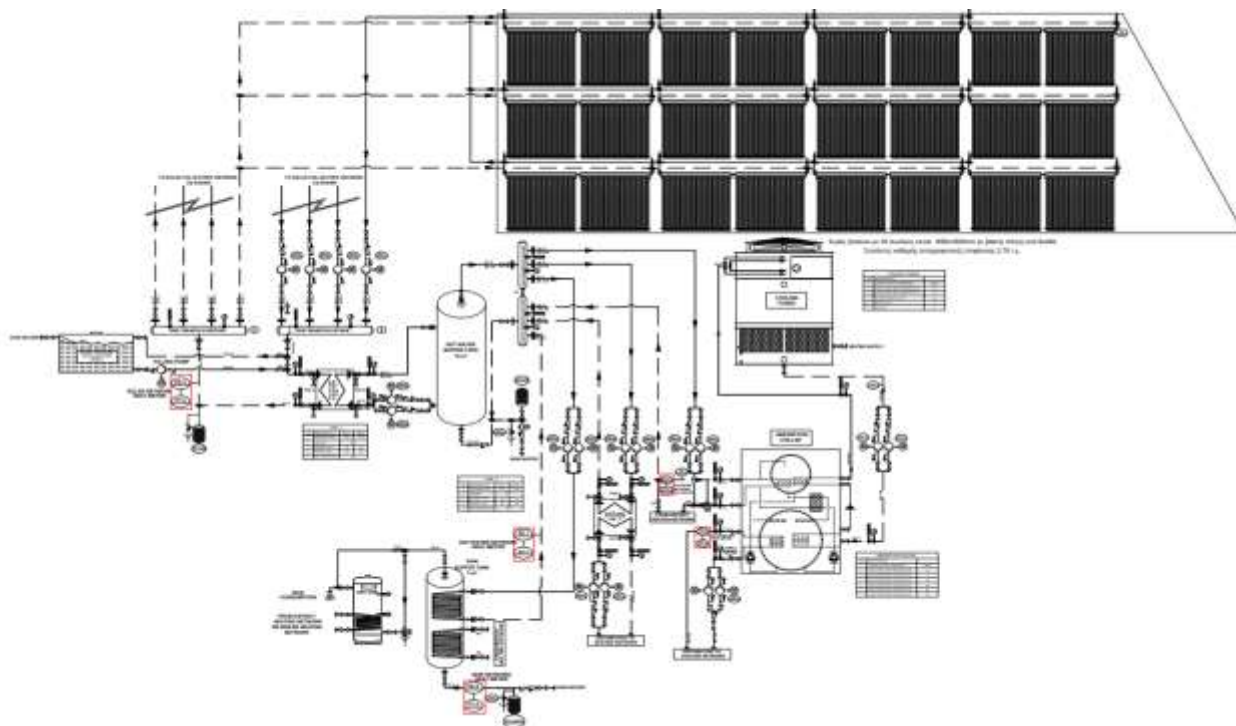


Figure 34. Measurement equipment in Mpodosakeio hospital (BEMS for solar thermal system). PS#5

Table 125 and Table 126 present the new assets that will be installed both in the CERTH (Table 125) and in Mpodosakeio (Table 126) and will help to monitor and control the energy performance of the facilities.

Table 125. Monitoring and Control of new assets in CERTH/CPERI building. PS#5

Scope (asset, building, other)	Measurement & Variables	Freq (min)	Monitoring and control	Com. with EVELIXIA
22 monitoring sensors	Temperature & humidity	1	BEMS	API
18 window sensors	Window opening	1	BEMS	
12 motion sensors	Human motion	1	BEMS	
16 air quality sensors	Indoor air quality (CO ₂)	1	BEMS	
25 smart energy meters	Energy consumption	1	BEMS	
45 smart plugs	Energy consumption	1	BEMS	

15 Smart actuators	Controlling heating/cooling units, fan coils, HVAC and lighting/electricity control panels	1	BEMS	
2 heat meters	Heating/cooling loads	1	BEMS	
KNX system	Lightning in offices	1	BEMS	

The new monitoring and control devices will be managed through the BEMS of Pragma IoT in CERTH building.

The “MOSE” BEMS (with available APIs) will be integrated into the existing PRAGMA IoT BEMS of CERTH building.

Table 126. Monitoring and Control of new energy assets in Mpodosakeio Hospital. PS#5

Scope (asset, building, other)	Measurement & Variables	Freq (min)	Monitoring and control	Com. with EVELIXIA
4 energy meters	Voltage, power, current intensity, energy consumption	1	BEMS	API
3 energy meters	Water temperature, water supply, thermal energy	1	BEMS	

In addition, 3 heat meters/water flow smart sensors (Collection data for DH network) will be installed **by partner DHCP** in the building of CERTH, Hospital and in one DH substation of the pilot area. Whereas 3 smart meters (3 MV/LV substations) will be installed **by partner HEDNO** (substation of CERTH, substation of Hospital, central substation of the pilot area). Communication with EVELIXIA will be achieved through API.

Access to existing BMS (Siemens Desigo for solar thermal system) for EVELIXIA platform is feasible (OPC server or BACNETIP etc).

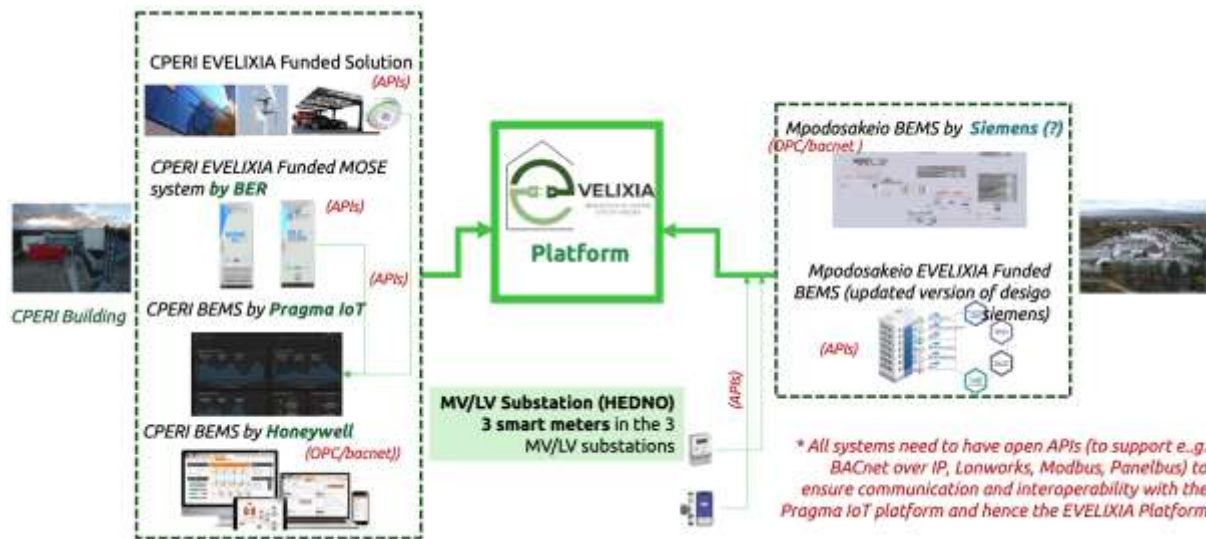


Figure 35. Energy management systems involved in PS#5

6.5 Use cases definition

EVELIXIA endeavours to underscore the viability and efficacy of integrating buildings as active utility nodes into the broader energy landscape by showcasing innovative strategies, technologies and services. Central to this initiative are the pilot demonstrations of the proposed solutions through their respective Use Cases. In the case of the Greek Pilot, the demonstration comprises into two distinct yet interconnected Use Cases each serving to advance the overarching objectives of enhancing energy efficiency, resilience, and sustainability within the energy ecosystem. Both Use Cases highlight the significance of real-time and near-real-time operations in congestion management and advocate for the establishment of a robust communication framework for seamless data exchange among stakeholders.

The primary focus of the first use case is on maximizing on-site self-consumption, a pivotal aspect in enhancing energy efficiency, reducing reliance on external sources, and offering flexibility potential to the grid. This use case encompasses a suite of services, notably Demand Side Flexibility (DSF) designed to efficiently manage energy consumption patterns in response to demand fluctuations. Additionally, portfolio management services are employed, involving strategic oversight to optimize future trading activities. The second use case revolves around grid management, particularly in collaboration with Distribution System Operators (DSOs) and District Heating Operators (DHOs), to mitigate congestion within distribution grids. These strategies entail a set intervention aimed at pre-empting

or alleviating grid congestion, thereby ensuring the seamless operation and reliability of the energy networks.

Table 127. Use Case Summary. PS#5

ID	Use Case	Description
UC-GR#1	Maximize self-consumption	Focuses on maximizing self-consumption on site while responding to a) user needs (e.g. occupant behaviour, thermal comfort etc.) and b) signals from the grid by making optimal use of the demand side flexibility potential and storage capacities.
UC-GR#2	Enable grid congestion management for power grid and DH operators	DSO/DHO set of strategies used to prevent or mitigate congestion within the DH and power distribution grid.

Table 128 presents the different services encompassed in each Use Case of the Greek Pilot Site.

Table 128. Energy Services to be demonstrated per Use Case. PS#5

Category	Energy Service	UC-GR#1	UC-GR#2
Behind the meter	DSM Implicit	✓	-
	Building Investment Planning	✓	-
Front of the meter	DER Dispatch	-	✓
	P2P energy (flexibility) trading	-	-
	Portfolio management services (day-ahead/intra-day)	✓	-
	Network Investment Planning	-	✓

Where:

- DSM Implicit: Adjusting demand fractions (load(s) curtailment or total shifting) by reducing/curtailing or entirely shifting energy-intensive loads during expensive periods to cheaper ones (within the same energy vector or between different sectors -coupling).
- Building Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.

- DER Dispatch: real-time distributed generation and storage (large farms or virtually pooled) dispatch based on grid conditions and financial incentives. Leverage the available local-grid storage farms during peak hours to cover local demand, thereby reducing congestion levels on central power distribution lines
- P2P energy (flexibility) trading: Decentralized synchronized coordination of demand between mutualized/aggregated/community customers (increase-to-decrease demand schemes to provide the same service to the grid)
- Portfolio management services (day-ahead/intra-day): Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading and maximize aggregators' returns, implementing explicit DR schemes in accordance to the upfront market bids. Upfront-selling the potential/estimated result of demand response actions in electricity markets. Based on appropriate predefined contracts (e.g., the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding of large loads is applied in response to incentives provided by aggregators/DR service providers.
- Network Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating, steam, gas) grid needs ensuring reliability, efficiency, and sustainability.

6.5.1 Use case 1. UC-GR#1: Maximize self-consumption

Use Case description
Name UC-GR#1: Maximize Self Consumption Scope UC-GR#1 focuses on maximizing self-consumption on site while responding to user needs (e.g. occupant behaviour, thermal comfort etc.) by making optimal use of the demand side flexibility potential and storage capacities. UC-GR#1 aims to a) optimize energy consumption patterns without direct user intervention. The scope encompasses a comprehensive list of actions:

- Establish a robust communication framework between grid operators, consumers, and demand-side resources.
- Cost-benefit analysis to evaluate the economic viability of demand-side flexibility measures

Document the methodologies, findings, and practices during the pilot activities

Objectives

- Analyse current demand patterns and historical data in electricity consumption data to identify peak demand periods
- Evaluate the variability of electricity demand across different time scales (hourly, daily, and seasonal)
- Survey and classify potential demand-side resources, including but not limited to the tertiary sector (Mpodosakeio Hospital and CPERI office buildings)
- Assess the feasibility of leveraging distributed energy resources (DERs) and demand response programs
- Explore strategies to seamlessly integrate renewable energy sources into the grid and align demand response with intermittent renewable energy generation
- Smartification of heating, ventilation, and air conditioning (HVAC) systems that automatically adjust temperature settings based on occupancy levels, user needs, and external weather conditions to help optimize energy consumption without compromising comfort or care standards (implicit flexibility)
- Contribute to the reduction of greenhouse gas emissions by optimizing the utilization of renewable energy resources.
- Coordinate electricity production from the PV (48 kW_p), and storage systems such as a) the BESS (7-8 KWh Total), b) the electrolyser (7.5kW), with a Fuel Cell (5kW), to store excess energy generated on-site or during low demand periods for use during peak demand times to help reduce resilience on the grid and provide back power in case of outages. (implicit flexibility)
- Coordinate the provision of electricity to the electrolyser (7.5kW) by the PV (48kW) or by the grid to optimize the source of energy based on factors such as cost, and environmental considerations.

Limitations & Assumptions

- Data Acquisition: The effectiveness of the activities and the accuracy of the results rely heavily on the availability of data pertaining to energy consumption, demand patterns, and other relevant variables. Inaccuracies or gaps in the data may introduce uncertainties.
- Occupant Behaviour: Demand-side flexibility initiatives often assume a certain level of responsiveness from end-users. Given the primary use for Mpodosakeio and CPERI buildings (hospital and offices respectively), assuming a homogenous and uniform response in both cases may lead to potential discrepancies between projected and actual outcomes, neglecting the inherent diversity in energy consumption patterns, preferences, and specific needs.

-
- **Infrastructure Constraints:** Demand-side flexibility initiatives is contingent both on the existing and on the planned infrastructure's adaptability. Limitations in grid capacity, communication networks, and technology integration may hinder the seamless implementation of the proposed activities. It is also essential that all systems support open APIs (to support e.g. BACnet over IP, Lonworks, Modbus, Panelbus) to ensure communication and interoperability with the EVELIXIA Platform.
 - **Technological Reliability:** The employed technologies, such as smart meters, actuators and automation systems, function reliably without any technical failures or inconsistencies throughout the pilot activities.
 - **External Factors:** Economic conditions, weather conditions, and market dynamics, may not be relatively stable throughout the pilot period. Such variables introduce unpredictability into the resulting related outcomes.
-

Assets of the Use Case

Below are presented the assets used for both Use cases (UC#1 and UC#2)

A. Mpodosakeio General Hospital of Ptolemaida

A1. Existing equipment

- **Heating:**
 - 1 Thermal substation 3.5MW_{th} (~97% efficiency) operating from mid-October to mid-May each year
 - 1 plate heat exchanger ($539.3\text{kW}_{\text{th}}$) supports extra heating needs
 - **Cooling:**
 - 1 water-cooled chiller (500kW_c) covering cooling loads (80.9 kW_e);
 - 1 absorption chiller (264kW_c) and 1 cooling tower (408kW_{ct}) driven by a solar thermal field
 - **DHW:**
 - 320 solar thermal collectors (456 MWh annual production - $236.7\text{MWh}_{\text{th}}$ hot water, $109.7\text{MWh}_{\text{th}}$ space heating, 106.7 MWh space cooling)
 - **Ventilation:**
 - Central Cooling Unit (HVAC) for surgery rooms, intensive care units etc. ($106.055\text{ m}^3/\text{h}$)
 - **Energy Storage:**
 - Hot water tanks (10m^3) (coupled with the solar thermal system), DHW boilers (12m^3)
 - **On-site RE generation:**
 - 320 vacuum solar thermal collectors (625kW_{th})
 - **Monitoring, Control and Operation:**
-

- A BEMS monitors the RES installed systems (solar vacuum collectors).
- Metering Systems record and monitor the operational performance of the solar thermal system and assess the impact of interventions on energy consumption and CO₂ emissions.
- A pyranometer is installed in the solar collector support system; a heat meter is installed in the primary solar energy system circuit, measuring the solar energy converted into heat energy;
- 4 heat meters (M-Bus) are installed to measure the consumption and the distribution of thermal energy across the whole hospital building facilities, at any time, with a 1-minute time granularity.
- The system consists of automation stations, signal collection cards, Desigo CC workstations and Green Building Monitor energy consumption statistics display system (time step: ~1').

A2. Planned installations (EVELIXIA)

- A cutting-edge BEMS system (Siemens Desigo updated version 7.0) with predictive and operation scheduling algorithms to realize significant energy savings, promote the RES uptake in buildings, lower electricity costs, and reduce CO₂ emissions. Extension and upgrade of the current BEMS (by Siemens Desigo updated version 7.0) will incorporate HVAC monitoring for five (5) surgery units and will oversee the solar thermal system (625KW_{th}), the hot water buffers, the DHW distribution, and hospital's cooling and heating. The upgraded BEMS provide open APIs to enable communication by third parties, specifically with the project platform "EVELIXIA".
- Four (4) meters (M-bus) (to be installed) measuring and controlling a) central power supply, b) system energy consumption, and c) back-up system energy consumption (Variables measured: voltage, power, current intensity, energy consumption)
- Three (3) meters (M-bus) (to be installed) measuring the thermal energy used in the building coming from the solar thermal system, the actual thermal energy consumption of the building, and the cooling energy consumption of the building. (Variables measured: water temperature, water supply, thermal energy)

B. CERTH/CPERI Building

The existing Building Energy Management System (BEMS) by Pragma IoT provides access to the monitoring equipment installed in offices and electric panels (14 temperature and humidity sensors, 10 occupancy sensors, 14 air quality-CO₂ sensors, 10 window opening sensors, 25 smart (3-phase) energy meters in the electric panels), 40 smart plugs and a Weather station). The interface enables the user to manage alarms, record and analyse historical data etc. The devices have open APIs and support BACnet over IP, Lonworks, Modbus, Panelbus. Pragma IoT will also monitor the equipment to be installed with a) own funds and b) EVELIXIA funds.

B1. Existing equipment

- Heating:
 - DH connection with heat exchanger (175kW)

- Cooling:
 - Central HVAC (268kW_c)
- Ventilation:
 - HVACs covering building needs (offices, laboratories, open spaces etc.); Mechanical ventilation for offices (3m³/h/m²)
- Lighting:
 - LED lighting for all spaces (18.5kW)
- Energy Storage:
 - Battery (5kWh) coupled with roof PV (10 kW_p)
- On-site RE generation:
 - 6 kW_p Monocrystalline and 4 kW_p Polycrystalline PV system coupled with the 5-kWh battery
- Monitoring, Control and Operation:
 - Building Energy Management System (BEMS) Honeywell - for on-off heating/ cooling control – The BEMS will be accessible via OPC server or BacnetIP
 - Building Energy Management System (BEMS) by Pragma IoT providing access to the monitoring equipment installed (14 temperature and humidity sensors, 10 occupancy sensors, 14 air quality-CO₂ sensors, 10 window opening sensors, 25 smart (3-phase) energy meters, 40 smart plugs and a Weather station). The interface enables the user to manage alarms, record and analyse historical data etc. The devices have open APIs and support BACnet over IP, Lonworks, Modbus, Panelbus

B2. Planned installations (own funding)

- 4 heating/cooling units (14.65kW, nominal power) supporting heating and cooling of open spaces
- 1 BESS (2-3kWh) for extra PVs
- 2 EV chargers (22kW_e) in the Solar Car Parking (pergolas)
- 1 V2G charger in the Car Parking (11kW)
- Roof monocrystalline PVs (38 kW_p)
- Vertical Axis Wind Turbine (1.5 kW_e) on the roof
- Solar pergola in the parking (~10 kW)
- Extra Novel human thermal sensation control & IoT smart meters (14 monitoring sensors, 10 window sensors, 10 motion sensors, 14 air quality sensors, 25 smart energy meters, 40 smart plugs)

B3. Planned installations (EVELIXIA)

- A new small-scale power-to-hydrogen-to-power system “MOSE” developed by BER. To provide flexibility, a fully automated monitoring and control system will be developed for the MOSE system based on a proprietary predictive approach

to allow for remote control and operation of the system, defining the operational schedule of the system and load controls. (Variables measured: %load of electrolyser, H2 storage)

- Fifteen (15) Smart actuators for controlling:
 - four (4) actuators to be installed at the heating/cooling units
 - one (1) actuator to be installed at the existing HVAC of the foyer
 - eight (8) actuators to be installed at the fancoils in new eight (8) offices to control temperature based on presence sensors
 - 2 actuators to be installed at 1 lighting/electricity control panel (controlling on-off of the power to selected 2 spaces)
- Ten (10) smart magnets, to be installed in 8 new offices of the building (monitoring the status of window, open or close)
(Variables measured: electricity consumption)
- Two (2) heat meters to be installed for
 - Measuring the heating/ cooling energy inserted to the building (through fancoils in the offices)
 - Measuring the heating/cooling energy inserted to open space-foyer (HVAC of foyer)
 - (Variables measured: water temperature, mass flow)

C. District level installations

C1. Purchased from DHCP through EVELIXIA funds

- 3 heat meters (water flow sensors) to collect data for DH network (1 to Mpodosakeio, 1 to CPERI building, 1 to DH substation near to the above buildings)

C2. Purchased from HEDNO through EVELIXIA funds

- 3 smart meters to measure the voltage at 3 MV/LV substations (1 to CPERI electric substation, 1 to Mpodosakeio electric substation and 1 to main grid giving power to the above buildings)

C3. Planned installations (own funding)

- Energy flow monitoring platform (BEMS) for optimizing energy flows between the PV park, the electrolyzer, the fuel cells, batteries, and final users (buildings)
- Energy flow assessment via emulation through Digital Twin

Further information

UC-GR#1 centres on the optimization of on-site self-consumption, dynamically responding to user demands by leveraging demand-side flexibility and storage capacities autonomously. This Use Case strives to reduce reliance on direct user intervention by adapting energy consumption patterns to prevailing conditions. The integration of flexibility resources, such as demand response and energy storage,

assumes a critical role in ameliorating congestion and streamlining grid operations, thereby aligning with the objectives of UC-GR#2.

Grid Services Selection

Related services to enhance the grid's stability, reliability, resilience, efficiency, and adaptability to fluctuations by actively managing the electricity demand:

- **RES Harnessing:** EVELIXIA will prioritize using this solar PVs to power the electrolyser. The excess solar energy will be stored in 36 batteries (230Ah/12V, 4.968 kWh) or used for other on-site operations.
- **Grid Connection:** In situations where solar PV generation is insufficient, such as at night or during periods of low sunlight, the facility can seamlessly switch to drawing electricity from the grid to power the electrolyser. This ensures continuous operation of hydrogen production without interruptions, maintaining production levels to meet demand requirements.
- **Dynamic Energy Management:** EVELIXIA will monitor electricity generation from the solar PV system, grid electricity prices, and electrolyser demand to allow for dynamic decision-making on the most cost-effective and environmentally friendly energy source at any given time. This system can automatically switch between solar PV and grid power based on real-time conditions.
- **Cost Optimization:** EVELIXIA will analyse electricity prices from the grid and factoring in the costs of electricity generation from solar PV, the CPERI building can strategically choose the energy source that offers the most cost savings. This could involve using grid electricity during off-peak hours when prices are lower and relying on solar PV during peak demand periods to offset expensive grid electricity usage.
- **Sustainability Benefits:** Prioritizing solar PV electricity for electrolysis helps reduce the facility's carbon footprint and dependence on fossil fuel-based grid electricity. By maximizing the use of renewable energy sources, the facility will favour its sustainability efforts and contribute to a cleaner energy transition.
- **Load Shifting:** Adjusting a portion of the demand for electricity consumption in the system by moving electricity-intensive end-users activities to different time-frames. Occupants and end users can be encouraged to shift their energy usage to times when renewable energy generation is abundant or during periods of reduced overall demand.
- **Load Shedding:** The deliberate and temporary reduction of electricity supply through advanced active control of electricity consumption in response to real-time specific signals or commands from the grid operator or the energy management systems. These systems can automatically implement measures based on predefined criteria, such as peak demand thresholds or equipment failures.
- **Portfolio management** services (day-ahead/intra-day): Day-ahead portfolio strategic management involves forecasting electricity demand and generation patterns for the upcoming day, optimizing the scheduling of power generation resources. Intra-day portfolio management addresses short-term fluctuations in

electricity supply and demand by adjusting generation, storage, and consumption in real-time to maintain grid stability and reliability.

Prioritisation of the use case

Obligatory.

Market mechanisms

Out of scope for this UC.

Use Case Narrative

UC-GR#1 envisions to investigate and implement demand side flexibility measures with the aim to maximize self-consumption, with a focus on enhancing grid reliability, reducing peak load demand, and integrating renewable energy sources efficiently.

UC-GR#1 is divided into 2 phases:

- Comparison: Service definitions and initial evaluation
- Selection: State estimation and forecasting of demand side flexibility

Complete description of the use case.

- PS#5 creates offers for flexibility based on current assets

Assets have the ability to measure the energy required for consumption, but also the energy produced by renewable source systems, while at the same time the price of the energy provided by the grid is also known. Thus, a model is created for choosing the energy source (RES/self-consumption or grid) to be used, and the most beneficial solution is followed in each case. In this way, energy efficiency is maximized, reduction of costs is achieved and energy responsible of the building takes the right decisions the right time.

- PS#5 delivers a baseline per asset and makes sure that information is updated

Assets create a baseline for the percentage of self-consumption of the Pilot Site, but also of the energy that is either surplus and will be injected to the grid, or is in short supply and must be absorbed from the grid. Obviously, this process has different data for each day (hour) as it directly depends on the climatic and meteorological conditions, but also on the operating conditions of the site premises.

Table 129. Technical details and actors involved. UC-GR#1

Name	Actor Type	Description	Further information specific to this Use Case
CERTH/CPERI	Building Operator		Responsible for UC implementation in the Greek Pilot.
Mpodosakeio General Hospital of Ptolemaida	Building Operator		Supportive role in UC implementation.
BlueEnergy Revolution (BER)	Technology Provider	Integration, testing, project, and product development services.	Integrated, containerized Power-to-Hydrogen-to-Power solution "MOSE" including monitoring and controlling capabilities

Table 130. Step by step analysis. UC-GR#1

No	Scenario name	Scenario description	
MPODOSAKEIO HOSPITAL			
1	Solar DHW production	The EVELIXIA platform will contain the climatic data (solar radiation) as well as the demand of the hospital for DHW. Thus, it will be possible to predict the percentage (volume of hot water) of the needs that can be covered by the solar panels and through the BEM it will be possible to activate the hot water supply system through district heating when the energy generated from solar panels is not adequate.	
		Primary actor	EVELIXIA platform
		Triggering event	Solar radiation-BEMS
		Pre-condition	DHW demand, Prediction of the amount of hot water that the solar panels can produce
		Post-condition	Percentage of DHW demand covered by solar panels
2	Solar cooling	The EVELIXIA platform will include the climatic data (solar radiation) as well as the hospital's cooling demand. Thus, it will be possible to predict the percentage of cooling load that can be covered by the solar panels and through the BEM it will be possible to activate the	

		operation of the system with the electric chiller when the solar panels cannot cover more cooling needs.	
		Primary actor	EVELIXIA platform
		Triggering event	Solar radiation-BEMS
		Pre-condition	Demand for cooling, Prediction of the amount of cooling loads that the solar panels can produce
		Post-condition	Cooling loads covered by solar panels
3	Surgery units monitoring	Temperature/humidity monitoring and control systems will be installed in the 5 surgery units, connected to BEM. It is thus possible to schedule the systems to maintain the conditions at the required values, according to the planning of the surgeries (automatic scheduling the on-off function and setting points of temperatures).	
		Primary actor	EVELIXIA platform
		Triggering event	Time schedule, desired temperature
		Pre-condition	Temperature of surgeries, Humidity of surgeries, Planned actions in surgeries
		Post-condition	Implementation of the actions in surgeries under the required conditions
CERTH/CPERI BUILDING			
4	Heating system actuation	The EVELIXIA platform checks the presence data and when no presence is observed in the building, BEM proceeds to shutdown of the heating system (DH) throughout the building (winter months)	
		Primary actor	EVELIXIA platform
		Triggering event	Presence sensor data in the office/BEMS
		Pre-condition	Presence or not inside the building, Operation of the heating system
		Post-condition	Stop heating system's operation if there is no presence in the building
5	Cooling system actuation	The EVELIXIA platform checks the presence data and when no presence is observed in the building, BEM proceeds to shutdown of the cooling system throughout the building (summer months)	
		Primary actor	EVELIXIA platform
		Triggering event	Presence sensor data in the office/BEMS
		Pre-condition	Presence or not inside the building, Operation of the cooling system
		Post-condition	Stop cooling system's operation if there is no presence in the building
6		The EVELIXIA platform checks the presence data and when no presence is observed in the building, BEM proceeds to shutdown of the HVAC system throughout the building	

	HVAC system actuation	Primary actor	EVELIXIA platform
		Triggering event	Presence sensor data in the office/BEMS
		Pre-condition	Presence or not inside the building, Operation of the HVAC system
		Post-condition	Stop HVAC system's operation if there is no presence in the building
7	Fancoils actuation	The platform checks the presence data in each office (2nd construction phase) and when no presence is observed, BEM proceeds to the shutdown of the fan coil in the specific office.	
		Primary actor	EVELIXIA platform
		Triggering event	Presence sensor data in the office/BEMS
		Pre-condition	Presence or not inside the offices, Operation of the corresponding fan coils
		Post-condition	Stop fan coils' operation if there is no presence in the offices
8	HVAC foyer actuation	Two heating sensors will be installed in the foyer area and will provide the platform with information about the space temperature. When the temperature falls below the desired limit (17°C), BEM launches the operation of the HVAC in the foyer increasing the temperature to the desired level.	
		Primary actor	EVELIXIA platform
		Triggering event	Temperature sensor data in the foyer/BEMS
		Pre-condition	Temperature in the foyer, Need for heating/cooling
		Post-condition	Start the operation of HVAC at foyer if is needed
9	Heating unit's actuation in foyer	Four (4) heating units will be installed in the foyer. When the space temperature falls below the desired levels (17 °C) BEM will launches the operation of the units to increase the temperature to the desired level.	
		Primary actor	EVELIXIA platform
		Triggering event	Temperature sensor data in the foyer/BEMS
		Pre-condition	Temperature in the foyer, Need for heating loads
		Post-condition	Start the operation of heating units if is needed
10	Fuel cell operation (MOSE)	The PV system will be connected to the electrolyser that will be installed at CERTH producing hydrogen, which will be stored in the electrolyser/storage/fuel cell system. When the battery charge falls below the desired limits (80%), BEM starts operating the fuel cell to use the stored hydrogen to generate electricity and charge the battery. Also load of electrolyser can be controlled through the platform according to the needs of fuel cell system.	

		Primary actor	EVELIXIA platform
		Triggering event	Battery charging status/BEMS
		Pre-condition	Battery charging status, Hydrogen stored, Ability of PV system to re-produce the amount of hydrogen which is going to be used
		Post-condition	Battery full of charged

6.5.2 Use case 2. UC-GR#2: Enable grid congestion management for power grid and DH operators

Use Case description

Name

UC-GR#2: Enable grid congestion management for power grid and DH operators

Scope

UC-GR#2 deals with the DSO/DHO set of strategies used to prevent or mitigate congestion within the DH and power distribution grid. The scope encompasses various aspects related to the management of grid constraints and the facilitation of grid flexibility:

- Management of congestion at distribution system operator (DSO) level, through manual operation of the DERs
- Activation and utilization of flexibility resources (e.g., demand response, distributed generation, energy storage) to alleviate congestion.
- Coordination with relevant stakeholders (e.g., aggregators, prosumers) for efficient utilization of flexibility.
- Design, development, and optimization of the energy infrastructure to meet the current and future needs ensuring reliability, efficiency, and sustainability.

Objectives

The objectives are designed to address specific goals and outcomes that the actors (distribution system operators, aggregators, prosumers, etc.) aim to achieve through the implementation of the Use Case. These objectives are focused on improving the efficiency, reliability, and resilience of the DH and electricity distribution network, particularly in managing grid congestion effectively.

- Minimize the risk of grid overloads or voltage violations due to congestion.
- Enable the efficient activation and utilization of flexibility resources (e.g., demand response, distributed generation, energy storage) to alleviate congestion.
- Ensure that flexibility activations are coordinated and optimized to minimize grid constraints while maximizing the utilization of available resources.
- Demonstrate adherence to relevant EU directives and regulations governing electricity market operation and grid management.

-
- Improve the resilience of the distribution network to withstand and recover from external disruptions (e.g., extreme weather events, equipment failures) by effectively managing congestion.
 - Strategically schedule energy-intensive tasks and production of electricity/heating to align with off-peak hours or when energy prices are lower, to maximize energy savings and grid support (explicit flexibility)
 - Align and coordinate the use of voluntary and mandatory active power flexibility for the process of re-dispatch.
-

Limitations & Assumptions

By acknowledging the following limitations and assumptions stakeholders can contextualize the applicability and potential challenges associated with the implementation of the Use Case:

- Network specific topology and characteristics (e.g., radial or meshed structure, line capacities, transformer configurations)
- Availability and capacity of flexibility resources such as demand response, distributed generation, and energy storage.
- Availability accuracy and quality of data on grid conditions, demand patterns, and resource availability are critical for effective congestion management, real-time monitoring and control.
- Regulatory and market constraints may limit the ability of distribution system operators to implement certain congestion management strategies or engage with flexibility providers. Lack of market mechanisms or incentives for flexibility provision may impede the scalability and sustainability of congestion management initiatives.
- Behaviour of flexibility providers (e.g., prosumers, aggregators) may not be homogenous or have a certain level of consistency or predictability in responding to congestion signals.
- Sudden or significant fluctuations in network conditions may challenge the effectiveness of congestion management strategies designed under stable operating assumptions.
- Technological compatibility and interoperability between different technologies and systems used for monitoring, control, and communication within the distribution network. Integration and communication between grid equipment, control systems, and flexibility resources

Responsiveness of end-users to demand-side management initiatives or price signals aimed at alleviating congestion. Consumer preferences, willingness to participate, and adoption of new technologies may impact the effectiveness of demand-side congestion management strategies.

Assets of the Use Case

Same than in GR-UC#1

Further information

UC-GR#2 addresses congestion management strategies employed by Distribution System Operators (DSOs) and District Heating Operators (DHOs) within the district heating and power distribution network. Coordinating with pertinent stakeholders, including aggregators and prosumers ensures the efficient utilization of flexibility resources, thereby augmenting the overall efficacy of demand-side management strategies outlined in UC-GR#1. The design, development, and optimization of energy infrastructure spotlighted in UC-GR#2 contribute to ensuring reliability, efficiency, and sustainability, thereby bolstering the objectives of maximizing self-consumption and responding to grid signals delineated in UC-GR#1.

Grid Services Selection

Several grid services will be implemented in UC-GR#2 to address specific needs related to managing grid congestion effectively. These grid services are designed to provide various functionalities aimed at improving the reliability, efficiency, and resilience of the distribution network:

- **Demand Response (DR):** adjusting electricity consumption in response to price signals or grid conditions to alleviate congestion and balance supply and demand. Actors will reduce or shift based on financial incentives (provided through EVELIXIA platform) their electricity consumption during these periods, thereby relieving stress on the grid and mitigating congestion.
- **Distributed Generation (DG):** reducing the output of distributed generation sources during periods of grid congestion to avoid overloading local distribution infrastructure. During periods of high congestion, distributed generation sources will curtail their output or operate at reduced levels to prevent grid overloads. The DSO will communicate congestion signals to distributed generation owners/operators and coordinate curtailment actions to ensure grid stability.
- **Energy Storage:** store excess energy during periods of low demand and discharge it during periods of high demand or congestion to support grid balancing. During periods of congestion, energy storage systems will discharge stored energy to supplement grid supply and alleviate pressure on congested grid segments.
- **Distributed Energy Resources (DERs) dispatch:** Real-time balancing of supply and demand by grid operators or utilities by dynamically controlling the operation of power generation of decentralized renewable energy sources based on grid conditions, grid support functions, and market participation. This service will be simulated with the EVELIXIA platform as the DSO (HEDNO) cannot perform dynamic control of active power generation since there is no instant control of DERs
- **State of substations at distribution level:** The DSO will monitor grid voltage levels. Metering devices, will be deployed at the three-substations:
 - a. at CETH/IDEP
(Y/Σ 223-X, <https://maps.app.goo.gl/Ewf7wVzMBZXCJprb7>)

- b. at Mpodosakeio
(Υ/Σ 58-X, <https://maps.app.goo.gl/yPqgfRdqmpWLea9L8>)
- c. at Eordaia (Starting line)
(40Υ/Σ, <https://maps.app.goo.gl/xQyXVs6n3grwvpFv9>)

At the beginning of the distribution line of Greek PS. The devices will provide EVELIXIA platform with critical measures (e.g. voltage, amperage, and power) about the state of the substations and the local grid.

Prioritisation of the use case

Obligatory.

Market mechanisms

Out of scope of this UC.

Use Case Narrative

UC-GR#2 envisions to incorporate the measurements and the observations in the management process, in order to better react/behave on energy consumption curtailment signals and grid congestion. The purpose is to enhance grid's stability and reliability

Complete description of the use case.

HEDNO

- DSO collects data (metering data). The meter devices, that will be deployed by HEDNO will provide EVELIXIA platform with electric measurements (voltage, amperage, power)
- DSO evaluates updated grid information and potential congestions. This process starts in D-1. HEDNO collects the measurements to assess the state of the substations and the distribution line that feed the Greek PS based also on the demand side management state.

DHCP

DHCP collects data (metering data). The measurements include the heat supply to the CPERI and Mpodosakeio buildings as well as the water temperature to assess the state of the district heating line and control the water temperature that feeds the Greek PS.

Table 131. Technical details and actors involved. UC-GR#2

Name	Actor Type	Description	Further information specific to this Use Case
CERTH/CPERI	Building Operator		Responsible for UC implementation in the Greek Pilot.
Mpodosaio General Hospital of Ptolemaida	Building Operator		Supportive role in UC implementation.
HEDNO	DSO	Operation, maintenance and development of the power distribution network and electricity systems	Transparent and impartial access of consumers and network users to data
DHCP	DH Operator	Operation, maintenance and development of the district heating network	RES implementations in thermal energy production

Table 132. Step by step analysis. UC-GR#2

No	Scenario name	Scenario description	
MPODOSAKEIO HOSPITAL			
1	Monitoring of electricity	The energy metering systems that will be installed, will provide the EVELIXIA platform with information about the voltage, current and total electric consumption of the building. Thus, through the platform, the hospital administration will be able to be informed of any malfunctions or damage to the electricity system.	
		Primary actor	EVELIXIA platform
		Triggering event	Electricity malfunction-BEMS
		Pre-condition	Electricity characteristics (power, voltage, intensity)
		Post-condition	Correction of any malfunction
2	Alleviate congestion in DH grid	EVELIXIA platform will gather data both on the production of energy from RES (solar thermal), as well as on the demand for thermal energy and the supply of thermal energy from the district heating network. In this way, it will be possible to correlate the data and when the production of thermal energy from RES is sufficient, to throttle the electric valve for the supply of district heating in Mpodosaio, to reduce the operating rate of the feed pumps and to reduce the supply of thermal energy to the building.	

		Primary actor	EVELIXIA platform
		Triggering event	Alleviate congestion
		Pre-condition	Thermal energy demand, supply from network, supply from RES
		Post-condition	Supply from network, supply from RES

CERTH/CPERI BUILDING

3	Grid and battery system	Additional BESS will be installed at the CPERI Building, connected to the new PV system (in total ~38kW). The platform will manage the prices of electricity coming from the grid and recommend charging the batteries at times when the prices are low and advantageous.	
		Primary actor	EVELIXIA platform
		Triggering event	Energy price of electricity/ Battery charging status
		Pre-condition	Battery charging status, Energy price, Amount of energy produced by the PV system
		Post-condition	Full charged battery

BOTH BUILDING/DHCP

4	Monitoring of thermal energy	The energy metering systems that will be installed, will provide the EVELIXIA platform with information about the supply, temperature and thermal power of the buildings. Thus, through the platform, DHCP will be able to check the conditions prevailing in the transmission network, before the two pilot case buildings, and distinguish any problems or malfunctions that arise.	
		Primary actor	EVELIXIA platform
		Triggering event	Thermal energy malfunction-Metering systems
		Pre-condition	Thermal energy characteristics (supply, temperature, thermal power)
		Post-condition	Correction of any malfunction

7 PILOT SITE 6. SPAIN

Location: Estación de Esquí y Bike Park Manzaneda Estación de Montaña. Estación Invernal, 24-25, 32786 A Pobra de Trives, Province of Ourense

Scope: The tourism activity associated with the ski resort represents a critical source of employment and business creation for the area. Environmental sustainability is a key element in the development of the resort. The use of alternative energies, the implementation of technologies that reduce emissions and the digitization of different processes are aspects that have been particularly considered from the outset in the planning of the buildings.



Figure 36. Top view of the Spanish Pilot Site. PS#6

7.1.1 Relevant stakeholders

At Manzaneda six stakeholder groups were participating: MEISA, Xunta de Galicia (Galician government), NTT DATA, the Deputation of Ourense, the community of owners of Manzaneda and ITG.

Table 133. Relevant stakeholders. PS#6

Stakeholder	Role
MEISA	Owner and operator
Xunta de Galicia	Public body (financing)
NTT DATA	Technical partner / ESCO / platform integrator
Ourense Deputation	Public body (financing)
Property (private buildings) owners' community	Owner/end-users
ITG	Technology provider

7.2 Current situation

7.2.1 Buildings and energy assets

The Manzaneda site has five main buildings, of which the Galicia building, and the restaurant will participate in the project.

Regarding the energy facilities, there is a biomass plant for heating and domestic hot water production for the entire site, although some apartments in the Galicia building have heating and hot water produced by electricity. Additionally, it is worth noting the presence of a 150-kW_p photovoltaic system and a 20-kWh battery storage system.

Below, the buildings involved in the project and the main energy assets of the site are described.

Table 134. Building 1. PS#6

Variable	Description
Name / Type	Galicia Building / Residential and tertiary
Floor Area (m ²)	16,369 m ²
Year of Construction	1976
N. of Occupants	500/10,000 – Depends on seasonality

Table 135. Building 2. PS#6

Variable	Description
Name / Type	Restaurant / Tertiary
Floor Area (m ²)	1,186 m ²
Year of Construction	1973
N. of Occupants	160



Figure 37. Galicia Building. PS#6



Figure 38. Restaurant. PS#6

7.2.1.1 Energy Assets

Tables below present information regarding existing controllable building assets at site and at building level.

Table 136. Energy assets at site/district level. PS#6

Energy assets	Description
Heating	Biomass Central Heating (800 kWth)
DHW	Biomass Central Heating (800 kWth)
Energy Storage	Hot water storage tank of 5m ³
On-site RE generation	Biomass Central Heating

Monitoring, Control and Operation	- Flythings platform: PV production and Biomass plant M&O - SCADA platform: Medium voltage network (transformation centres). MEISA has direct access - CIDE Platform: End-users consumption (approximately 273 CUPS). Pretty large files to be easily shared. Interoperability with EVELIXIA platform: - Flythings platform: API REST - SCADA platform: not possible, only manually - CIDE Platform: not possible, only manually
Other	i) artificial snow guns, ii) ski lifts, and iii) ancillary facilities

Table 137. Energy assets Building 1. Galicia Building. PS#6

Energy assets	Description
Heating	Biomass Central Heating, some apartments also have electric radiators (1- 2kWe)
DHW	Biomass Central Heating, 60 apartments have electric boilers (1.5 kWe)
Lighting	Conventional (from 40 W for incandescent luminaires; 20 W/m ²) and LED (from 8W; 5W/m ²)
Energy Storage	Hot water storage tank at site level and 1 BESS (20 kWh)
On-site RE generation	PV 40 kW _p (restaurant roof)
Monitoring, Control and Operation	See energy assets at site/district level
Other appliances	Typical office equipment and domestic appliances,
Other	User consumption data is available.

Table 138. Energy assets Building 2. Restaurant. PS#6

Energy assets	Description
Heating	Biomass Central Heating
DHW	Biomass Central Heating
Ventilation	3 Ventilation units (30,000 m ³ /h, 10,000 m ³ /h per unit)
Lighting	Conventional (from 40 W for incandescent luminaires; 20 W/m ²) and LED (from 8 W; 5 W/m ²)
Energy Storage	Hot water storage tank at site level
On-site RE generation	108 kW _p (72 kW _p parking + 36 kW _p Ski lift building)
Monitoring, Control and Operation	See energy assets at site/district level
Other appliances	Kitchen appliances
Other	Shared monitoring platform with the Galicia building

7.2.1.2 Other characteristics

The main characteristic of this pilot site is the variety of end-users and, hence, consumption profiles: dwellings, street lighting, some industrial equipment and a hotel with sport and commercial facilities.

In the Residential section (Galicia Building), typical kitchen and office appliances can be found, as well as small heating and DHW equipment. There are a total of 220 end users, of which 53 are owned by MEISA. In the Hotel there is also a laundry room, there are classrooms where educational activities are performed, a reception and shop, and a mountain shelter.

In the Tertiary/Industrial section, a 460KVA-power, a 630KVA-power and other smaller ski lifts can be found. There are also a commercial area, several shops, 500-KVA power for the coffee shop, a restaurant, a swimming pool and a multi-sport hall, a water treatment plant, and artificial snow guns of 1600KVA of power.

7.2.2 Energy baseline

The main indicators related to energy consumption and production are presented below.

Table 139. Total energy Consumption (kWh/m²/y). PS#6

Variable	Value
Final energy consumption	106
Primary energy consumption	147

Table 140. Consumption per type (MWh/y). PS#6

Variable	Value
Electricity (from the grid)	409
Electricity (self-generated from RE)	57
District Heating (biomass)	1,400
Solar Thermal	-
Geothermal	-
Other (define, e.g. gas, oil)	-
TOTAL	1,866

Table 141. On-Site RE Generation (MWh/y). PS#6

Variable	Value
PV and Wind	217
Solar Thermal	-
Geothermal	-
Biomass	1,400
TOTAL	1,617

7.2.3 Cost of energy

Table 142. Cost of Energy (€/MWh). PS#6

Components	Value
Cost of electricity	140
Cost of heating	70

7.2.4 SRI scores

Table 143. SRI scores. PS#6

Building	SRI Score
Building 1. Galicia	26%
Building 2. Restaurant	25%

7.2.5 Grid Level. Energy infrastructure

7.2.5.1 Grid topology

Distribution Network

Manzaneda has its own electrical grid which is connected to the main grid through an overhead power line. It is a ring topology MV grid, and it has six control points with TCs in major end use consumers:

- Pt. 0: Main Grid border point
- CS1-2 & TC1: Galicia Building
- CS3 & TC3: Workshop/Ski Lift Manzaneda, restaurant, sport facilities, etc.
- CS4 & TC4: Ski Lift Fonte Fría
- CS5 & TC5: Snow Production
- CS6 & TC6: Pena das Veigas

The total length of the grid is approximately 5,5 km, with 11 transformation centres (CSs & TCs) and 5,96 MVA of total installed capacity to fulfil the electrical energy needs of around 290 customers.



Figure 39. Grid Topology. PS#6

A grid-balancing graph is shown in the next figure.



Figure 40. Grid balance. PS#6

7.2.5.2 Other characteristics

The useful life is approximately 25 years for all systems. The energy system has been quite stable during the last years.

7.3 Future situation

7.3.1 New energy assets, hardware and software

Table 144. New technical systems. PS#6

New technical systems	Description
Battery	Connecting and commissioning the battery in the building's electrical system.
Digitization of 5 apartments	5 indoor multifunctional wireless air quality sensors (e.g., temperature, humidity, CO ₂), 5 communication hardware with web server for configuration and data visualization and programmable control and actuation functions, 5 meters, 5 modular control units.
Restaurant digitization	IoT devices to monitor and control electric heating and cooling systems (heat pumps, electric hot water, and electric radiators). IoT devices (1 communication hardware, 2 meters, and 2 modular control units) with Ethernet and 3G communication and with web server for configuration and data visualization and with programmable control and actuation functionalities. 2 indoor multifunctional wireless air quality sensors (e.g., temperature, humidity, CO ₂)

7.3.2 Future Consumption and Generation

Table 145. Total energy Consumption (kWh/m²/y). PS#6

Variable	Value
Final energy consumption	105
Primary energy consumption	144

Table 146. Consumption per type (MWh/y). PS#6

Variable	Value
Electricity (from the grid)	387
Electricity (self-generated from RE)	64
District Heating (biomass)	1,400

Solar Thermal	-
Geothermal	-
Other (define, e.g. gas, oil)	-
TOTAL	1,851

Table 147. On-Site RE Generation (MWh/y). PS#6

Variable	Value
PV and Wind	217
Solar Thermal	-
Geothermal	-
Biomass	1,400
TOTAL	1,617

7.3.3 Future SRI scores

Table 148. SRI scores. PS#6

Building	SRI Score
Residential (5 apartments)	53%
Restaurant	56%

7.4 Energy management systems and data communication protocols

Table 149. Energy management, monitoring and control systems. PS#6

System	Description
SCADA	Scope: MV network (transformation centres) API: No Protocol: -
FlyThings	Scope: PV production in three points, biomass thermal plant API: Yes Protocol: REST

CIDE platform	Scope: Final consumers (approximately 273) API: No Protocol: -
---------------	---

Table 150. Monitoring and control of energy assets. PS#6

Scope (asset, building, other)	Measurement & Variables	Freq (min)	Monitoring and control	Com. with EVELIXIA
CURRENT				
PV1, PV2 & PV3	energy meters: voltage, power, energy, amperage, Cos φ	15	M: Flythings C: none	API REST
Biomass thermal plant	energy meter: thermal energy	60	M: Flythings C: none	API REST
FUTURE				
Battery	BMS: voltage, power, energy, amperage, Cos φ , SOC, operation mode	15	M&C: Flythings	API REST
Galicia building Apartments (5x)	- energy meters (5): voltage, power, energy, amperage, Cos φ - modular control units (5): on/off - air quality sensors (5): temperature, humidity, CO2	15	M&C: Flythings	API REST
Restaurant	- energy meters (2): voltage, power, energy, amperage, Cos φ - modular control units (2): on/off - air quality sensors (2): temperature, humidity, CO2	15	M&C: Flythings	API REST
Weather	- AEMET web services: external temperature and humidity, irradiance observations and forecast	60	M: Flythings	API REST
Electricity market	- ESIOS WEB services: hourly electricity price	24 (hours)	M: Flythings	API REST

Where:

- Scope (asset, building, other): energy asset, building or environment (electricity market, weather...) where monitoring and control is carried out
- Measurement & Variables: measuring equipment and monitored and control variables
- Frequency: monitoring frequency

- Monitoring and control: system responsible for managing monitoring and control and that will communicate with the EVELIXIA platform
- Communication with EVELIXIA: existence of API and protocol to use to communicate with the EVELIXIA platform

Figure 41 presents the current assets and systems, as well as those to be deployed in the future.

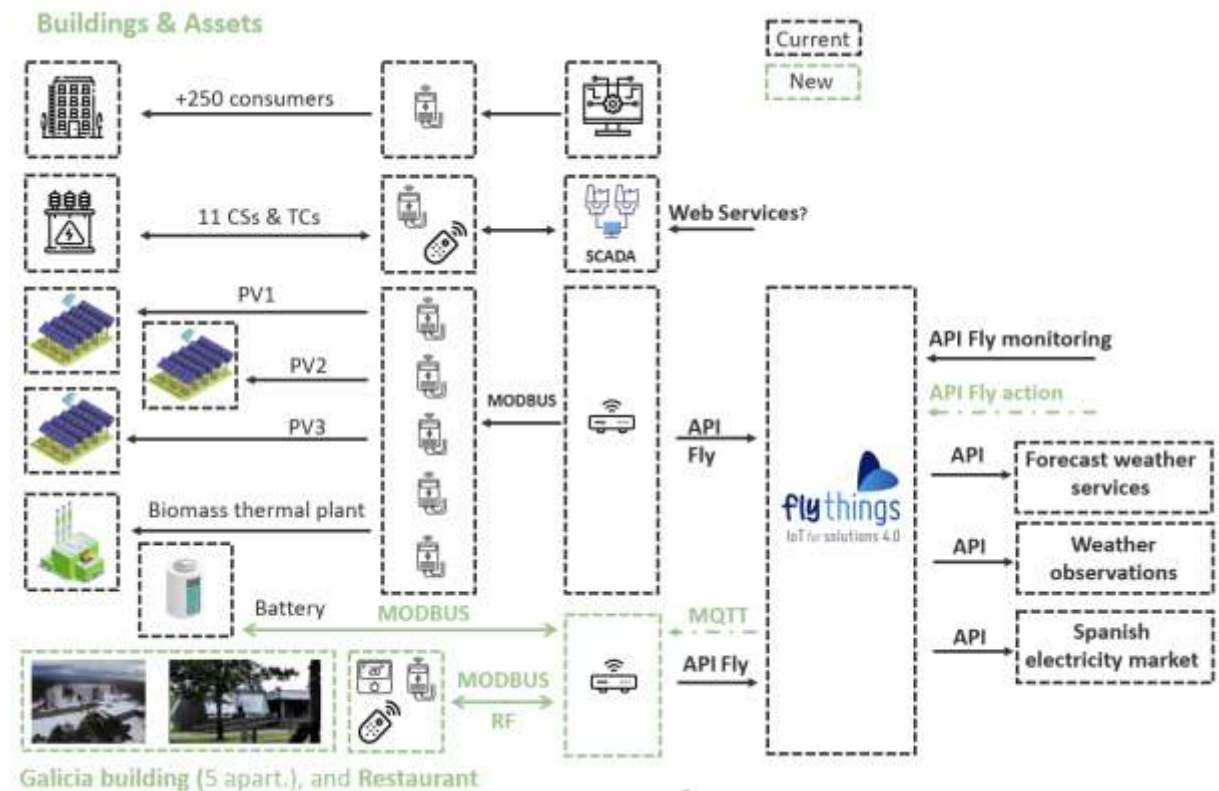


Figure 41. Assets and systems involved at the pilot site level. PS#6

Figure 42 shows the details of the systems and equipment to be deployed during the project.

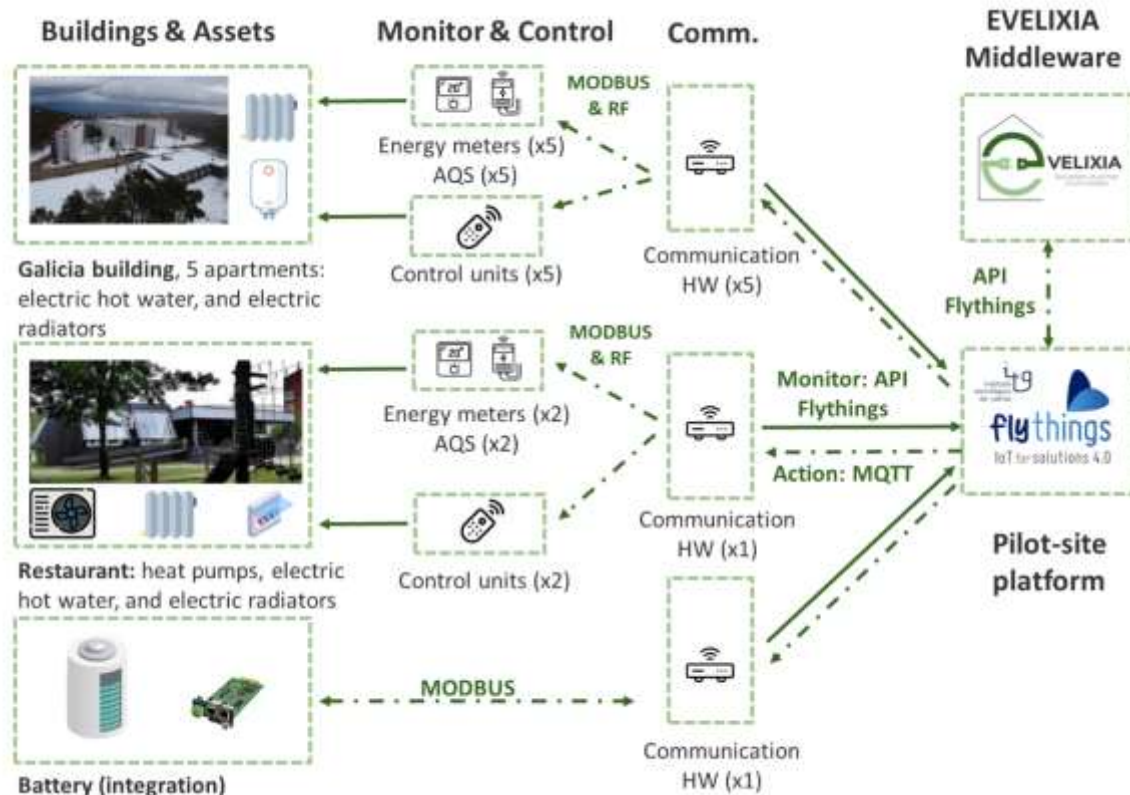


Figure 42. Monitoring, control, and communication systems to be deployed in the project. PS#6

7.5 Use cases definition

EVELIXIA endeavours to underscore the viability and efficacy of integrating buildings as active utility nodes into the broader energy landscape by showcasing innovative strategies, technologies and services. Central to this initiative are the pilot demonstrations of the proposed solutions through their respective Use Cases

Table 151. Use Case Summary. PS#6

ID	Use Case	Description
UC-SP#1	Demand side flexibility (implicit and explicit)	UC includes flexibility activation. It deals with a) leveraging the ability of the Spanish pilot site consumption patterns without direct user intervention (implicit flexibility), and b) automatically adjust energy consumption in response to grid signals and market mechanisms (explicit flexibility).

Table 152 presents the different services encompassed in each Use Case of the Spanish Pilot Site.

Table 152. Energy Services to be demonstrated per Use Case. PS#6

Category	Energy Service	UC-ES#1
Behind the meter	DSM Implicit	✓
	Building Investment Planning	✓
Front of the meter	DER Dispatch	✓
	P2P energy (flexibility) trading	-
	Portfolio management services (day-ahead/intra-day)	✓
	Network Investment Planning	-

Where:

- DSM Implicit: Adjusting demand fractions (load(s) curtailment or total shifting) by reducing/curtailing or entirely shifting energy-intensive loads during expensive periods to cheaper ones (within the same energy vector or between different sectors -coupling).
- Building Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.
- DER Dispatch: real-time distributed generation and storage (large farms or virtually pooled) dispatch based on grid conditions and financial incentives. Leverage the available local-grid storage farms during peak hours to cover local demand, thereby reducing congestion levels on central power distribution lines
- P2P energy (flexibility) trading: Decentralized synchronized coordination of demand between mutualized/aggregated/community customers (increase-to-decrease demand schemes to provide the same service to the grid)
- Portfolio management services (day-ahead/intra-day): Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading and maximize aggregators' returns, implementing explicit DR schemes in accordance with the upfront market bids. Upfront selling the potential/estimated result of demand response actions in electricity markets. Based on appropriate predefined contracts (e.g., the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding

of large loads is applied in response to incentives provided by aggregators/DR service providers.

- Network Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating, steam, gas) grid needs ensuring reliability, efficiency, and sustainability.

7.5.1 Use Case 01. UC-ES#1 Demand side flexibility

Use Case description
Name UC-ES#1 Demand Side Flexibility (implicit, explicit, Load shifting and shedding, DER dispatch)
Scope This Use Case scope is short-term network operation at MV level. UC includes flexibility activation. It deals with a) leveraging the ability of the Spanish pilot site consumption patterns without direct user intervention (implicit flexibility), and b) automatically adjust energy consumption in response to grid signals and market mechanisms (explicit flexibility). The scope encompasses a comprehensive exploration of: • Analyse current demand patterns and historical data in electricity consumption data to <u>identify peak demand periods</u>. • Evaluate the <u>variability of electricity demand</u> across different time scales (hourly, daily, and seasonal) • Survey and <u>classify potential demand-side resources</u>. • Assess the <u>feasibility of leveraging distributed energy resources</u> (DERs) and demand response programs. • Align and coordinate the use of <u>voluntary and mandatory active power flexibility</u> for the process of re-dispatch. • Align demand response with intermittent renewable energy generation. • Increase the <u>smartification of the buildings</u> to track the performance of demand response initiatives. • Conduct a comprehensive cost-benefit analysis to evaluate the economic viability of demand-side flexibility measures.
Objectives • Smartification of heating and domestic hot water production systems that automatically adjust temperature settings based on occupancy levels, user needs, and external weather conditions to help optimize energy consumption without compromising comfort or quality standards (implicit flexibility).

-
- **Strategically schedule** DHW storage tanks operation, and battery charging, to align with use hours, off-peak hours or when energy prices are lower, to maximize energy savings without compromising users' comfort.
 - **Coordinate electricity production** from the PV (150 kW_p), and storage systems such as a) the BESS (20 kWh), b) the DHW storage tanks (7.5kW), to store excess energy generated on-site or during low demand periods for use during peak demand times to help reduce congestion on the grid and provide back power in case of outages.
 - **Coordinate the provision of electricity** to the battery (20 kWh) or by the grid to optimize the source of energy based on factors such as cost, and environmental considerations, without compromising battery's functioning.
 - **Solar PV Generation:** During sunny days when the solar PV panels are generating ample electricity, EVELIXIA can prioritize using this clean and renewable energy source to power the battery. The excess solar energy that is not immediately consumed by the facility can be stored or used for other on-site operations to maximize self-consumption i.e. lighting.
 - **Grid Connection:** In situations where solar PV generation is insufficient, such as at night or during periods of low sunlight, the facility can seamlessly switch to drawing electricity from the grid. This ensures continuous operation without interruptions and meeting demand requirements.
 - **Cost Optimization:** EVELIXIA will analyse electricity prices from the grid and factoring in the costs of electricity generation from solar PV, the Galicia building can strategically choose the energy source that offers the most cost savings. This could involve using grid electricity during off-peak hours when prices are lower and relying on solar PV during peak demand periods to offset expensive grid electricity usage.
 - **Sustainability Benefits:** Prioritizing solar PV electricity helps reduce the facility's carbon footprint and dependence on fossil fuel-based grid electricity. By maximizing the use of renewable energy sources like solar PV, the facility will enhance its sustainability efforts and contribute to a cleaner energy transition.
 - **Load Shifting:** Adjusting a portion of the demand for electricity consumption in the system by moving electricity-intensive end-users' activities to different timeframes. Occupants and end users can be encouraged to shift their energy usage to times when renewable energy generation is abundant or during periods of reduced overall demand.
 - **Load Shedding:** The deliberate and temporary reduction of electricity supply through advanced active control of electricity consumption in response to real-time specific signals or commands from the grid operator or the energy management systems. These systems can automatically implement measures based on predefined criteria, such as peak demand thresholds or equipment failures.
 - **Distributed Energy Resources (DERs) dispatch:** Updating the operation schedule based on changes in the predictions made.
-

Limitations & Assumptions

- **Data Acquisition:** The effectiveness of the activities and the accuracy of the results rely heavily on the availability of data pertaining to energy consumption, demand patterns, and other relevant variables. Inaccuracies or gaps in the data may introduce uncertainties.
 - **Occupant Behaviour:** Demand-side flexibility initiatives often assume a certain level of responsiveness from end-users. Given the primary use for Manzaneda buildings (apartments and restaurant respectively), assuming a homogenous and uniform response in both cases may lead to potential discrepancies between projected and actual outcomes, neglecting the inherent diversity in energy consumption patterns, preferences, and specific needs.
 - **Infrastructure Constraints:** Demand-side flexibility initiatives is contingent both on the existing and on the planned infrastructure's adaptability. Limitations in grid capacity, communication networks, and technology integration may hinder the seamless implementation of the proposed activities. It is also essential that all systems support open APIs to ensure communication and interoperability with the EVELIXIA Platform.
 - **Technological Reliability:** The employed technologies, such as smart meters, actuators and automation systems, function reliably without any technical failures or inconsistencies throughout the pilot activities.
 - **External Factors:** Economic conditions, weather conditions, and market dynamics, may not be relatively stable throughout the pilot period. Such variables introduce unpredictability into the resulting related outcomes.
-

Assets of the Use Case

Existing equipment

Galicia building

- Electric boilers and electric radiators of 5 apartments
- On-site RE generation: PV 40 kW_p (restaurant roof)
- 1 BESS (20 kWh)

Restaurant

- On-site RE generation: 108 kW_p
- Restaurant appliances

Monitoring, Control and Operation

- FlyThings IoT platform

Planned installation (EVELIXIA)

Galicia building

- 5 indoor multifunctional wireless air quality sensors
- 5 communication hardware, 5 meters and 5 modular control units

Restaurant

- 2 indoor multifunctional wireless air quality sensors
-

- 1 communication hardware, 2 meters, and 2 modular control units
-

Further information

No relation with other Use Cases

Grid Services Selection

Further related services to enhance the grid's stability, reliability, resilience, efficiency, and adaptability to fluctuations by actively managing the electricity demand:

Applicable for demonstration:

- DSF
 - Implicit
 - Explicit
 - Load Shifting
 - Load Shedding
 - DER dispatch
 - Portfolio management services (day-ahead/intra-day)
 - DSO level services: Congestion management (e.g., via dynamic tariffs)
 - System planning
-

Prioritisation of the use case

Obligatory. The use case has been already defined as a cluster of different sub-cases, mainly organized by energy services.

Market mechanisms

Hourly electricity spot prices and tariffs on the electricity market.

Use Case Narrative

UC-ES#1 aims to investigate and implement demand side flexibility measures and portfolio management within the electricity grid of the Spanish Pilot, with a focus on enhancing grid stability, reducing peak load demand, and integrating renewable energy sources and storage devices efficiently.

Complete description of the use case.

UC-ES#1 is structured in two phases:

- **Analysis of the energy behaviour of assets**
-

In this first phase, the consumption and generation patterns of the assets participating in the use case will be studied. The usage schedules, energy prices, and operational restrictions of the systems will be considered. This will lay the foundation for predicting demand, generation, and flexibility, as well as optimizing performance.

To achieve this, various energy monitoring equipment will be deployed, and integration will be carried out to access external sources of atmospheric data and hourly electricity prices.

- **Management of assets in real time**

Based on the above information, the following processes will be carried out on an hourly basis:

- Prediction of hourly demand
- Prediction of PV generation
- Prediction of flexibility, according to schedules and limitations

With this information, the operation programming of the assets will be carried out with the objective of minimizing the economic cost (DSF Implicit). During operation, deviations may occur in relation to the forecast situation (for example, different demand or generation), which will require a review of the operation of flexible loads. (DSF Explicit, Load shifting, Load shedding, DER dispatch).

Table 153. Technical details and actors involved. UC-ES#1

Name	Actor Type	Description	Further information specific to this Use Case
NTT DATA	PS Implementation leader	Responsible for UC implementation in the Spanish Pilot	-
ITG	RTO	Technology and knowledge provider	-
MEISA	Owner and operator	Building owner and grid operator	-

Table 154. Step by step analysis. UC-ES#1

No	Scenario name	Scenario description	
1	DSF Implicit	Program and control the operation of the storage devices	
		Primary actor	EVELIXIA platform, storage systems
		Triggering event	Low electricity prices, forecasted high load, schedules
		Pre-condition	Current operation plan
		Post-condition	New operation plan

2	DSF Explicit	Activate/deactivate a flexible load (storage systems)	
		Primary actor	EVELIXIA platform, storage systems, PV system, EMS
		Triggering event	PV production surplus, EMS command, DSO command
		Pre-condition	Current flexible load/battery set points
		Post-condition	New flexible load/battery set points
3	Load shifting	Plan the activation of a flexible load to maximize self-consumption	
		Primary actor	EVELIXIA platform, storage systems, PV system, EMS
		Triggering event	PV surpluses
		Pre-condition	Current flexible load/battery operation plan
		Post-condition	New flexible load/battery operation plan
4	Load shedding	Active battery charging and discharging for peak load management and promote grid stability	
		Primary actor	EMS, Battery
		Triggering event	Peak load
		Pre-condition	Current battery set point
		Post-condition	New battery set point
5	DER dispatch	Activate/deactivate photovoltaic generation based on demand	
		Primary actor	EMS, PV system
		Triggering event	Excessive PV production
		Pre-condition	PV on, Load: off, Battery: current setpoint
		Post-condition	PV off, Load: on, Battery: new setpoint
6	Portfolio Management services	Optimize flexible loads (battery, DHW storage tanks) based on forecasted demand, weather and energy prices at D-1	
		Primary actor	EVELIXIA platform, EMS, manageable assets
		Triggering event	Optimization once per hour
		Pre-condition	Current operational plan and setpoints
		Post-condition	Same/new operational plan and setpoints

8 PILOT SITE 7. FINLAND

8.1 General description of the site

Location: Lounatuuli 13, 15, Naantali, Varsinais Suomi, Finland

Scope: The residential district of Lounatuuli was build a few years ago in the frame of the national bi-annual housing fair and exhibition. It represents the latest development and trends in real estate for middle class families in Southern Finland, will all comfort and infrastructures. The need for durability has motivated the builders to include renewable energy production and energy storages systems. The site will allow EVELIXIA partners to evaluate how well innovative solutions and energy management tools developed within the project can fit to the Scandinavian market at the scale of a small residential district.

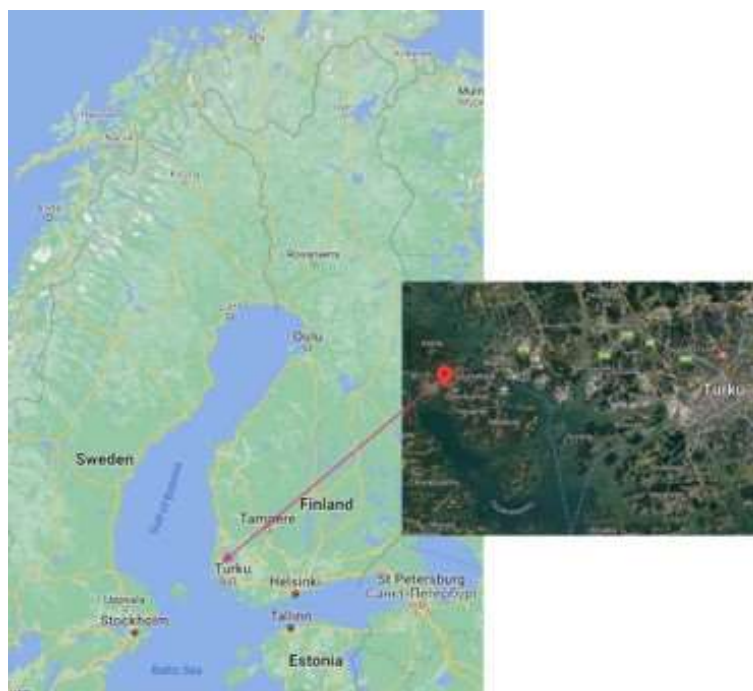


Figure 43. Geographical location of Naantali Pilot site in Finland. PS#7



Figure 44. Aerial view of Naantali pilot site. PS#7



Figure 45. Bi-facial PV Modules based installation at Naantali pilot site. PS#7

8.1.1 Relevant stakeholders

The relevant stakeholders are the building users, ca. 70 tenants in 21 rented apartments, the real-estate company owning the buildings and land, the real-estate maintenance company and the local Electrical energy distributor (DSO). Local energy supplying company, sister company of DSO could also be involved in the project as owner of the 108 kW_p PV plant and of the BESS located at the smart energy power substation. Other electrical energy supplier from free market are not considered as relevant stakeholders.

Two stakeholders participate as EVELIXIA partners, Turku University of Applied Sciences (TUAS) as coordinator and Naantali Energy OY as electrical energy distribution system operator. Other stakeholders do not participate directly to the project but have expressed their interest in supporting the use of the infrastructures as a pilot site.

Table 155. Relevant stakeholders. PS#7

Stakeholder	Role
TUAS	Pilot site coordinator, implementation and evaluation of EVELIXIA solutions, technical solutions provider
Naantalin Energia OY	Distribution System Operator, owner of PV plant and Smart distribution substation
TA Yhtiöt	Property owners
Tenants	People living and renting apartments at the Pilot site
To be defined	Building and infrastructure maintenance subcontractor
ABB / FIDELIX / Gebwell	Technology providers BESS at smart substation, Building & Energy automation, Central Heat pump and DHW production

8.2 Current situation

8.2.1 Buildings and energy assets

Luonaatuuli is a recently built residential district located on the shore of Baltic Sea near the city of Naantali in Southwest Finland. The demo-site infrastructure owned by TA-Yhtiöt includes 21 residential apartments shared within 6 semi-detached

houses integrated into a fully new residential district. The common building energy infrastructure include a ground source heat pump, Domestic Hot water production and storage, three PV plants, a small-scale battery energy storage and an EV charging station. The LV distribution network is connected to MV grid through a smart distribution substation, which includes a 162-kWh battery energy storage system. A 108 kWp PV plant is installed on canopies by the South shore of the district. The smart substation and the PV plant are owned by the local DSO and EVELIXIA project partner, Naantalin Energia Oy.

Table 156. Building 1. PS#7

Variable	Description
Name / Type	Lounatuuli 13, 15
Floor Area (m2)	1905 m ²
Year of Construction	2022
N. of Occupants	approx. 70



Figure 46. One of 6 semi-detached houses. PS#7



Figure 47. Smart distribution substation. PS#7

8.2.1.1 Energy Assets

The energy system was planned and designed at the beginning of the building construction project in 2018. The centralised heating and DHW production system was commissioned in 2022 and fine-tuned between 2022 and 2023.

Table 157. Common building energy infrastructure. PS#7

Energy assets	Description
Heating (common)	Geothermal heat pump. Water circulation underfloor heating. The heat pump is Gebwell Taurus 110 EVI.
Cooling (common)	Geothermal free cooling. Apartment-specific convectors
DHW (common)	Geothermal heat pump
Heating (distributed)	Electric radiators (1 – 2 kW)
DHW (distributed)	Electrical boilers (1.5 kW)
Lighting	All the buildings are equipped with LED lighting.
Energy Storage	DHW 2 x 750L + 1 x 500L Heating 1x 100L BESS
On-site RE generation	PV arrays installed at each of the 6 buildings. 5 arrays are connected to 2 Fronius Symo 20 kW inverters. 1 PV array is connected with BESS to the 17 kW Fronius Symo Hybrid inverter.
EV Charging	4 EV charging stations (4 x 11kW AC/AC 16A)
Monitoring, Control and Operation	Gebwell heat pump and DHW production controller and monitoring unit

Table 158. Energy assets in apartments located in Buildings 1 to 6. PS#7

Energy assets	Description
Ventilation	Apartment-specific supply and exhaust air with heat recovery. The air-handling-unit: AIRFI model 100-125
Monitoring, Control and Operation	- FIDELIX Easyliving – Rooms temperature and ventilation are monitored and controlled with flexible modern home automation. Each room is equipped with its own temperature and humidity sensors.

	- End users can control temperature and ventilation manually. - Thermal energy is provided by a central heat pump, several heat exchangers with large thermal capacity and auxiliary electric coils in case the heat pump cannot follow the thermal energy demand. The thermal energy production is centralised and controlled based on the demand from inhabitants and of weather conditions. - BEMS is hosted in a FIDELIX Programmable Logic Controller.
Lighting	All the apartments are equipped with LED lighting.
Domestic appliances	Each of the 21 apartments is equipped with modern, high energy class laundry machine, dish washer. Half of the apartments equipped with electric sauna, which uses occasionally up to 6 kW.
Other appliances	Each parking place is equipped with a controllable car heating socket with 2 kW capacity.
Other	Common sauna building. The stove is heated with wood.

Table 159. Energy assets Smart distribution substation. PS#7

Energy assets	Description
BESS	- Two 81 kWh batteries are charged from AC grid through a bidirectional inverter and a LV DC bus. - The BESS is controlled by DSO with the help of ABB energy automation platform.
PV plant	108 kW _p PV Plant based on Bi-facial PV modules installed on canopies.

8.2.1.2 Other characteristics

The main characteristic of this pilot site is the common thermal energy production for 21 apartments located in 6 semi-detached houses. Due to the location in Nordic Country, the Heat Pump and DHW production represent together ca 2/3 of the

energy consumption. Modern automation equipment is installed but, but rather controlled in a basic manner so far. There is a good potential for improvement.

8.2.2 Energy baseline

Energy Consumption for Heating, DHW, HVAC systems estimated according to yearly consumption and monthly average temperatures. Energy delivered to EV-charging stations is simply included. Monthly generation of electrical energy from PV installation are estimated based on PV plant design and simulations. Total yearly consumers energy use by tenants is estimated during the design of the buildings. The buildings are new, the consumption can be 15-30 % higher in the first years.

Table 160. Total energy Consumption (kWh/m²/y). PS#7

Variable	Value
Final energy consumption (estimation)	176
Primary energy consumption	147

Table 161. Consumption per type (MWh/y). PS#7

Variable	Value
Electricity (from the grid)	188
Electricity (self-generated from RE)	37
TOTAL	221

Table 162. On-Site RE Generation (MWh/y). PS#7

Variable	Value
PV on building's roof	37
PV produced on district (Canopies)	80
TOTAL	117

8.2.3 Cost of energy

Any individual smart meter owned and accessible by the local DSO measures the energy consumed by home appliances, lighting and car heating plugs located at

each apartment. Apartment tenants have their own electricity supply agreements and are directly invoiced for both energy supply and delivery.

Electrical energy delivered to the heat pump, DHW storage tanks, ventilation systems, heat recovery units, EV charging stations, technical and sauna rooms is directly charged by DSO to the building owners. Thermal energy including DHW supply will be charged individually by building's owner to each apartment tenant. As PV inverters are connected behind the main single energy meters, electrical energy produced by PV installations is automatically deducted from the total electrical energy used by heating, DHM and ventilation equipment. Cooling energy is not produced out of electricity. A thermal exchanger is connected in line with the pipes delivering brine from the ground pipes.

In Finland, electrical energy delivery and transport are charged with a fixed price per kWh, separately from electrical energy supply. Consumers can choose their energy supplier and type of deal, either based on fluctuating spot prices or based on a fixed price per kWh for a period of time.

Table 163. Cost of Energy (€/MWh). PS#7

Components	Value
Cost of electricity (based on average 2023)	105

8.2.4 SRI scores

SRI scores were evaluated in 2022 at the time of the application for the project. Residential buildings 1 to 6 with 21 apartments. Non-residential includes commodities building technical rooms, EV charging stations, car heating plugs and common infrastructure.

Table 164. SRI scores. PS#7

Building	SRI Score
Residential	14%

8.2.5 Grid Level. Energy infrastructure

8.2.5.1 Grid topology

Distribution Network

The Lounatuuli pilot site district is supplied with electricity via the 400V low voltage distribution grid owned by project partner Naantalin Energia Oy. The low voltage

grid is connected to 20 kV MV distribution grid via a smart power substation. All the installations relating to heating, cooling, production of DHW, ventilation with heat recovery, the EV-charging stations, the sauna room, the technical and storage rooms, the PV and hybrid inverters are connected to a main switchboard located in the technical room. The energy consumed by these loads or produced by PV inverters is measured individually by separate energy meters, accessible only by the company TA Yhtiöt owning the buildings. The sum of total energy consumed or produced is measured by one single energy meter owned by the local DSO, Naantalin Energia OY. Each apartment of the 6 buildings is directly connected to the central switch board. Any individual smart meter owned and accessible the local DSO measures the energy consumed by home appliances, lighting and car heating plug located at each apartment. Apartment tenants have their own electricity supply agreements and are directly invoiced for both energy supply and delivery.

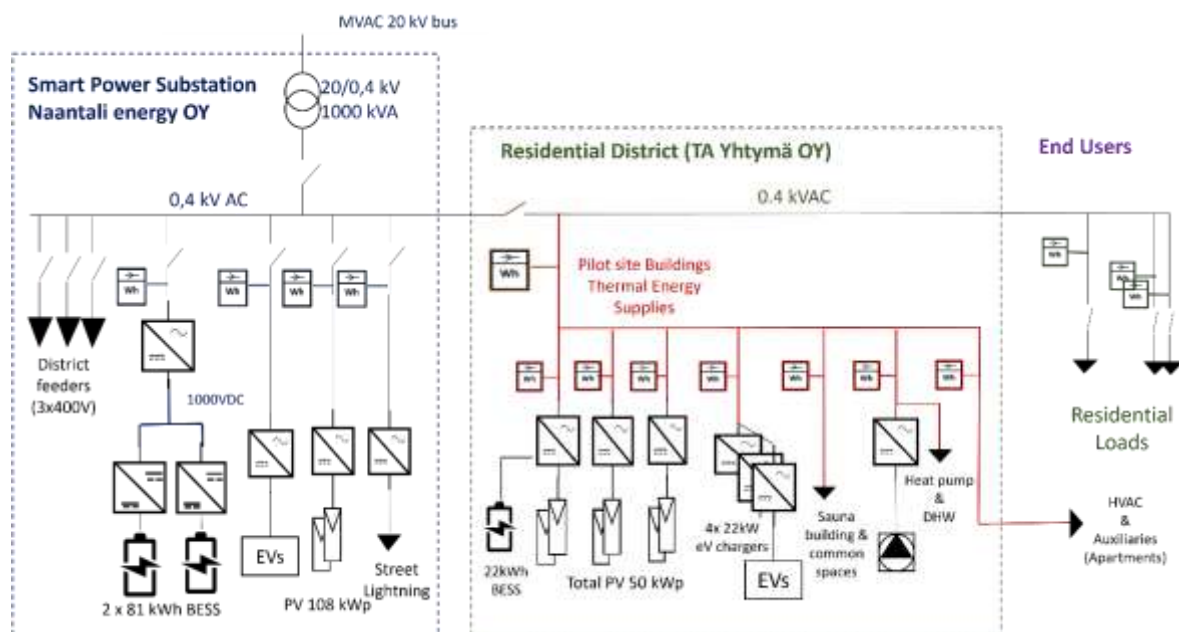


Figure 48. Grid topology including electrical energy metering. PS#7

8.2.5.2 Other characteristics

Beside energy provided by the grid, the secondary side of the MV/LV substation is connected to a 106 kW_p PV plant and a 162 kWh Battery energy storage system owned by the Energy selling division of NE Oy.

The minimal design outdoor temperature for the heating system is -26°C. The heating system is equipped with electric backup. Cooling is accomplished without

the use of compressor directly through the use of brine coming from the heat well. The local 22 kWh electrical energy storage system has not been commissioned yet. According to the local DSO, no congestions have been recorded in the LV distribution grid in the district, neither on the MV lines supplying the distribution substation. Peak loads are within the specification of the distribution grid and in relation to system stability, no issues have been recorded.

8.3 Future situation

Some solutions and improvements will be implemented within the EVELIXIA project. The local DSO, Naantalin Energia Oy is interested in developing solutions to control the BESS located in the Smart Power substation, according to electrical energy demand, price and PV energy production. The installation of new smart energy meters and access to data in 'real time' are key elements in the project.

Evolution of the control infrastructure for the common heating generation and DHW production is in the hands of building owner, TA Yhtiöt, not directly involved as a partner in the EVELIXIA project.

8.3.1 New energy assets, hardware and software

New generation of Smart Metering Infrastructure has started. Planned features:

- Customer interface for local metering data transfer,
- Market-based load control,
- Measurement of off-peak and on-peak energy input and output (four power directions)
- Phase specific measurement (three phases),
- Registration of power failure and zero fault,
- Remote readout,
- Remotely updatable,
- Remote switchable,
- Measurement period 15 min.

The next generation electricity meter will control loads 24 hours a day at market conditions. In practice, the customer will contract load control with a service provider of his choice, who will then send load control commands to the network operator for implementation. In the future, load-serving may be based on market

price, availability, bidding hour etc. Data transfer between Smart Meters and DSO SCADA will be realised with GSM connection. Some smart meters could be accessed through WIFI connection via Smart meters HAN connection.

Table 165. New technical systems. PS#7

New technical systems	Description
Battery Energy Storage System at building	22 kWh off-grid BESS (BYD Battery-Box Premium) supported by 10 kW hybrid inverter (Fronius)
New smart meters for users' consumption	Advanced Smart meters for end user's consumption with GSM communication and HAN port will be installed at common switchboard. The number of smart meters depends on end user's response to the project
Data collection API (building level)	- IoT devices to collect data from equipment will be installed. The API will transfer data to a dedicated database hosted at TUAS. - Electric submeters dedicated to measure electricity consumption of ground source heat pump, PV production, BESS and eV charging station need to be accessed or changed.
Data collection (substation)	- IoT devices to collect data from equipment will be installed. The API will transfer data to a dedicated database hosted at TUAS. - Canopy PV inverters and Smart Substation BESS need to be accessed and key data need to be shared in Real Time

8.3.2 Future Consumption and Generation

Table 166. Total energy Consumption (kWh/m²/y). PS#7

Variable	Value
Final energy consumption	172.3
Primary energy consumption	144

Table 167. Consumption per type (MWh/y). PS#7

Variable	Value
Electricity (from the grid)	184
Electricity (self-generated from RE on buildings)	37
TOTAL	221

Table 168. On-Site RE Generation (MWh/y). PS#7

Variable	Value
PV	117
TOTAL	1,617

8.3.3 Future SRI scores

Table 169. SRI scores. PS#7

Building	SRI Score
Residential (21 apartments)	53%

8.4 Energy management systems and data communication protocols

Energy Management Systems (EMS) will be deployed to manage the BESS located inside of the Smart Distribution substation and at the central technical room of the pilot sites buildings. Optimisation criteria will consider PV energy production, SOC of battery, current energy demand, forecasted energy demand and market indicators.

The TUAS Energy Management System (EMS) is an advanced solution designed to optimize energy usage and enhance sustainability in residential areas. At the Pilot site real estate level, the system will integrate the Photovoltaic (PV) systems, Battery Energy Storage System (BESS), smart energy meters, and Electric Vehicle (EV) chargers to ensure efficient energy distribution and cost savings. Smart energy meters monitor real-time consumption, enabling the EMS to dynamically manage energy resources, reducing waste and electricity costs through optimization techniques such as peak shaving and load shifting. This approach minimizes grid reliance, lowers energy bills, and reduces the carbon footprint. Additionally, the user-friendly interface allows residents to monitor and manage their energy usage, further enhancing efficiency and reliability. At Smart Substation level, the EMS will integrate Photovoltaic (PV) systems and Battery Energy Storage System (BESS). The EMS will support energy services at the distribution grid level, i.e. mitigating physical congestions (overloading of lines/transformers, voltage band violations) using market-based active power flexibility in a cost-efficient way. It will also help increasing self-consumption factor at the district level.

In Figure 49, the current assets and systems are shown, as well as those to be deployed in the future.

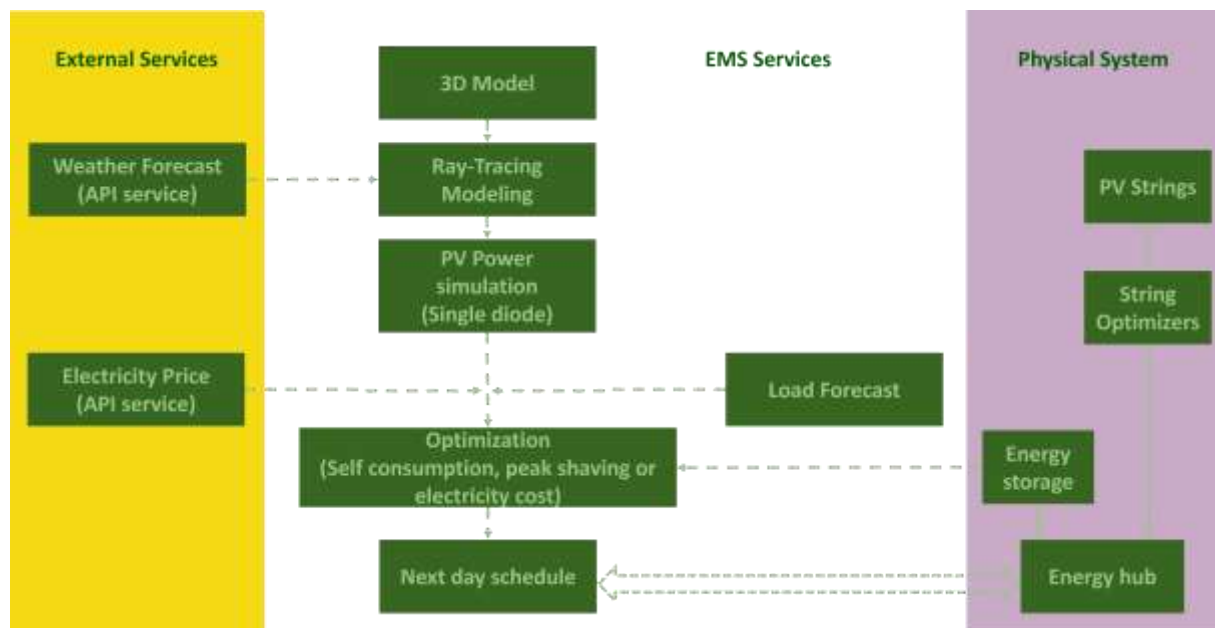


Figure 49. Overview of EMS developed at TUAS, to be deployed at PS in Naantali. PS#7

Table 170. Energy management, monitoring and control systems. PS#7

System	Description
Data collection and control	Scope: BESS at smart distribution substation API: Yes Protocol: REST
Data collection	Scope: All submeters located in the main switch boards for common energy equipment API: Yes Protocol: REST
Data collection	Scope: Final consumers (number to be defined) API: YES Protocol: REST
Data collection	Scope: Gebwell Heat pump and DHW controller API: YES Protocol: REST

Table 171. Monitoring and control of energy assets. PS#7

Scope (asset, building, other)	Measurement & Variables	Freq (min)	Monitoring and control	Com. with EVELIXIA
CURRENT				
PV1, PV2 & PV3	FRONIUS Converters: voltage, power, energy	10	Web interface	API REST
eV charging station	Total Energy delivered to the charging station		Not available	
HVAC and auxiliaries for apartments	Total Energy delivered to the HVAC auxiliaries		Not available	
Heat pump	Heat pump electricity consumption	1	Not accessible	
Domestic hot water	Electricity consumption for additional Domestic hot water	1	Not accessible	
Common installations and sauna room	Not available			
End users' smart meters	energy meter: voltage, power, energy, amperage	24H	Smart Meter PLC1	1 CSV/DAY
Canopy PV plant	PV inverters: power, energy,	10	M: PV inverters C: RasPI	API REST
Main energy meter for common infrastructure	energy meter, electricity	60	M: Energy meter	API REST
FUTURE				
BESS at buildings	FRONIUS Hybrid converter	10	Web Interface	API REST
Thermal energy delivered by Heat pump and DHW thermal energy delivered	Based on possible access to the Main Heating Control System (VAK)	10	Web Interface	API REST
DHW thermal energy delivered to apartments	Based on possible access to the Main Heating Control System (VAK)	10	Web Interface	API REST
eV charging station	Total energy delivered to the eV charging station through submeter	10	Submeter + Modbus TCP/IP	API REST
HVAC and auxiliaries for apartments	Total energy delivered to the HVAC auxiliary functions in apartments	10	Submeter + Modbus TCP/IP	API REST
Electrical energy consumed by the central heat pump	Central Heating control System (VAK) power, energy, DHW temperatures	10	Web Interface	API REST

Average room temperature in the apartments	Central Heating control System (VAK) temperature	10	Web Interface	API REST
Electrical energy consumed for DHW production	Central Heating control System (VAK) power, energy, DHW temperatures	10	Web Interface	API REST
End Users Smart Meters	- new generation energy smart meters (2): voltage, power, energy, amperage, Cos ϕ	10	M: HAN port C: RasPI	API REST
Main energy meter for common infrastructure	New energy meter, electricity	1	M: New Energy meter	API REST
Grid Frequency	Frequency meter at substation (need to be confirmed)	1	M: New Energy meter	API REST
BESS at smart substation	BES controller and monitoring system (ABB)	10	Web interface	API REST
Weather	Web services: external temperature and humidity, irradiance observations and forecast	60	Web	TO BE DEFINED
Electricity market	WEB services: hourly electricity price	24 (hours)	Web	API REST

Where:

- Scope (asset, building, other): energy asset, building or environment (electricity market, weather...) where monitoring and control is carried out
- Measurement & Variables: measuring equipment and monitored and control variables
- Frequency: monitoring frequency
- Monitoring and control: system responsible for managing monitoring and control and that will communicate with the EVELIXIA platform
- Communication with EVELIXIA: existence of API and protocol to use to communicate with the EVELIXIA platform

8.5 Use cases definition

EVELIXIA endeavours to underscore the viability and efficacy of integrating buildings as active utility nodes into the broader energy landscape by showcasing innovative strategies, technologies and services. Central to this initiative are the pilot demonstrations of the proposed solutions through their respective Use Cases.

Table 172. Use Case Summary. PS#7

ID	Use Case	Description
UC-FI#1	Smart energy scheduling	Flexible end-user energy demand management
UC-FI#2	EMS for smart power substation	EMS for the control of the grid connected battery located at Smart Substation
UC-FI#3	Frequency Reserve	Frequency Containment Reserve for Normal Operation (FCR-N) emulation based on aggregation of energy assets

Table below presents the different services encompassed in each Use Case of the Finish Pilot Site.

Table 173. Energy Services to be demonstrated per Use Case. PS#7

Category	Energy Service	UC-FI#1	UC-FI#2	UC-FI#3
Behind the meter	DSM Implicit	✓	-	-
	Building Investment Planning	✓	-	-
Front of the meter	DER Dispatch	-	✓	-
	P2P energy (flexibility) trading	✓	-	-
	Portfolio management services (day-ahead/intra-day)	-	✓	✓
	Network Investment Planning	-	✓	✓

Where:

- DSM Implicit: Adjusting demand fractions (load(s) curtailment or total shifting) by reducing/curtailing or entirely shifting energy-intensive loads during expensive periods to cheaper ones (within the same energy vector or between different sectors -coupling).
- Building Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.
- DER Dispatch: real-time distributed generation and storage (large farms or virtually pooled) dispatch based on grid conditions and financial incentives. Leverage the available local-grid storage farms during peak hours to cover

local demand, thereby reducing congestion levels on central power distribution lines

- P2P energy (flexibility) trading: Decentralized synchronized coordination of demand between mutualized/aggregated/community customers (increase-to-decrease demand schemes to provide the same service to the grid)
- Portfolio management services (day-ahead/intra-day): Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading and maximize aggregators' returns, implementing explicit DR schemes according to the upfront market bids. Upfront-selling the potential/estimated result of demand response actions in electricity markets. Based on appropriate predefined contracts (e.g., the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding of large loads is applied in response to incentives provided by aggregators/DR service providers.
- Network Investment Planning: Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating, steam, gas) grid needs ensuring reliability, efficiency, and sustainability.

8.5.1 Use case 01. UC-FI#1 Smart Energy Scheduling

Use Case description
Name
UC-FI#1 Smart Energy Scheduling
Scope
This Use Case deals with influencing end user's energy consumption patterns without direct user intervention (implicit flexibility) or adjust energy consumption in time in response to grid signals, grid conditions or DER availability (explicit flexibility, Load Shifting, Load shedding) • Analyse demand patterns data in electricity consumption data to identify peak demand periods • Evaluate the variability of electricity demand across different time scales (hourly, daily, and seasonal)

-
- Assess the feasibility of leveraging distributed energy resources (DERs) and energy storage, aligning demand response with intermittent renewable energy generation
 - Align and coordinate the use of voluntary and mandatory active power flexibility for the process of re-dispatch
 - Explore strategies to promote Peer to Peer energy exchanges between end users and Building through the distribution
 - Establish a robust communication framework for real-time data exchange between grid operators, consumers, and demand-side resources.
 - Capitalize on the existing monitoring systems to track the performance of demand response initiatives
 - Conduct a comprehensive cost-benefit analysis to evaluate the economic viability of demand-side flexibility measures

Document the methodologies, findings, and practices during the pilot activities

Objectives

- Increase of self-consumption
- Global reduction of global energy consumption
- Energy cost reduction

Limitations & Assumptions

- **Data Acquisition:** The effectiveness of the activities and the accuracy of the results rely heavily on the availability of data pertaining to energy consumption, demand patterns, and other relevant variables. Data access to central Heating Control system must be granted by building owner and eV charging station by the CPO.
 - **Occupant Behaviour:** Demand-side flexibility initiatives often assume a certain level of responsiveness from end-users. Residents' involvement needed to access to energy data from smart metering infrastructure. Data filtering and anonymization is a key factor.
 - **Infrastructure Constraints:** The Finnish pilot site is equipped with advanced energy infrastructures. Limitations in communication networks, and technology integration may hinder the seamless implementation of the proposed activities. It is also essential that all systems support open APIs to ensure communication and interoperability with the EVELIXIA Platform.
 - **Other stakeholder involvement:** Building owner and technology providers are not partners to EVELIXIA. Accessing to control infrastructures and modifying control pattern will be limited.
 - **Technological Reliability:** Web interfaces rely on Information and Communication Technology, which are not always reliable.
-

- **External Factors:** Economic conditions, weather conditions, and market dynamics, may not be relatively stable throughout the pilot period. Such variables introduce unpredictability into the resulting related outcomes.

Assets of the Use Case

Existing equipment

- Smart Metering infrastructure
- 50 kW_p PV Plant on building roofs
- eV charging station with 4 x 11 kW charging points
- Auxiliary HVAC components in apartments
- Local BESS (21kWh) in TA residential area
- Geothermal heat pump. Water circulation underfloor heating. The heat pump is Gebwell Taurus 110 EVI.
- Production and storage of Domestic Hot Water (2 x 750l + 1 x 500 l with Heating)
- Distributed Electrical boilers (1.5 kW)
- Control centre for the common Heat Pump and DHW storage

Planned installations (EVELIXIA)

- Energy submeters

Planned installations (Own funding)

- API for local data acquisition and storage

Further information

n/a

Grid Services Selection

Further related services to enhance the grid's stability, reliability, resilience, efficiency, and adaptability to fluctuations by actively managing the electricity demand:

Applicable for demonstration:

- **Demand Side Flexibility (Implicit and Load Shifting):** Adjusting a portion of the demand for electricity consumption in the system by moving electricity-intensive end-users activities to different time-frames. Occupants and end users can be encouraged to shift their energy usage to times when renewable energy generation is abundant or during periods of reduced overall demand.
- **Peer to Peer Energy Trading:** Decentralized synchronized coordination of demand between mutualized/ aggregated/ community customers (increase-to-

decrease demand schemes to provide the same service to the grid)

- **Building Investment Planning:** Design, development, and optimization of the energy infrastructure to meet the current and future buildings needs ensuring reliability, efficiency, and sustainability.

Out of scope for demonstration:

- **DSF Modulation:** Aligning adaptable electricity consumption patterns of end-users with the dynamically varying needs and conditions of the grid. This modulation can occur through various mechanisms such as a) time-of-use pricing, b) demand response programs, c) automated demand-side management, and d) energy storage integration.

Prioritisation of the use case

Obligatory.

Market mechanisms

Peer to peer energy trading.

Use Case Narrative

UC-FI#1 envisions to investigate and implement demand side flexibility measures for the end users, based on common energy assets at buildings level, DER availability and energy market prices

The Use Case is divided into 4 phases:

- **Registration and Prequalification:** Product definitions and initial pre-qualification
- **Implementation of data acquisition:** Access to measured data with self-designed API
- **Selection/Bidding:** State estimation and prediction of demand side flexibility
- **Deployment of EMS:** Adaption and installation of building scale EMS

Complete description of the use case.

Product definitions

- FS-UC#1 creates offers for flexibility based on current assets

Registration and pre-qualification

- The project is presented to building owner TA-Yhtiöt
 - Data access in pilot site is approved and supported by building owner TA-Yhtiöt
 - The project is presented to end users (tenants)
 - Data access is granted by a relevant part of the tenants (End users)
 - Smart Energy Meter upgrade with HAN interface
-

- Access to data related to PV production directly from inverters
- Access to data from and control of the local BESS
- Installation of a grid analyser at the building's main switch board
- Collection of end users data at DSO level (metering data, forecasts).
- The NERC-TUAS APIs are adapted and implemented for all measuring applications.
- Energy demand profiles are measured and analysed
- DER production profiles are collected.
- eV charging station power use profile is collected.
- Access to data monitored by the Central Control Unit supervising Heat pump and DHW production system
- Implementation of DSF mechanisms
- P2P energy trading is implemented together with Building owner, DSO and End users
- Impact on SRIs, Self-consumption, Energy cost is evaluated

Table 174. Technical details and actors involved. UC-FI#1

Name	Actor Type	Description	Further information specific to this Use Case
New Energy Center at TUAS	Research Centre (academic)	Pilot site coordinator	Responsible for UC implementation in the Finnish Pilot.
TA Yhtiöt	Real Estate company	Building Owner and energy assets operator	Supportive role in UC implementation.
Naantalin Energia Oy	DSO	Operation, maintenance and development of the power distribution network and electricity systems	Transparent and impartial access of consumers and network users to data

Table 175. Step by step analysis. UC-FI#1

No	Scenario name	Scenario description
1	Maximize self-consumption	Optimize the real-time operation of on-site flexibilities (EV charging, manageable appliances, battery energy storage systems, Domestic Hot Water production) in order to maximize the annual self-consumption ratio while achieving the most profitable scenario.

		The energy management strategy will aim, in particular, to reduce demand peaks by shifting flexible energy consumption and storing excess energy generated on-site during low-demand periods for use during peak demand times. Lithium battery storage will be used for intraday storage	
		Primary actor	TUAS-EMS dedicated to control 22 kWh BESS at buildings technical room, based on PV energy production, SOC of battery, current energy demand, forecasted energy demand and market indicators
		Triggering event	Optimal energy dispatch plan every 10 minutes
		Pre-condition	Current energy dispatch plan and setpoints
		Post-condition	Same/new energy dispatch plan and setpoints
2	Peer2Peer Energy Exchange	P2P energy trading is implemented together with Building owner, DSO and End users (Virtual energy community)	
		Primary actor	Power meters, PV inverters and BESS at Lounatuuli 13-15 technical room
		Triggering event	PV production and energy consumption monitoring
		Pre-condition	Energy costs based on actual transfers through the distribution grid
		Post-condition	Energy costs based on Direct energy exchange between building common facility and end-users
3	System planning	Recommendations to building owner for investing on PV installation and enlarged local BESS, as well as EMS including Central Heat pump and DHW production	
		Primary actor	Common Energy assets at the Lounatuuli buildings technical room
		Triggering event	Analysis of technical and financial performance of current assets
		Pre-condition	Current energy assets
		Post-condition	Recommendations for investments

8.5.2 Use case 02. UC-FI#2 EMS for BESS at smart substation

Use Case description

Name

UC-FI#2 EMS for BESS at Smart substation

Scope

Implementation of an Energy Management System dedicated to the control of the 160 kWh battery energy storage system located at the Smart distribution substation

Objectives

- Mitigate physical congestions (overloading of lines/transformers, voltage band violations) using market-based active power flexibility in a cost-efficient way.
 - Increase DER production
 - Increase of self-consumption at the district level
 - Secure distribution grid resilience
- Long term energy cost reduction by efficient grid planning

Limitations & Assumptions

- **Data Acquisition:** The effectiveness of the activities and the accuracy of the results rely heavily on the availability of data pertaining to energy consumption, demand patterns, and other relevant variables. Data access to BESS Control system (ABB) must be granted by Project partner Naantalin Energia Oy.
- **Infrastructure Constraints:** The Smart Substation at Lounatuuli is equipped with advanced energy storage infrastructure. Limitations in communication networks, and technology integration may hinder the seamless implementation of the proposed activities. It is also essential that all systems support open APIs to ensure communication and interoperability with the EVELIXIA Platform.
- **Other stakeholder involvement:** Pilot site buildings owner and technology providers are not partners to EVELIXIA. Accessing to control infrastructures and modifying control pattern require their commitment.
- **Technological Reliability:** Secured data transfer required for grid operations
- **External Factors:** Economic conditions, weather conditions, and market dynamics, may not be relatively stable throughout the pilot period. Such variables introduce unpredictability into the resulting related outcomes.

Assets of the Use Case

Existing equipment

- 108 kW_p PV plant on canopies

- BESS (162 kWh) located in the distribution substation
- Geothermal heat pump. Water circulation underfloor heating. The heat pump is Gebwell Taurus 110 EVI.
- Production and storage of Domestic Hot Water (2 x 750l + 1 x 500 l with Heating)
- Distributed Electrical boilers (1.5 kW)
- Control and monitoring unit for the BESS (ABB)

Planned installations (EVELIXIA)

- Energy submeters

Planned installations (Own funding)

- API for local data acquisition and storage

Further information

n/a

Grid Services Selection

Further related services to enhance the grid's stability, reliability, resilience, efficiency, and adaptability to fluctuations by actively managing the electricity demand:

Applicable for demonstration:

- **Portfolio management services (day-ahead/intra-day):** Strategic management of assets to optimize day-ahead (spot market) and real-time (balancing market) trading implementing explicit DR schemes in accordance to the upfront market bids. Upfront-selling the potential/estimated result of demand response actions in electricity markets.
- **Distributed Energy Resources (DERs) dispatch:** Real-time balancing of supply and demand by grid operators or utilities by dynamically controlling the operation of power generation of decentralized renewable energy sources based on grid conditions, grid support functions, and market participation.
- **Network investment Planning:** Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating) grid needs ensuring reliability, efficiency, and sustainability.

Out of scope for demonstration:

- **Validation of aggregated resources participation in TSO services:** Upfront-selling the potential/estimated result of demand response actions in electricity markets. Based on appropriate predefined contracts (e.g, the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding of large loads is applied in response to incentives provided by aggregators/DR service providers.

Prioritisation of the use case

Obligatory.

Market mechanisms

Spot Market, Balancing Market

Use Case Narrative

UC-FI#2 envisions to implement an advanced Energy Management System for specific battery storage unit and PV plant. UC-FI#2 aims at investigating demand side flexibility measures for the main building geothermal heat pump, based on energy assets at district level (BESS and PV) and pilot site building level, DER availability and energy market prices

The Use Case is divided into the 4 phases:

- Registration and Prequalification: Product definitions and initial pre-qualification. Agreement with BESS owner.
- Implementation of data acquisition: Access to measured data with self-designed API. EMS adaptation and implementation
- Selection/Bidding: State estimation and prediction of DER production, market prices and demand side flexibility
- Evaluation: Monitoring Voltage levels and grid load flows, establish grid stability assessment

Complete description of the use case.

Product definitions:

- EMS specifications are discussed with BESS owner (NE Oy).
 - Access to ABB supervising platform is granted by NE Oy.
 - The supervising platform is connected to Rest API developed by NERC-TUAS
 - NE Oy informs TUAS of their statistics and strategies related to Congestion prevention.
 - The energy produced by Canopy PV plant is monitored.
 - PV energy production profiles are established.
 - Large energy consumers are monitored.
 - The EMS is implemented to control battery charging and discharging cycles.
 - The impact of BESS on grid stability, self-consumption is monitored and evaluated.
 - Recommendations for the future installations to develop the distribution grid are delivered to the DSO.
-

Table 176. Technical details and actors involved. UC-FI#2

Name	Actor Type	Description	Further information specific to this Use Case
New Energy Center at TUAS	Research Centre (academic)	Pilot site coordinator	Responsible for UC implementation in the Finnish Pilot site. (APIs, and EMS)
Naantalin Energia Oy	DSO	Operation, maintenance and development of the power distribution network and electricity systems	Agreement and support for the implementation.
TA-Yhtiöt	Real estate company	Building Owner and energy assets operator	Supportive role in UC implementation.
ABB	Solution provider	Design and implementation of the BESS and its supervising platform	Support for the implementation of the EMS

Table 177. Step by step analysis. UC-FI#2

No	Scenario name	Scenario description	
1	Maximization of self-consumption	Optimize the real-time operation of BESS at Smart substation in order to maximize the annual self-consumption ratio at district level while achieving the most profitable scenario	
		Primary actor	TUAS-EMS adapted to BESS at Smart Substation and PV plant installed on canopies.
		Triggering event	Optimal energy dispatch plan every 10 minutes
		Pre-condition	Current energy dispatch plan and setpoints
		Post-condition	Same/new energy dispatch plan and setpoints
2	Line Voltage Stabilisation	This scenario is an analysis based on virtual implementation of EVELIXIA developed tools in order to stabilise Line voltage with the help of PV inverter and BESS control, according to Finnish grid code	
		Primary actor	BESS installed at Smart Substation and PV inverter at the canopies
		Triggering event	Line voltage monitoring at Point of Common Connection of the Lounatuuli 13-15 buildings and at the PV installation on canopies
		Pre-condition	PV inverter and BESS current setpoint
		Post-condition	New Q(U) and/or P(U) set points at BESS and PV inverter

8.5.3 Use case 03. UC-FI#3 Frequency Reserve

Use Case description

Name

UC-FI#3 Emulation of Frequency Containment Reserve for Normal Operation (FCR-N) emulation based on aggregation of energy assets

Scope

- Frequency Containment Reserve for Normal Operation (FCR-N) is active power reserves that are automatically controlled based on the frequency deviation. Their purpose is to contain the frequency during normal operation and disturbances. FCR-N aims to keep the frequency within the standard frequency range of 49,9 Hz to 50,1 Hz.
- Local reserve resources providing FCR-N does not meet the technical requirements. Aggregation with multiple BESS is necessary.
- The scope of this Use case is to emulate the implementation of local BESS controller and to simulate the control of the Smart Substation BESS and other BESS located in the area based on FCR-N.

Objectives

- Evaluate the conditions and challenges for the implementation of FCR-N services in Finnish pilot site
- Implement the required measurement equipment and data collection at the pilot site
- Simulate FCR-N services of a defined period of time
- Assess the financial gain virtually with FCR-N with aggregated small BESS in the area of the Finnish PS.

Limitations & Assumptions

- Data Acquisition: The effectiveness of the activities and the accuracy of the results rely heavily on the availability of data pertaining to grid frequency and State of Charge of the BESS. Data access to BESS Control system (ABB) must be granted by Project partner Naantalin Energia Oy. Frequency measurement might need to be implemented at the substation.
- Infrastructure Constraints: The Smart Substation at Lounatuuli is equipped with advanced energy storage infrastructure. Limitations in communication networks, and technology integration may hinder the seamless implementation of the proposed activities. It is also essential that all systems support open APIs to ensure communication and interoperability with the EVELIXIA Platform.
- Other stakeholder involvement: Technology providers are not partners to EVELIXIA. Accessing to control infrastructures and modifying control pattern

require their commitment. FINGRID is managing Frequency Containment Reserves.

- Technological Reliability: Secured data transfer required for grid operations
- External Factors: Grid frequency, availability of real time data from another BESS in the area.

Assets of the Use Case

Existing equipment

- BESS (162 kWh/160 kW) located in the distribution substation
- Control and monitoring unit for the BESS (ABB)
- BESS (22kWh/22kW) located in the pilot site building infrastructure
- BESS (50kWh/50kW) located in a building in Turku

Planned installations (EVELIXIA)

- Frequency meter (to be confirmed)
- Interface to charging power control signal from Fingrid

Planned installations (Own funding)

- API for local data acquisition and storage

Further information

Description and requirements for Frequency Reserve services
https://www.fingrid.fi/en/electricity-market/reserves_and_balancing/frequency-containment-reserves/#technical-requirementsDescr...

Grid Services Selection

Further related services to enhance the grid's stability, reliability, resilience, efficiency, and adaptability to fluctuations by actively managing the electricity demand:

Applicable for demonstration:

- **Validation of aggregated resources participation in TSO services.** Strategic management of assets to optimize real-time (balancing market) trading and maximize aggregators' returns. Based on appropriate predefined contracts (e.g, the aggregator is allowed to (even manually through a phone call) shed 10 times per year a maximum amount of 1MWh), imposed demand shedding of large loads is applied in response to incentives provided by aggregators/DR service providers.

- **Portfolio management services (day-ahead/intra-day):** Strategic management of assets to optimize real-time (balancing market) trading implementing explicit DR schemes in accordance to the upfront market tools. Upfront-selling the potential/estimated result of demand response actions in electricity markets.
- **Network investment Planning:** Design, development, and optimization of the energy infrastructure to meet the current and future (power, heating) grid needs ensuring reliability, efficiency, and sustainability.

Out of scope for demonstration:

- **Distributed Energy Resources (DERs) dispatch:** Real-time balancing of supply and demand by grid operators or utilities by dynamically controlling the operation of power generation of decentralized renewable energy sources based on grid conditions, grid support functions, and market participation.

Prioritisation of the use case

Mandatory.

Market mechanisms

Balancing Market (Frequency Containment Reserve)

Use Case Narrative

UC-FI#3 envisions to analyse and evaluate the possible implementation of a Frequency reserve service at the level of a smart substation. UC-FI#3 aims at investigating what are the requirements and challenges linked to the implementation of a FCR service at the scale of small and aggregated BESS. Required measurements and Data communications related APIs will be implemented at the PS substation. Real service and commands from the TSO will be emulated rather than implemented. An analysis of return on investments based on FCR-N will be realized.

The Use Case is divided into the 4 phases:

- Registration and Prequalification: Product definitions and initial pre-qualification. Agreement with BESS owner and terms with TSO.
 - Implementation of data acquisition: Frequency and SOC measurements and access with self-designed API. Control signals from TSO
 - Selection/Bidding: Emulation of aggregation with other BESS
 - Evaluation: Estimation of revenues based on FCR services
-

Complete description of the use case.

Product definitions

- EMS specifications are discussed with BESS owner (NE Oy)
 - Access to ABB supervising platform is granted by NE Oy
 - The supervising platform is connected to Rest API developed by NERC-TUAS
-

- NE Oy informs TUAS of their strategies related to Congestion Frequency Reserve services
- The SOC of the BESS is monitored.
- The conditions and requirements for FCR-N service are negotiated with FINGRID (TSO)
- Large energy consumers are monitored
- The Equipment for FCR-N to control battery charging and discharging cycles is installed
- The revenues are calculated based on Spot market prices and FCR-N services
- Recommendation for the future installations to develop storage on the distribution grid are delivered to the DSO

Table 178. Technical details and actors involved. UC-FI#3

Name	Actor Type	Description	Further information specific to this Use Case
New Energy Center at TUAS	Research Centre (academic)	Pilot site coordinator	Responsible for UC implementation in the Finnish Pilot site. (APIs, and EMS)
Naantalin Energia Oy	DSO	Operation, maintenance and development of the power distribution network and electricity systems	Agreement and support for the implementation. Information about the congestion monitoring and energy markets
FINGRID	TSO	Transport System Operator	Provide information for a virtual implementation of FCR-N service and market tools
ABB	Solution provider	Design and implementation of the BESS and its supervising platform	Support for the implementation of the EMS

Table 179. Step by step analysis. UC-FI#3

No	Scenario name	Scenario description	
1	Frequency Containment	Emulation of FCR-N frequency reserve related ancillary service with Finnish TSO and aggregated resources	
		Primary actor	BESS at EVELIXIA PS Smart Substation + BESS at another PS, i.e. Tyssija in Turku

		Triggering event	Signal from aggregator
		Pre-condition	Idle battery converter, BESS SOC at 50%
		Post-condition	New setpoint for aggregated battery energy storage systems
2	Maintenance prediction and fault detection service of the BESS cooling system	The EVELIXIA platform will inform about the availability and fault risk of the system components	
		Primary actor	BESS at the Smart Substation
		Triggering event	Fault risk, unavailability of components
		Pre-condition	Monitoring of the SOC of BESS and systems
		Post-condition	Consideration of default risk in the EMS
3	System planning	Recommendations for BESS capacity increase based on potential revenues with Frequency Containment Reserve services	
		Primary actor	BESS at Smart Substation and other BESS in the areal
		Triggering event	Revenues based on emulation of FCR-N service in collaboration with TSO
		Pre-condition	Possible agreement with TSO and required investments (BESS capacity, frequency measurement)
		Post-condition	Recommendation to aggregator

9 CONCLUSIONS

As a result of the work carried out, the participating partners have collaborated in defining the current technical status of the different pilot sites and the demonstration framework according to the needs of the demonstrated Use Case (UC) scenarios and services.

D1.3 defines the requirements for each technology and service to be demonstrated by the relevant stakeholders, as well as the range of grid services to be demonstrated, supporting the developments under T5.2. The current state of each PS energy system is described in detail, which will facilitate the elaboration of the required technical details for EVELIXIA's Innovation Pathways. These pathways will lead to technical and product specifications for all equipment and systems to be engineered and deployed in WP2-WP5.

This deliverable will be updated in month 30 in D1.4, which will focus on refining its context according to the experience acquired from the pilot implementations and preliminary tests (WP5).

The tables shown below summarize the use cases defined for each pilot site and the energy services considered for each of them.

Table 180. Use Case Summary

ID	Use Case	Description
UC-AT#1	Thermal flexibility of district heating	Enhancing thermal flexibility in the district heating grid by decentralized thermal storage solutions at the end-user (DHW storage system Enerboxx) and/or at critical network locations (puffer storages)
UC-AT#2	Local optimization of electricity consumption	Flexible operation of heat pumps, electrical water heaters and/or possibly consuming assets at individual consumer and prosumer level to meet requirements of implicit and explicit demand side flexibility incorporating local production and DSO requirements
UC-RO#1	Implicit Demand Response	Demonstrate Demand Side Adaptability as inherent response to time of day tariffs
UC-RO#2	Explicit Demand Response	Demonstrate Demand Side Flexibility in response to external DSO signals and requests
UC-FR#1	Maximize self-consumption	Maximize self-consumption using a multi-time scale energy management strategy. The use case includes 1 main scenario and 2 simulated variant scenarios.
UC-FR#2	Provision of Ancillary grid services	Provision of Ancillary grid services: primary frequency setting and capacity mechanism
UC-DK#1	Electricity Optimisation on Building Level	Optimised operation of inverter, battery, and possibly consuming assets, to minimize cost of electricity.
UC-DK#2	Optimisation of District Heating Consumption and Production	Optimised operation of district heating assets, including conversion of surplus electricity to energy for district heating network.
UC-GR#1	Maximize self-consumption	Focuses on maximizing self-consumption on site while responding to a) user needs (e.g. occupant behaviour, thermal comfort etc.) and b) signals from the grid by making optimal use of the demand side flexibility potential and storage capacities.
UC-GR#2	Enable grid congestion management for power grid and DH operators	DSO/DHO set of strategies used to prevent or mitigate congestion within the DH and power distribution grid.
UC-SP#1	Demand side flexibility (implicit and explicit)	UC includes flexibility activation. It deals with a) leveraging the ability of the Spanish pilot site consumption patterns without direct user intervention (implicit flexibility), and b) automatically adjust energy consumption in response to grid signals and market mechanisms (explicit flexibility).
UC-FI#1	Smart energy scheduling	Flexible end-user energy demand management
UC-FI#2	EMS for smart power substation	EMS for the control of the grid connected battery located at Smart Substation
UC-FI#3	Frequency Reserve	Frequency Containment Reserve for Normal Operation (FCR-N) emulation based on aggregation of energy assets

Table 181. Energy Services to be demonstrated per PS and UC

Use Case	DSM Implicit	Building Investment Planning	DER Dispatch	P2P energy (flexibility) trading	Portfolio management services	Network Investment Planning
UC-AT#1	✓	-	✓	-	-	✓
UC-AT#2	✓	-	✓	-	✓	-
UC-RO#1	✓	✓	-	-	-	-
UC-RO#2	-	-	✓	-	✓	-
UC-FR#1	✓	✓	✓	-	✓	-
UC-FR#2	-	-	-	-	✓	-
UC-DK#1	✓	-	✓		✓	-
UC-DK#2	✓	-	✓	✓	✓	✓
UC-GR#1	✓	✓	-	-	✓	-
UC-GR#2	-	-	✓	-	-	✓
UC-ES#1	✓	✓	✓	-	✓	-
UC-FI#1	✓	✓	-	✓	-	-
UC-FI#2	-	-	✓	-	✓	✓
UC-FI#3	-	-	-	-	✓	✓

10 REFERENCES

- [1] CEN-CENELEC, 2015. EN 62559-2. Use case methodology - Part 2: Definition of the template for use cases, actor list and requirements list (IEC 62559-2:2015)
- [2] CEN-CENELEC, 2018. EN IEC 62559-3. Use case methodology - Part 3: Definition of use case template artefacts into an XML serialized format (IEC 62559-3:2017)
- [3] CEN-CENELEC-ETSI Smart Grid Coordination Group, 2012. Smart Grid Reference Architecture
- [4] CEN-CENELEC-ETSI Smart Grid Coordination Group, 2014. SGAM User Manual - Applying, testing & refining the Concepts, Elements and Tools for the Smart Grid Architecture Model
- [5] Grant Agreement No: 101123238— EVELIXIA— HORIZON-CL5-2022-D4-02

11 ANNEXES

11.1 Annex 1. Use Case description template

The scope of the template used for the characterization of use cases, based on the IEC 62559 standard, is described below.

Use Case description
Name Name of the use case: add a short name, which refers to the activity of the use case itself. We suggest you use “verb + description”, e.g., operate the distribution’s congestion management market or submit a flexibility bid to the distribution’s congestion management market.
Scope What is the scope of the use case? The scope defines the boundaries of the use case, i.e. what is in and what is out of the scope of the use case. This section may refer to the domain being considered (network, market...), the associated sub-domains (network level, type of market, e.g., balancing market, etc.), and time horizons (planning, real-time operations, etc.) for instance. E.g., scope: short-term network operation at MV level. UC includes flexibility activation. Out-of-scope: settlement process.
Objectives What are the objectives of the use case? List of objectives/goals the use case is expected to achieve (not for the writer or reader of the use case, but for the actor(s) using the system). For instance, objective: ensure flexibility activation of market bids (local market) will not create grid constraints.
Limitations & Assumptions What are the limitations and assumptions of the use case (for instance related to the building typology, types of use, site-specific, other boundary conditions, etc.).
Assets of the Use Case Please provide a list of assets that are needed specifically for this use case. (e.g. smart meters, actuators, APIs, etc.)
Further information Please provide relations to Other Use Cases if they exist (i.e. the use case is a more detailed one related to a High-Level Use Case, or it is an alternative to an existing use case).

Grid Services Selection

Please state which needs and related grid services will be implemented in this Use Case. Provide a detailed description and service definition based on the demo characteristics.

Prioritisation of the use case

Please provide a prioritisation of the use case. Considering a larger number of Use Cases, it might be interesting to cluster them according to priority (mandatory or optional). Examples:

- Obligatory/mandatory, optional, nice to have
- Political target/business need/prioritization from standardization point of view
- Time scale to deployment/timing, benefit, answer to new challenges

Market mechanisms

For the services that are used in this Use Case, please define the used market mechanisms.

Use Case Narrative

Give a short description of the use case. The goal is to provide a short text summarizing the UC. Please reflect on the main steps of the UC and provide an overview in no more than 10 lines.

Complete description of the use case.

Give a complete description of the use case. The objective is to provide a narrative of a concrete scenario (e.g., “main success scenario”) from a domain expert user’s point of view. This description should cover the motivations and intentions of various actors. It should guide the reader from the beginning (stating triggers) to the end (explaining how the service is completed). That is, the narrative should describe what occurs when, why, with what expectation, and under what conditions.

- While writing the narrative, please consider the following:
- Use “just one sentence form”
- Use present tense.
- Use active verbs in the active voice.
- Describe actions that move the process forward.
- For instance, “customer enters the card and pin into ATM”
- Keep it simple and to the point so that non-domain experts can understand it.

Bear in mind that the length of this section can range from a few sentences to a few pages, depending on the complexity and/or novelty of the use case. Good narratives support the domain expert to reflect on the requirements for the use case. We suggest including the following aspects in the narrative:

Type of mechanism used (please be specific) Interaction between roles (focus on the roles' intent bearing in mind that an action step reflects data circulating in one direction, e.g. "user enters name and address into the system")

Timeframe (e.g., local flexibility market opens at "x". The GCT is at "y". The clearing takes place 30 min. before the DA)

Data exchanges (please provide an indication of the data that is being exchanged, e.g., metered consumption data, contract data, generation forecast data)

Relevant phase (e.g., pre-qualification, procurement, activation, settlement)

Technical details and actors involved

Please fill in the table below. Use the roles agreed upon in the role model workshop. The list aims to limit the number of actors which is doubled using similar names.

Actor Type: Can be a Role (a DSO, a Balance Responsible Party, an Aggregator...), a Person (a Distribution Management System Operator), a System (a Weather Forecast System, a Demand Response Management System, a Building Management System...), a Device (a charging spot), or an application.

Table 182. Technical details and actors involved

Name	Actor Type	Description	Further information specific to this Use Case

Step by step analysis of the Use Case

Overview of scenarios

- No.: The scenarios are sequentially numbered.
- Scenario Name and Description: This is used to identify and describe the scenario.
- Primary Actor: Describes which actor(s) trigger(s) this scenario.
- Triggering Event: describes which event(s) trigger(s) this scenario.
- Pre-Condition: describes which condition(s) should have been met before this scenario happens.

- Post-Condition: describe which condition(s) should prevail after this scenario happens. The postconditions may also define “success” or “failure” conditions for each use case.

Table 183. Step by step analysis

No	Scenario name	Scenario description	
1			
		Primary actor	
		Triggering event	
		Pre-condition	
		Post-condition	
2			
		Primary actor	
		Triggering event	
		Pre-condition	
		Post-condition	
3			
		Primary actor	
		Triggering event	
		Pre-condition	
		Post-condition	

11.2 Annex 2. Pilot Sites: Additional Information

11.2.1 Pilot Site 1. Austria

11.2.1.1 Energy consumption of the pilot buildings

Table 184. Energy consumption of the pilot buildings. PS#1

Building	Heat [kWh]	Electricity [kWh]
Townhouse 1-8	17.500	25.600
PB1 Retirement & care centre	500.000	170.000
PB2 Elementary school	109.090	6.594
PB3 Municipality office	28.947	8.460
PB4 Mortuary	-	458
PB5 Machine Hall	-	15.216
Private building 1 - TRKL	25.180	not available
Private building 2 - KCH	35.250	not available
Private building 3 - KLVTS 1	13.740	not available
Private building 4 - KLVTS 2	not available	not available
Private building 5 - GSTS	7.300	not available
Total	737.007	226.328

11.2.1.2 Cost of Energy per building

Table 185. Cost of Energy per building (€). PS#1

Building	Value	
	Heat [€]	Electricity [€]
Townhouse 1-8	3.700	4800
PB1 Retirement & care centre	39.690	37.400
PB2 Elementary school	8.660	1.944
PB3 Municipality office	2.300	2.115
PB4 Mortuary	-	194

PB5 Machine Hall	-	3.804
Private building 1	not available	not available
Private building 2	not available	not available
Private building 3	not available	not available
Private building 4	not available	not available
Private building 5	not available	not available
Total	54.350	50.527

11.2.1.3 District heating grid

Grid analysis and status quo

For the district heating network, a simulation model was created by using the software for comprehensive analysis of district heating networks. Based on this, the pipe network system can be assessed with regard to a wide variety of aspects such as the pressure and temperature conditions in the network, the feed-in capacity and the load of heat consumed for each individual customer.

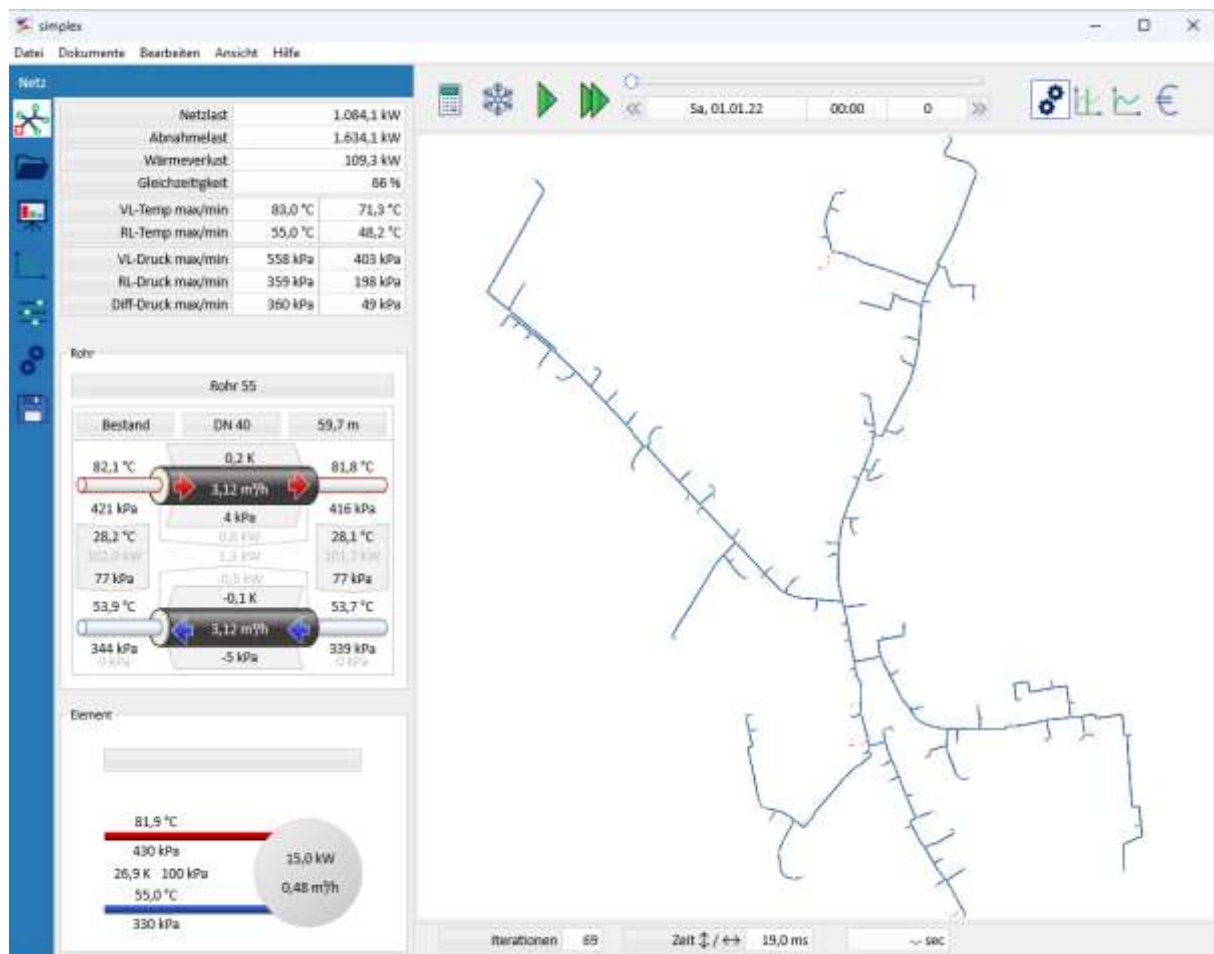


Figure 50. Overview of the DH model. PS#1

In addition to the overview of the DH model, the Figure 51 shows the pressure situation of the district heating system as well as the temperature and pressure course as well as the load profile for the feed-in capacity.

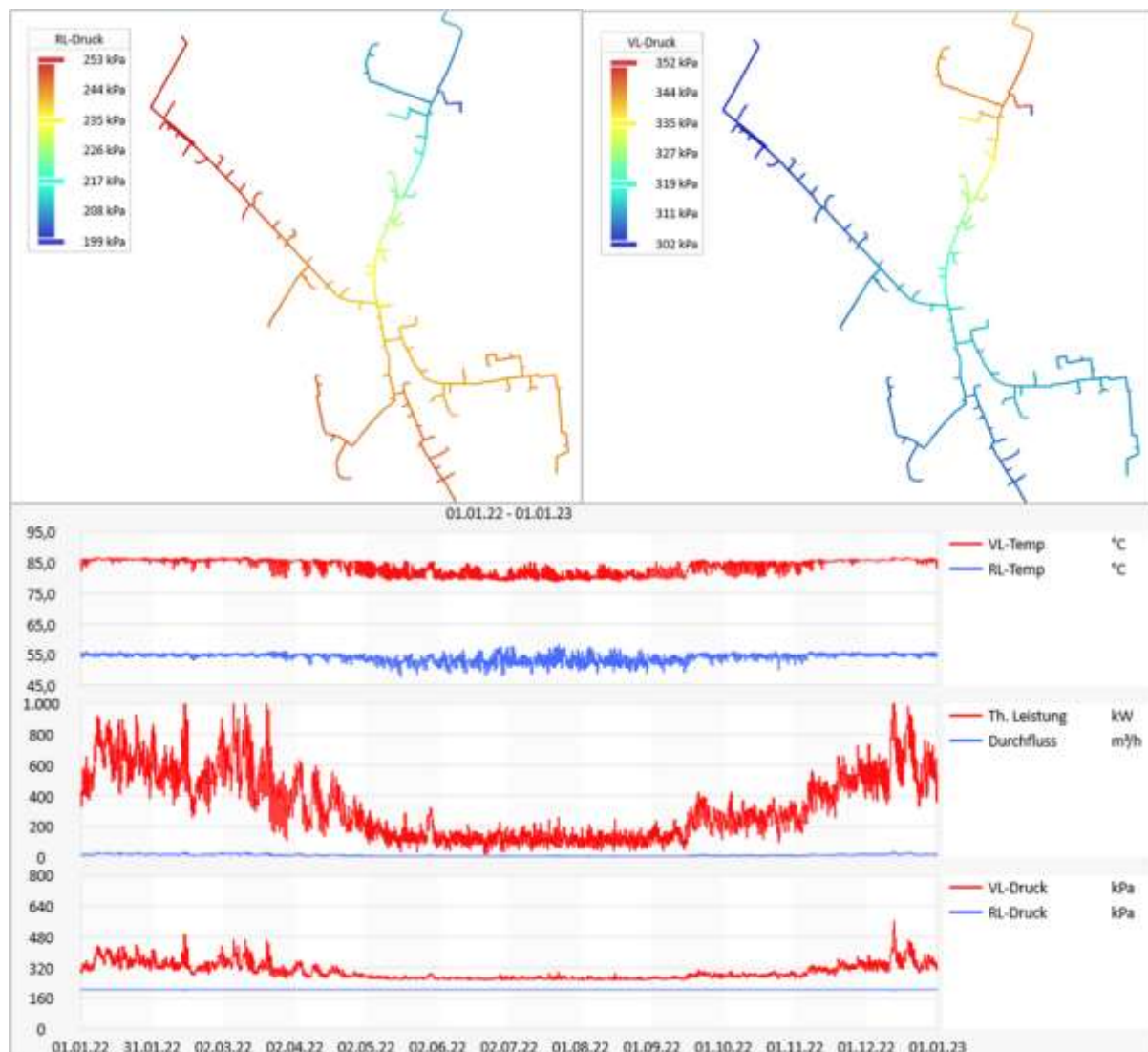


Figure 51. Simulation results of DH model. PS#1

Further analysis was carried out, in which possible areas where a temporary undersupply of the district heating system can occur under poor conditions was. This is particularly necessary with regard to the positioning of the thermal storage systems that will be installed as part of the project, through which these problems can be solved by creating thermal flexibility.

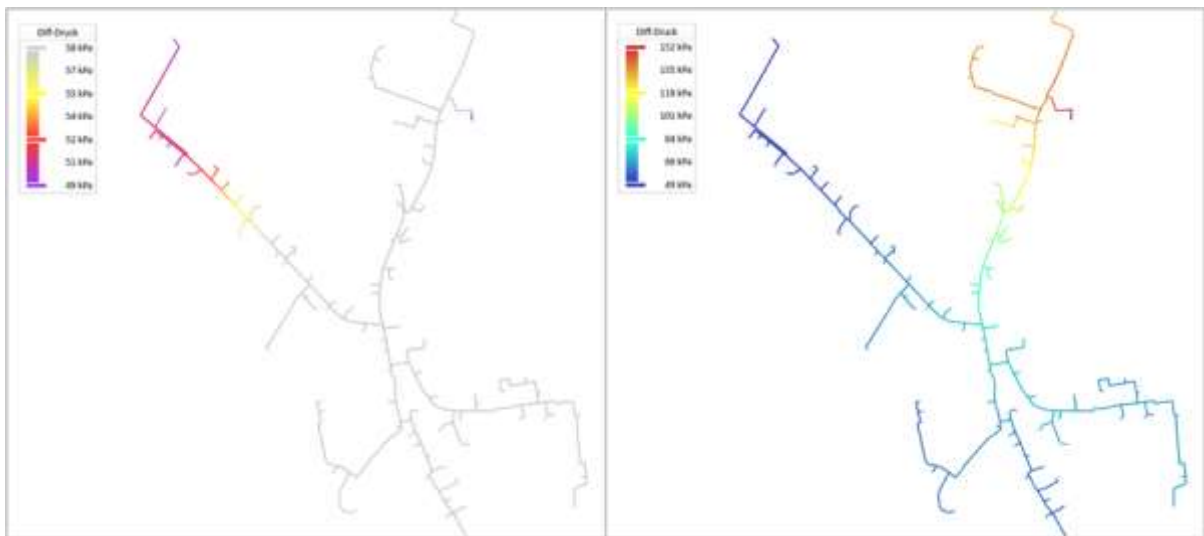


Figure 52. Areas of temporary undersupply / low diff-pressure. PS#1

Based on these analyses in combination with feasible locations for the integration of thermal storage systems, which has been elaborated together with the district heating operator, the geographical area for the integration of the two variants (buffer tank / hot water tank) could be determined. The Figure 53 gives an overview of these proper network areas.

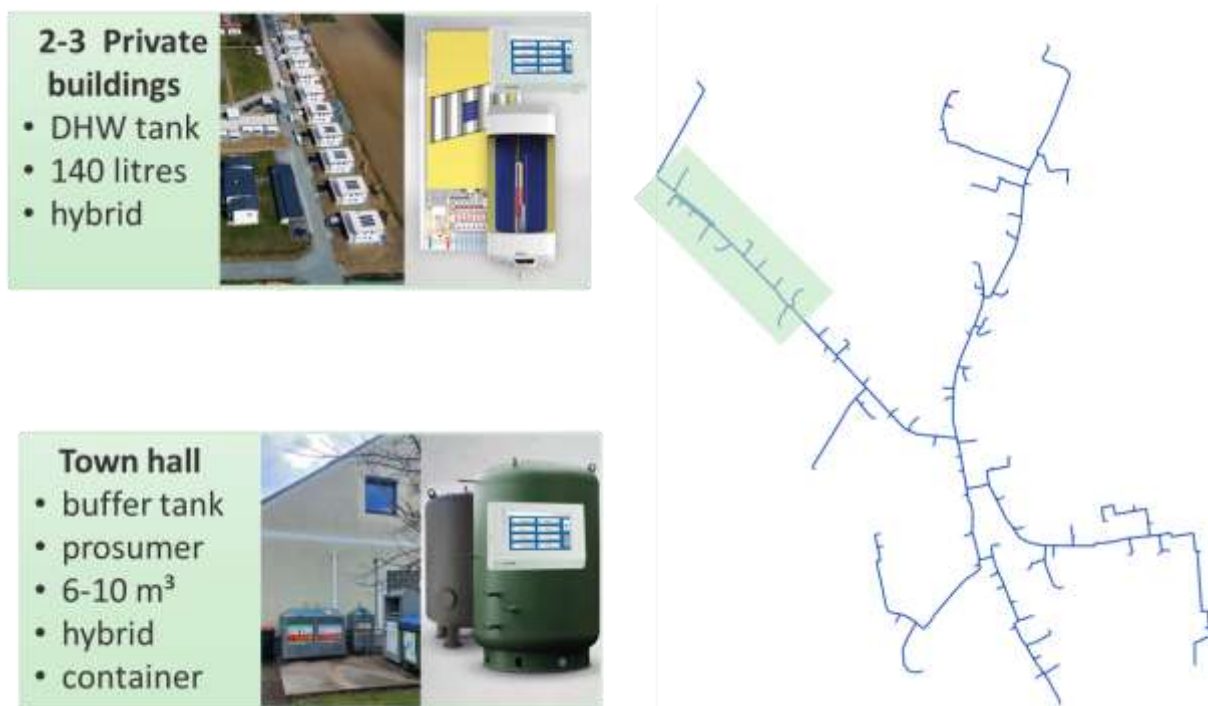


Figure 53. Installation areas for the thermal storage solution. PS#1

11.2.2 Pilot Site 2. Romania

11.2.2.1 Description of the Building Envelope

The core buildings' structure is a honeycomb reinforced concrete structure, built in 1978 and made of structural walls with 15 cm thickness and thermal conductivity $\lambda=1.74$ W/mK with integrated prefabricated slabs of 13 cm thickness. The energy performance of the building was carried out in 2007, and thermal rehabilitation measures were adopted to decrease the energy consumption of buildings. The associated retrofit solutions were the reinforcement of the (a) external walls with 15 cm mineral wool, (b) the roof area with 18 cm EPS insulation, and (c) the slab over the unheated basement with 10 cm EPS. Thus, the external walls of the buildings have a nominal U-value of 0.33 W/m²K. Respectively, the horizontal roof slab has a U-value of 0.248 W/m²K, and the basement is considered unheated with a U-value of the ground floor of 0.353 W/m²K.

Opaque Elements

Table 186. Description of the student dormitories buildings envelope. PS#2

Parameter	Value
Opaque structural elements	
In contact with neighbour building	Part of the west external wall
Area of the roof slab (m ²)	805.4
Area of the ground slab (m ²)	693.4
U-value of the external walls North-South (W/m ² K)	0.363
U-value of the external walls East-West (W/m ² K)	0.332
U-value of the roof/ceiling (W/m ² K)	0.248
U-value of the basement floor (W/m ² K)	0.468
U-value of the ground floor (W/m ² K)	0.353
Absorbance of the walls	60%
Emissance of the walls	80%
Number of apartments in the total building (rooms)	240
Transparent structural elements	
U-value of the window (W/m ² K)	2.325
g-value of the window	0.65

Fenestration

As it concerns the building's glazing system is concerned, the total windows area is 1096 m², with the majority of 90% to be located on the north and south façade. The mean U-value of the windows is calculated at 1.92 W/m²K, according to the window areas of the building, including the glazing, frame, and thermal bridge effects.

Table 187. Geometrical calculations of external walls and windows. PS#2

Opaque building structure	In contact with	Area [m ²]	U [W/m ² K]
South wall, without windows ($\gamma = -17^\circ$)	Ambient air	797	0.363
East wall, without windows ($\gamma = -107^\circ$)	Ambient air	436	0.332
North wall, without windows ($\gamma = 163^\circ$)	Ambient air	826	0.363
West wall, without windows ($\gamma = 73^\circ$)	Ambient air	428	0.332
	Neighbour building	85	0.332
Windows			
North windows	Ambient air	488	2.325
East windows	Ambient air	61	2.325
West windows	Ambient air	35.4	2.325
South windows	Ambient air	504	2.325
Total area of the windows	-	1096	-

All the data from the section Building Envelope are extracted from the Energy Audit and are related only to the Student Dormitories. There are no such data available for the Restaurant Campus.

11.2.2.2 Energy baseline

Electrical energy consumption – year 2021, 2022, 2023

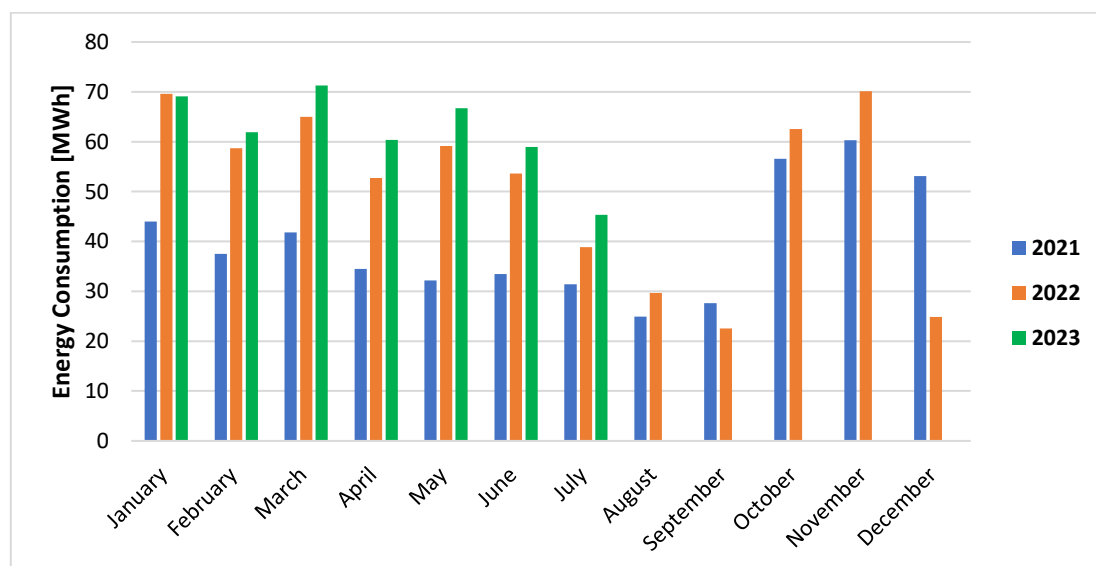


Figure 54. Monthly electrical energy consumption. PS\$2

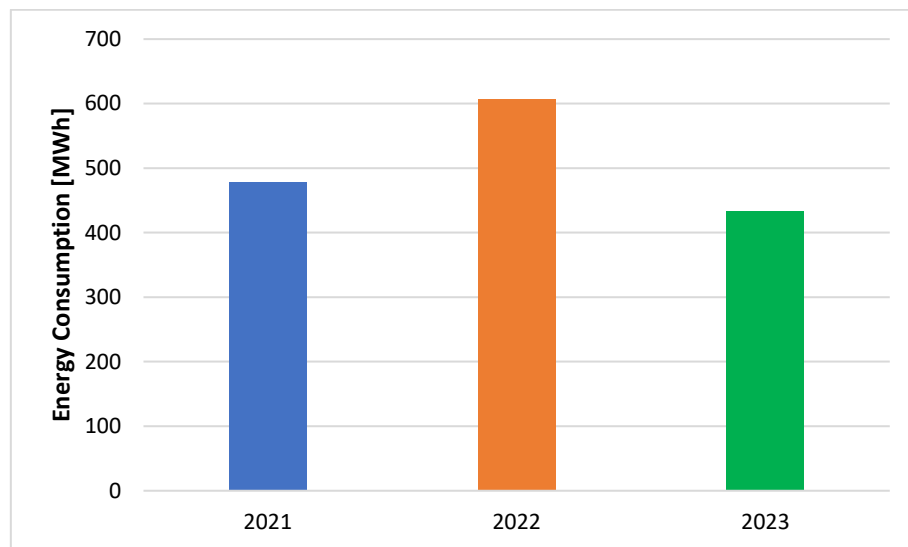


Figure 55. Yearly electrical energy consumption. PS\$2

Energy consumption recorded at 15 min in every day/per month from the BEMS

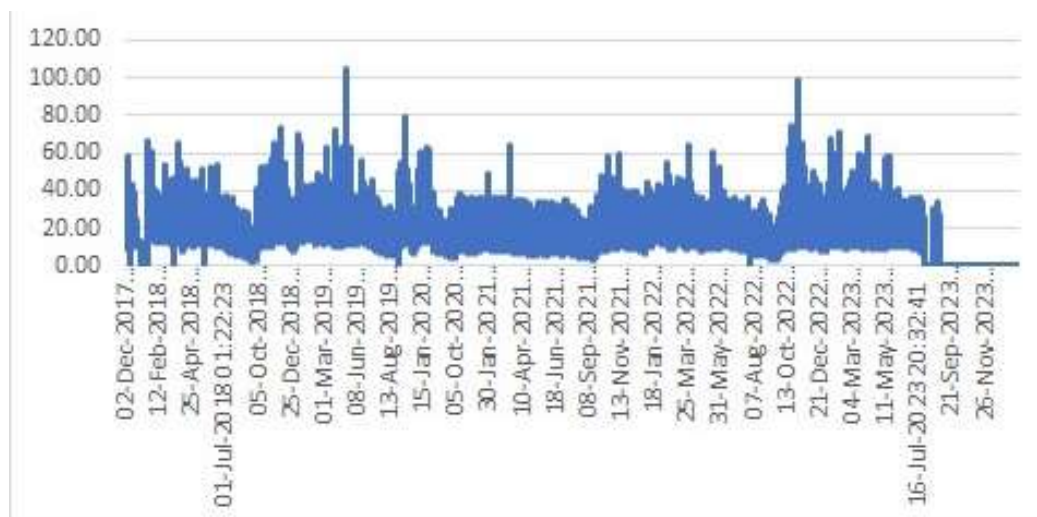


Figure 56. Energy consumption every 15 minutes (1). PS\$2

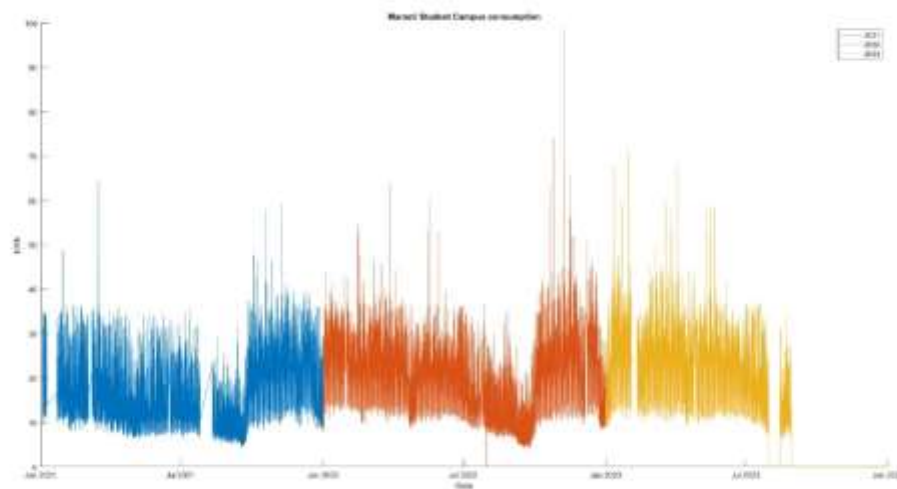


Figure 57. Energy consumption every 15 minutes (2). PS\$2

11.2.2.3 Cost of energy

Cost of Electrical energy – year 2021, 2022, 2023

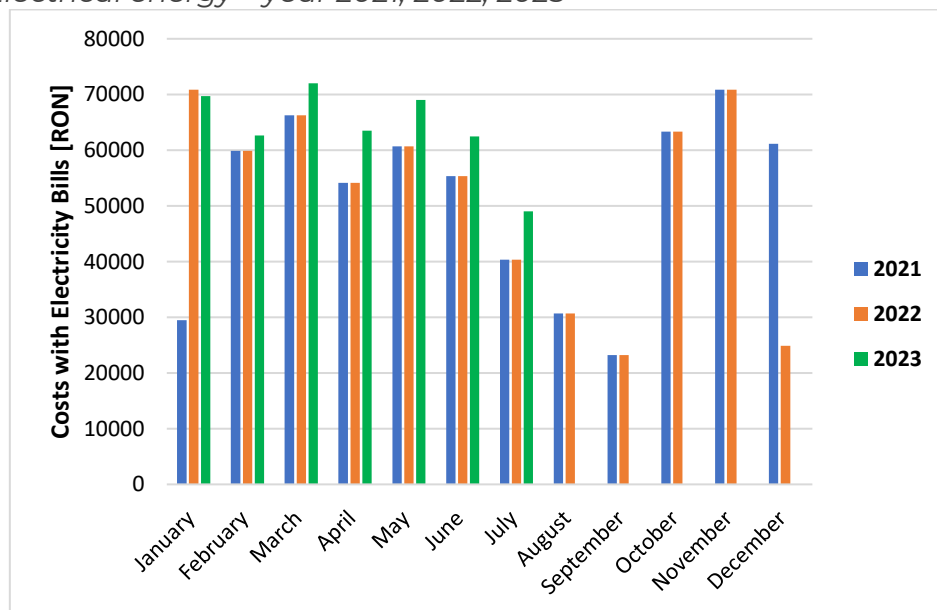


Figure 58. Monthly Cost of Electricity. PS\$2

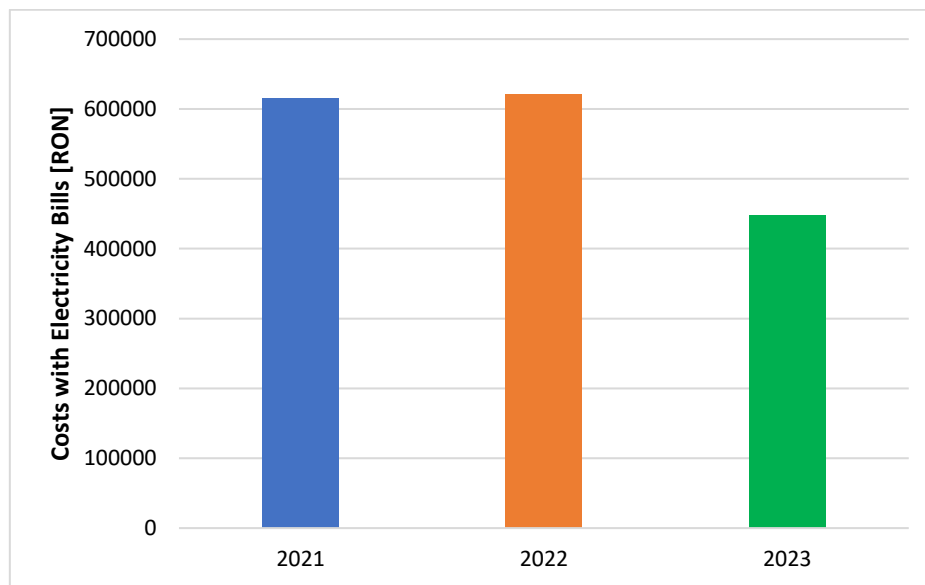


Figure 59. Yearly Cost of Electricity. PS\$2

11.2.3 Pilot Site 3. France

11.2.3.1 Energy Consumption and PV production

The energy consumptions and PV production presented below refer to the year 2023, according to the current available data.

Table 188. Energy Consumption Building. PS#3

Month	Total (MWh)	Including consumption from the grid (MWh)	Including self-consumption (MWh)
January	25,3	20,1	5,2
February	23,1	15,3	7,8
March	25,2	16,2	9,0
April	20	9,4	10,6
May	14,7	5,0	9,7
June	16,9	5,5	11,4
July	16,1	6,6	9,5
August	15,7	6,9	8,9
September	18,3	9,3	9,0
October	20,9	13,4	7,5
November	21,5	15,5	6,0
December	26,3	21,3	5,0
Total	244	144	99,6

Table 189. PV generation 1. PS#3

Month	Value (MWh)
January	12,1
February	13,2
March	14,6
April	28

May	34
June	33,7
July	25,5
August	25,5
September	21,1
October	13,7
November	11,2
December	11,2
Total	243

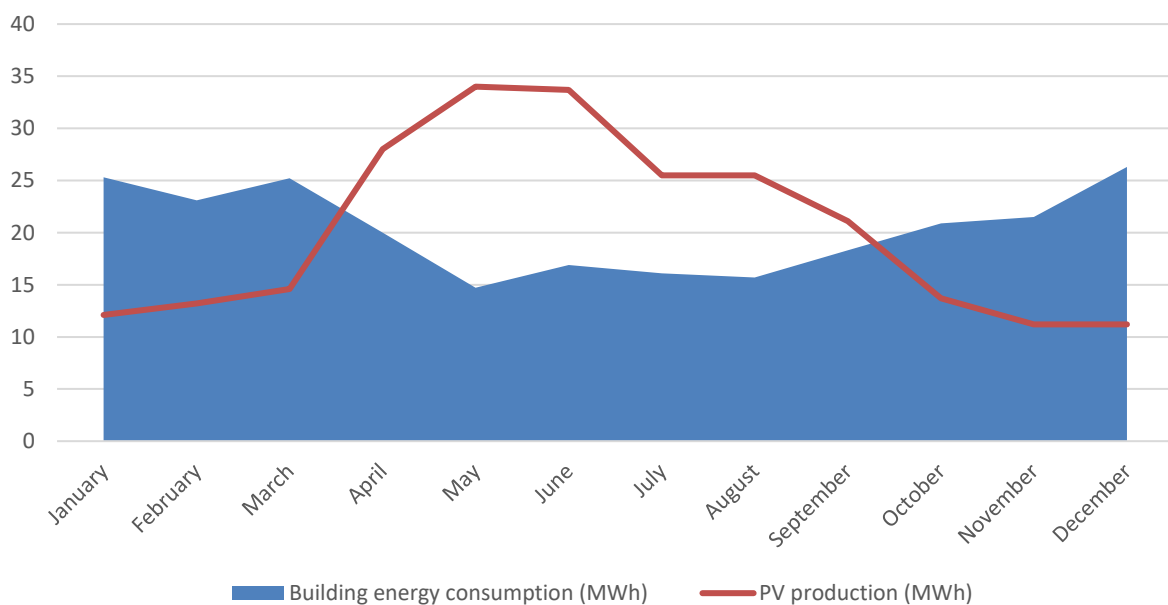


Figure 60. Monthly energy Consumption and PV production. PS#3

11.2.4 Pilot Site 5. Greece

11.2.4.1 Description of the Building Envelope

The two buildings of Pilot Case 5 have been erected in different periods and different technologies and materials have been used in their construction.

Opaque Elements

Regarding the opaque elements of the Mpodosakeio hospital building, can be divided into three different categories. The external masonry, the pillars and the roof. The exterior walls are made of alpha block 30cm thickness, 2.5cm exterior and 0.5cm interior plaster. The pillars of the building are made of 25cm concrete, with 5cm Heraklith insulation and 2cm internal and external plaster. Finally, the roof is made of 2cm thickness marble slabs and 25cm concrete, while between them there is a 2-centimeter-thick layer of reinforced concrete. In addition, there are 5cm Heraklith insulation slabs and 2cm plaster.

The opaque elements of the building in CERTH are divided into two categories. The external masonry consists of double brick (total thickness 20mm) with an internal and external coating of 2mm, with a thermal permeability coefficient of 0.85 (+0.2 increment) W/m²·K. The roof of the building consists of a conventional type of roof with a thermal permeability coefficient of 0.95 (+0.2 increment) W/m²·K.

Fenestration

The transparent structural elements of the Mpodosakeio hospital building consist of twin insulating glass panels with a gap of 12mm between placed in an aluminium frame with a coefficient of thermal permeability equals to 3kcal/m²hoC.

As far as the CERTH/CPERI building is concerned, the transparent elements are modern with an aluminium frame with thermal break – and double glazing. The coefficients of thermal permeability were derived from the thermal insulation study and are 3.72 for the openings and 0.688 (+0.2 increment) W/ m²·K for the wall.

11.2.4.2 Energy baseline

The energy consumptions presented below refer to the year 2022-2023, according to the current available data.

It should be emphasized that the two buildings of Pilot Case 5 cover their thermal needs through their connection with the district heating system of Ptolemaida city, which is in operation approximately from mid-October to mid-May. Also, another important part is that the thermal requirements in the hospital building are quite high, totally understandable due to the peculiarities of its operation (operation 24 hours per day).

Data on energy consumption were obtained from the respective electricity and heating bills.

In CETH/CPERI building, energy consumption on an annual basis amount to a total of 275000 kWh, with electricity accounts about 40% and thermal energy the remaining 60%. *Table 190* describes the energy consumption (electrical and thermal) of CETH on a monthly basis.

Table 190. Energy Consumption in CETH/CPERI building (2022-2023 data).
PS#5

Month	Value (kWh)		Total Monthly Energy (kWh)	Value (kWh)		Total Monthly Energy (kWh)
	Electricity	Thermal Energy		Electricity	Thermal Energy	
	2022			2023		
January	11,600.00	31,344.00	42,944.00	10,375.20	30,069.00	40,444.20
February	6,144.20	29,013.00	35,157.20	11,551.20	35,195.00	46,746.20
March	10,922.00	37,226.00	48,148.00	11,711.20	26,979.00	38,690.20
April	12,213.20	22,041.00	34,254.20	10,121.80	20,066.00	30,187.80
May	9,278.20	6,398.00	15,676.20	7,766.20	6,722.00	14,488.2
June	7,823.20	0.00	7,823.20	7,536.40	0.00	7,766.20
July	10,689.60	0.00	10,689.60	9,714.00	0.00	7,536.40
August	8,956.40	0.00	8,956.40	10,559.40	0.00	9,714.00
September	7,900.60	0.00	7,900.60	7,756.80	0.00	10,559.40
October	7,613.80	6,853.00	14,466.80	6,426.00	1,802.00	8,228.00
November	8,609.40	14,153.00	22,762.40	10,194.60	19,460.00	29,654.60
December	9,611.20	16,630.00	26,241.20		29,029.00	
Total	111,361.80	163,658.00	275,019.80		169.322.00	

Figure 61 presents a schematic illustration of the energy consumption in CETH/CPERI building for 2022 and 2023.

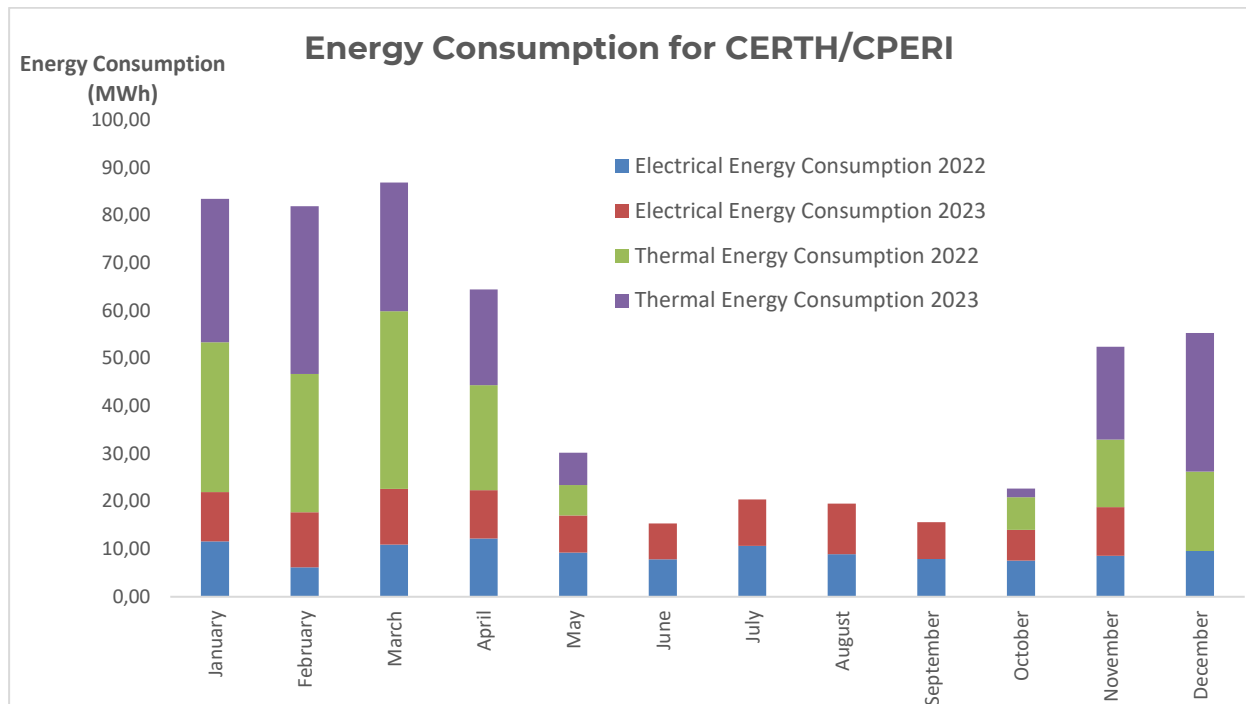


Figure 61. Energy consumptions in CETH/CPERI for 2022 and 2023. PS#5

Regarding the data of energy consumption or production from PV that can be monitored through Pragma_lot platform (per hour, minutes etc.) some examples for specific loads are presented in Figure 62 - Figure 64.



Figure 62. Electric consumption kWh (UPS loads in 1st floor offices) monitored by PragmaIoT (21-31 December 2023). PS#1



Figure 63. Electric production from PV (panels of 6KW-monocrystalline) monitored by PragmalIoT. PS#5

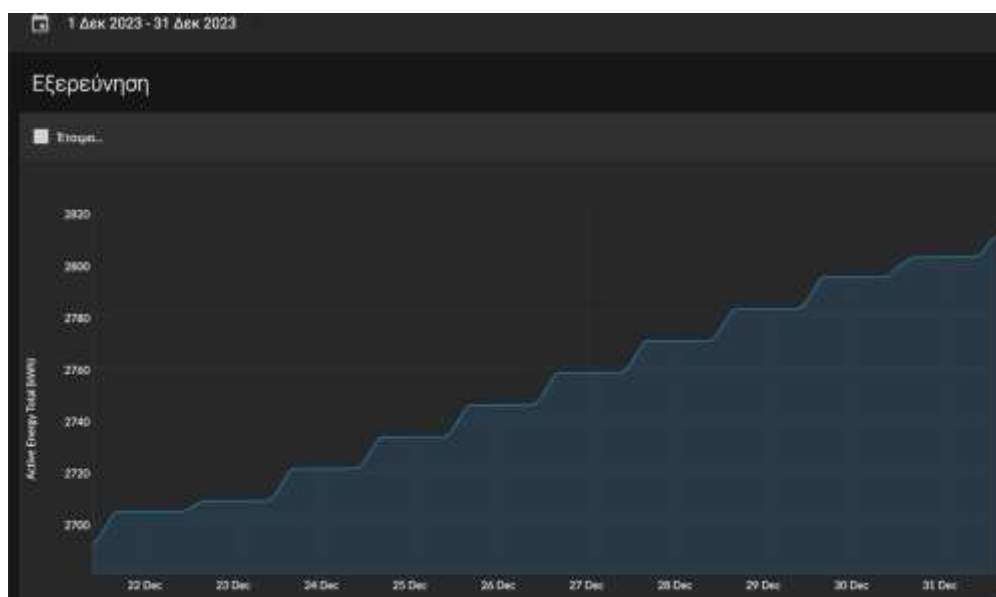


Figure 64. Electric production from PV (panels of 4KW-polycrystalline) monitored by PragmalIoT. PS#5

Modosakeio hospital building has (as expected) increased energy needs and this is also reflected in the consumptions. The annual energy consumption of electricity is higher than 3 million kWh, as described in *Table 191. Electrical Energy Consumption in Mpodosakeio Hospital building (2023 data). PS#5* Table 191, where the monthly variation is also presented.

Table 191. Electrical Energy Consumption in Mpodosakeio Hospital building (2023 data). PS#5

Month	Value (kWh)
January	264,280.08
February	224,477.16
March	251,877.24
April	231,947.76
May	246,713.88
June	251,788.20
July	306,517.68
August	301,628.52
September	277,657.20
October	259,191.36
November	234,162.12
December	263,574.35
Total	3,113,815.55

Figure 65 illustrates annual electrical energy consumption for Mpodosakeio hospital.

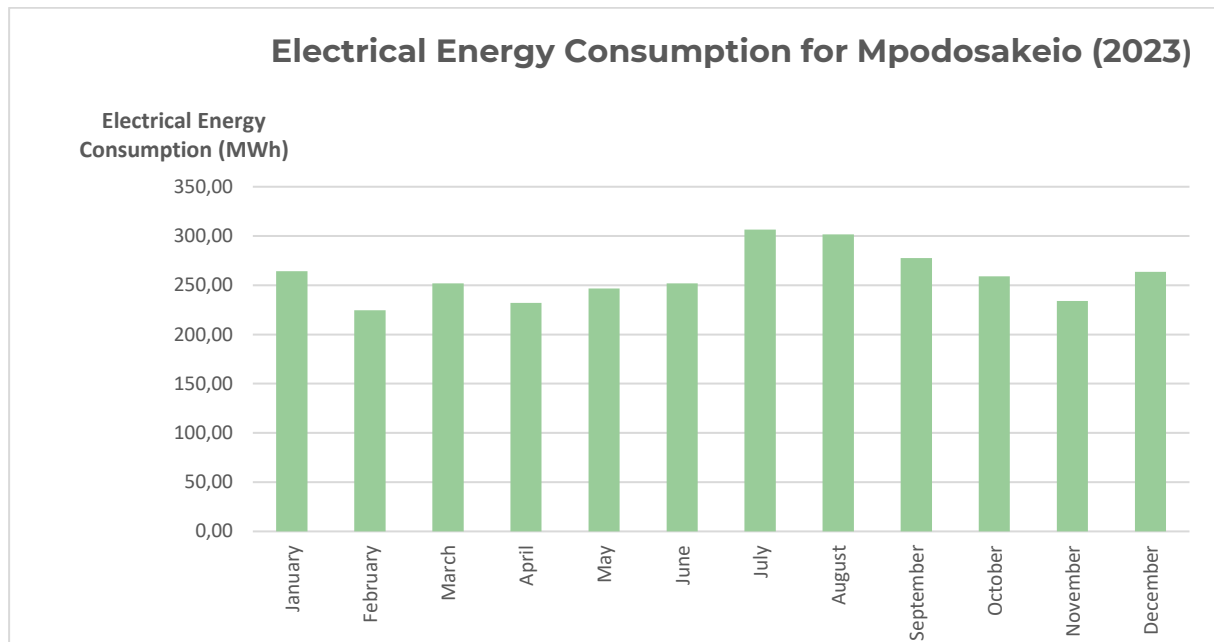


Figure 65. Electrical energy consumption for Mpodosakeio hospital (2023) . PS#5

Thermal energy demands in the hospital are even higher as they exceed 3 million MWh annually. *Table 192* shows the thermal consumption during one year.

Table 192. Thermal Energy Consumption in Mpodosakeio Hospital building (2022-223 data). PS#5

Period	Days	Value (MWh)	Period	Days	Value (MWh)
2022			2023		
03.12.21 to 14.01.22	42	716.60	02.12.22 to 16.01.23	45	692.60
14.01.22 to 16.02.22	33	636.70	16.01.23 to 17.02.23	32	516.90
16.02.22 to 21.03.22	33	610.40	17.02.23 to 23.03.23	34	409.6
21.03.22 to 13.05.22	52	524.40			
13.05.22 to 11.10.22	153	0.00			
11.10.22 to 02.12.22	52	557.20			
Total	365	3,045.30			

Figure 66 shows thermal energy consumption for Mpodosakeio hospital during a period between December 2021 and March 2023.

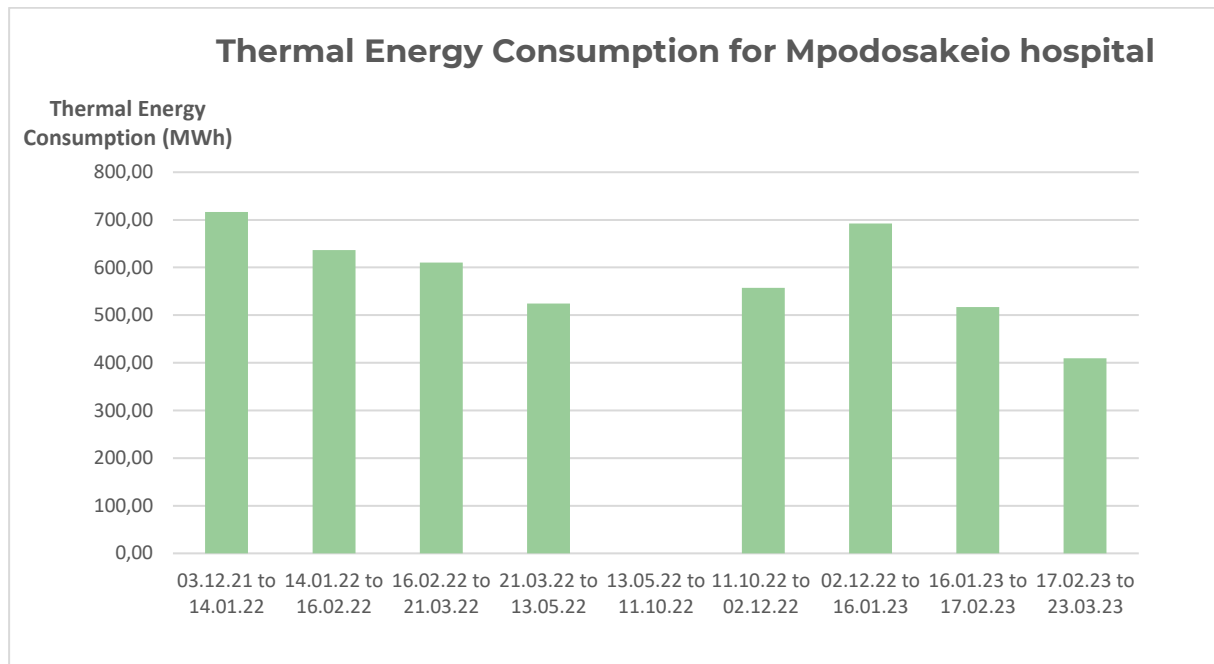


Figure 66. Thermal energy consumption for Mpodosakeio hospital. PS#5

11.2.4.3 Cost of Energy on an annual basis

According to the bills from PPC, the average annual consumption amounts to 111,361.80 kWh/year for CERTH building and 3,113,815.55 kWh/year for Mpodosakeio. Accordingly, the average annual consumption of thermal energy drawn from the bills of District Heating Municipal Company of Ptolemaida (DHCP) amounts to 163.66 MWh for CERTH and 3,045.30 MWh for Mpodosakeio.

Table 193 shows in detail the energy costs for the two buildings of Pilot Case 5.

Table 193. Cost of Energy on an annual basis. PS#5

Components	CERTH			Mpodosakeio			Total Cost
	MWh	€/MWh	€	MWh	€/MWh	€	€
Electricity	111.36	165	18,374.70	3,113.82	165	513,779.57	532,154.27
Heating	163.66	63.00	10,310.45	3,045.30	63.00	191,853.90	202,164.35
Total			28,685.15			705,633.47	734,318.62