Innovation Action

inteGRIDy

integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization & Storage Technologies

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WP1 – inteGRIDy Domain Analysis, Specifications & Architecture

D1.3 – Pilot Sites Surveys, Use Case Requirements & Business Scenarios

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Abstract:	This document is devoted to describing the ten Pilot implementations under development in the inteGRIDy project. For each Pilot, a description of the implementation area and a discussion on the needs and opportunities is provided. The architecture of the Pilots is detailed adopting the ISO/IEC/IEEE 42010. Goals and Use Cases are described referring to the four pillars on which the inteGRIDy project is based: Demand Response, Smartening the Distribution Grid, Energy Storage, Smart Integration of grid users from Transport. A preliminary description of the Regulatory Framework, of the technology bounds is reported in order to provide a proper contextualisation of the Pilots. Eventually Pilots' replicability is discussed.
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Executive Summary

Renewable Energy Sources (RES) are probably the main driver of the ongoing energy revolution all over the world which in turn drives for a deep review in the energy infrastructure design, control and regulation logics. Moreover, the regulatory framework and the energy market infrastructure need also to be consequently updated.

Actually, in such a context, inteGRIDy envisions the realisation and demonstration of a solution that helps to meet the challenges under a variety of environmental, market and societal conditions at 10 pilot and demonstration sites throughout EU.

In this report, the 10 Pilots are presented summarising for each one of them a description of the implementation site and of the needs and opportunities is the area. This is to point out the different characteristics of each Pilot in order to motivate approaches proposed.

Isle of Wight (UK, Section 2), TERNI (IT, Section 3), Nicosia (CY, Section 7), Xanthi (GR, Section 9) Pilots are related to grids in geographical islands or to microgrids (i.e. localised loads and generators that could operate connected to the traditional centralised electrical grid, but can disconnect and function autonomously). Actually, these Pilots are addressed to effectively manage the intermittent renewable generation, avoiding costs for grid extension.

San Severino Marche (IT, Section 4), St-Jean (FR, Section 6) Pilots are also committed to tackle renewables in a distribution grid. In these Pilots, the connection to the main grid is supposed to be strong, nevertheless significant needs are in the optimisation of the infrastructures management, increasing the efficiency and reliability, and developing effective market structure, capable to open the electric pool both to the small (renewables) generators and loads.

The market organization is then the main target of Barcelona (ES, Section 5), Lisboa (PT, Section 8), Ploiesti (RO, Section 10), Thessaloniki (GR, Section 11) Pilots. They are related to the management of buildings (residential and commercial) energy needs (electric and thermal ones) in order to identify effective demand response approaches.

Subsequently, the architecture of each Pilot is described, adopting the standard ISO/IEC/IEEE 42010. With respect to these architectures, Goals and Use Cases are described. Actually, inteGRIDy project is arranged with respect to four pillars on which the inteGRIDy project is based: Demand Response, Smartening the Distribution Grid, Energy Storage and Smart Integration of grid users from Transport. Goals and Use Cases have been consequently classified.

Furthermore, a preliminary description of the regulatory framework in place is provided with the goal to point out the main needs in term of evolution required in order to open a feasible commercial target for the approaches investigated. Similarly, technology bounds, for each Pilot, are discussed.

In all the Pilots an evolution of the regulatory framework is considered to be mandatory in order to allow innovative energy approaches (demand response, energy storage exploitation) and in order to have an economic viability of the renewables exploitation (opening the ancillary services markets today somehow confined to traditional power plants).

The current European regulatory framework on demand response [EUR12] states that National regulatory authorities shall encourage these new strategies to participate alongside supply in wholesale, balancing, ancillary services and retail markets and should define technical modalities for the participation of demand response in balancing reserves and other system service markets on the basis of the technical requirements of these markets. Actually, [EUR12] results perfectly coherent with respect to the review provided in this report; consequently, inteGRIDy Pilots will result an adequate, on time, test bed for the definition and validation of effective demand response approaches for inteGRIDy Pilots.

Similarly, the recent EU Winter Package [NIC15] puts strong emphasis on the ancillary services provision from dispersed generation, renewables and energy storage. In many EU countries, consultation are ongoing in order to identify adequate approaches to the opening of the ancillary services market. inteGRIDy Pilots result coherent also with respect to this topic and will test on-field approaches devoted to aggregate resources and provide a balancing contribution to the grid.

In the end, miscellaneous concerning each Pilot are discussed in order to point out their peculiarities:

Isle of Wight Pilot, leaded by a public-sector organization will particularly focus on ensuring that all residents, especially the more vulnerable, will benefit from the smart grid transition. The focus is to provide an appropriate level of service to those not able to navigate the new market.

San Severino Marche geographically is located in an area presenting hydrogeological and seismic risk, which could have an impact on the electric grid, causing system reliability reduction. Consequently, smart approaches could be quite useful in order to provide a reliable and safe service to dwellers.

From a technological point of view, in the Ploiesti Pilot a demand response solution will be developed from the scratch. Being the first implementation of this type in Romania, it will offer a good opportunity not only for testing a technological architecture but also to validate the approach effectiveness, the social impact and the specific business models.

In Thessaloniki Pilot the final users perception of the demand response approach proposed will be evaluated; on top of that, final users will be properly engaged in order to have an effective knowledge with regards to energy saving measures, pursuing educative approaches.

In conclusion, the report represents a cross analysis of the Pilots Use Cases mainly aiming to bridge Deliverable 1.3 to the work packages that will follow in the inteGRIDy project.

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List of Acronyms and Abbreviations

Term	Description
AD	Anaerobic Digestion
AMI	Advanced Metering Infrastructure
ANM	Active Network Management
BAE	British Aerospace
BEMS	Building Energy Management System
BESS	Battery Energy Storage Systems
BMS	Battery Management System
BMS's	Buildings Energy Management Systems
B-PLC	Broadband Power Line Communications
CAM	Capacity Assurance Market
CHP	Combined Heat and Power
CfDs	Contract for Differences
CMP	Cross – Functional Platform
CPP	Critical Peak Pricing
CRM	Capacity Remuneration Mechanism
DER	Distributed Energy Resources
DG	Distributed Generation
DNOs	Distribution Network Operators
DR	Demand Response
DRMS	Demand Response Management System
DSR	Demand Side Response
EIIS	Energy Integrated Information System
EMCS	Energy Management and Control System
ESCO	Energy Service Company
ESS	Energy Storage System
EV	Electric Vehicle
FOMC	Optimized Management Cockpit
GHG	Greenhouse Gas
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HANs	Home Area Networks
HMI	Human Machine Interface
HMIs	Hazardous Materials Identification Systems
HTSO	Hellenic Transmission Systems Operator
HVAC	Heating, Ventilation and Air-Conditioning
ICT	Information and Communication Technologies
IoT	Internet of Things
LCOE	Levelized Cost Of Electricity
LTE	Long-Term Evolution
MDMS	Meter Data Management System
MG	Micro Grid
MV	Medium Voltage

NAN	Neighborhood Area Network
NB-PLC	Narrowband Power Line Communications
NEMO	Nominated Electricity Market Operator
NZEB	Nearly Zero Energy Buildings
OPF	Optimal Power Flow
PLC	Power Line Communications
PVs	Photovoltaic Systems
RAE	Regulatory Authority of Energy
RES	Renewable Energy Systems
RF	Radio Frequency
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SMP	System Marginal Price
SoC	State of Charge
STOR	Short Term Operating Response
ToU	Time of Use
TSO	Transmission Systems Operator
UCY	University of Cyprus
UMTS	Universal Mobile Telecommunications System
VES	Virtual Energy Storage
WAN	Wide Area Network
WG	Wind Generator

1. Introduction

1.1 Scope and objectives of the deliverable

In this report the survey of all inteGRIDy pilots, Isle of Wight, Terni, San Severino, Barcelona, St Jean, Nicosia, Lisboa, Xanthi, Ploiesti and Thessaloniki is carried out.

The main target of this report is to give readers information about the area of each pilot, its architecture, goals and use cases regarding to each pilot's pillars, with the final objective to present a cross analysis of the different Pilots Use Cases, aiming to provide support to the following Work Packages of the inteGRIDy project.

1.2 Structure of the deliverable

Actually, inteGRIDy project is based on ten Pilots, six of them (Isle of Wight, Terni, San Severino Marche, Barcelona, St-Jean, Nicosia) are classified as Large scale Pilots, while the others are classified as small scale Pilots; in the following a short introduction for each one of them is provided.

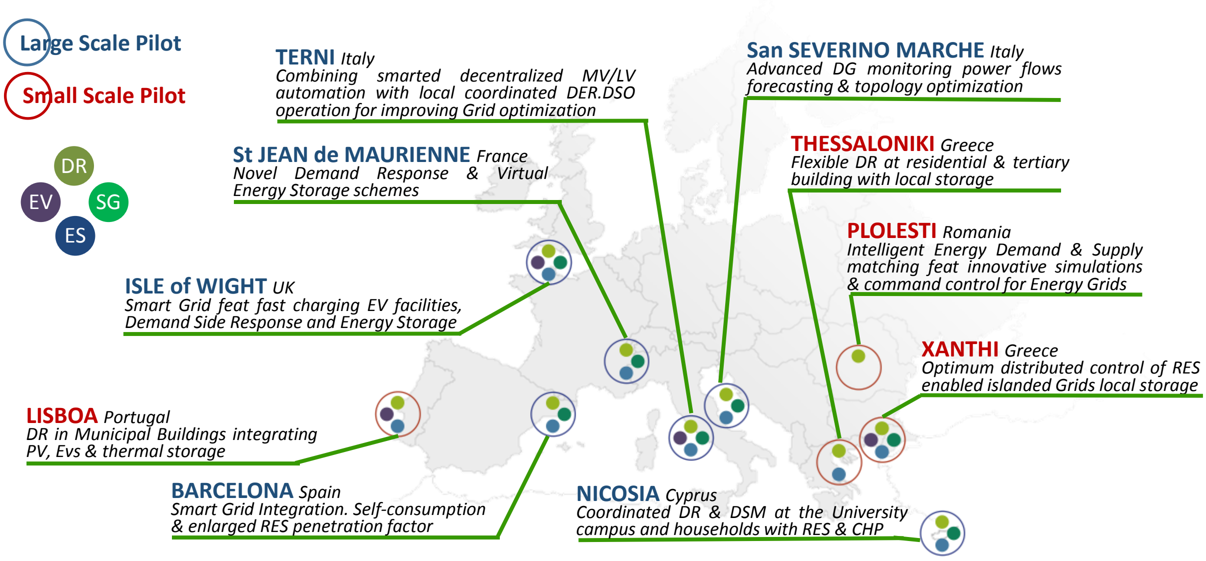

Figure 1. inteGRIDy pilots.

The **Isle of Wight Pilot** is located off the south coast of Great Britain. It has the opportunity to grow high tech businesses and has identified the potential for the Island to be a base for research and development in renewable energy technologies. This pilot is based on all the four inteGRIDy pillars: Demand Side Management, Energy Storage, Smart Grid and Electrical Vehicle Integration.

The **Terni Pilot** is located in Central Italy, as rural microgrid, the largest opportunity is in providing higher electric service reliability and better power quality to the end customers. Microgrid can also provide additional benefits to the local utility. This pilot is based on all four inteGRIDy pillars: Demand Side Management, Energy Storage, Smart Grid and Electrical Vehicle Integration.

The **San Severino Pilot** project is related to the distribution grid of San Severino Marche which is managed by the local distribution system operator A.S.S.E.M. SpA. The area is particularly suitable for a pilot to investigate the effective management of the Dispersed Generation and the maximisation of the grid's hosting capacity. This pilot is based on 3 pillars which include Demand Side Management, Energy Storage and Smart Grid.

The **Barcelona Pilot** is the Spanish demonstration site placed in Barcelona. It is a sport centre, which is being currently refurbished under energy efficiency criteria as part of the

GrowSmarter project. This pilot is based on 3 pillars: Demand Side Management, Energy Storage and Smart Grid.

The **St Jean Pilot** has to face with the issues related to the exploitation of the renewables sources already available on the grid, which require the adoption of Demand Response strategies to achieve a better balancing between production and consumption for the different patterns of demand depending on the season's periods considered. This pilot is based on 3 pillars: Demand Side Management, Energy Storage and Smart Grid.

The **Nicosia Pilot** in Cyprus will test two different pilot cases. The first one regards the microgrid within the campus of University of Cyprus (in Nicosia city), while the second one regards dispersed prosumers within the Cyprus island. This pilot is based on the 3 pillars concerning Demand Side Management, Energy Storage and Smart Grid.

The **Lisboa Pilot** is at Campo Grande 25, a 5-block building, where most administrative part of the Municipality work is performed. Around 2,000 people work there every day and many others are visiting the building. A fleet of around 60 electric vehicles is charged in this building in 2 charging stations. This pilot is based on 3 different pillars of Demand Side Management, Energy Storage and Electrical Vehicle Integration.

The **Xanthi Pilot** deals with the case of isolated small scale smart grid networks with local energy storage options where RES is the main source of power. This pilot is based on 4 pillars, Demand Side Management, Energy Storage, Smart Grid and Electrical Vehicle Integration.

The **Ploiesti Pilot** is based on Building Type Intelligent Energy Demand and Supply Matching feat innovative simulation and command-control for energy grids. It consists of three buildings with residential apartments in Ploiesti, the Prahova County seat, in Romania. This pilot is focused on the Demand Side Management pillar.

The **Thessaloniki Pilot** will mainly focus on the demonstration and assessment of different Demand Response techniques and the sustainability of related business models offered from a Utility/ESCO company to residential consumers (not prosumers) and commercial customers. This pilot is based on 2 pillars: Demand Side Management and Smart Grid.

Notably, this report is structured in 12 chapters with Chapter 1 providing some information regarding the objective of this deliverable and its structure; moreover, a brief introduction of each pilot and the main discussed pillars in each of them is reported. From Chapter 2 to Chapter 11 inteGRIDy Pilots are described, while Chapter 12 provides a first Pilots cross evaluation, elaborating their similarities, weaknesses and strengths. General conclusion is eventually provided.

1.3 Relation to Other Tasks and Deliverables

Use Cases are described referring to the four pillars the inteGRIDy project is based on: Demand Response, Smartening the Distribution Grid, Energy Storage, Smart Integration of grid users from Transport. Actually, this is the first description of the inteGRIDy Use Cases, consequently the aim of this report is to drive the partnership to adopt a common view and a common approach. Next Tasks, in particular Task 1.5, will provide a deeper Use Cases investigation. This work will be also continued on WP4, where inteGRIDy's Cross Modular Platform is defined.

Moreover, a preliminary description of the Regulatory Framework, of the technology bounds and of the business models is reported in order to provide a proper contextualization of the Pilots. Eventually, Pilots' replicability is discussed. On the former case, this contribution will be further continued through WP2 deliverables. On the latter case, WP3 will subsequently work on business models.

2.Survey on the Isle of Wight Pilot

2.1 Pilot Area Description

A. Area and Geographical Overview

The Isle of Wight is located off the south coast of Great Britain. It has a population of 139,000 and 70,000 residential properties. 64% of these properties are in urban areas (towns) and 36% are in rural areas (villages, hamlets and isolated properties).

Figure 2. Isle of Wight geographical location

The Isle of Wight, like other seaside areas, is a popular retirement destination. There is a net outflow of 15 to 29 year olds as young people leave for higher education and career opportunities, and a net inflow at age 50 to 79 as older people retire to the Island.

The Island is home to some 4,500 businesses. Most of these are small, but there are also some large, world class organisations in the aerospace, clean tech, marine and advanced manufacturing sectors such as BAE Systems, GKN, MHI Vestas and Gurit. Tourism is an important economic sector and the Island is a global centre for yachting. Employment on the Island in 2013 was 50,900 jobs, approximately 40% of which are part-time roles The Island currently has lower productivity, lower skill levels and less high value employment compared to the rest of England.

The Island's electrical demand typically varies between a minimum of approximately 40 MW and a maximum of approximately 140 MW, which normally results in the Isle of Wight importing electrical power from the mainland. The power supply comes from a primary substation at Fawley, via an intermediate substation at Langley, by three 132 kV circuits. Each of the three 132 kV circuits comprises a submarine cable section beneath the Solent, with an underground cable section on the Isle of Wight and an overhead line section on the mainland. Each of the three circuits is rated at 124 MVA (winter) / 99 MVA (summer). All three circuits are normally in service, and the 132 kV system normally operates with all elements interconnected.

Primary power distribution on the Isle of Wight is effected at 33 kV, via ten primary substations and an associated distribution network comprising predominantly overhead lines in rural areas and on the outskirts of built-up areas, with a small extent of underground cabling to terminal connections located within built-up areas. Additionally, there are three further substations under Network Rail ownership, supplying the Island's electrical traction railway system from the 33kV network. The Island's 33 kV network is supplied from Wootton Common 132 kV / 33 kV substation and from East Cowes 132 kV / 33 kV substation, with an additional contribution from numerous distributed generation projects, including the Arreton combined heat and power plant (22 MW), 13 solar farms (0.6-9.2 MW), an AD plant (1.1 MW), gasification waste-to-energy plant (2.3 MW) and landfill gas scheme (2 MW). There is also a large (140 MW) oil-fired power station at East Cowes, which operates as a Short-Term Operating Response (STOR) facility for mainland demand.

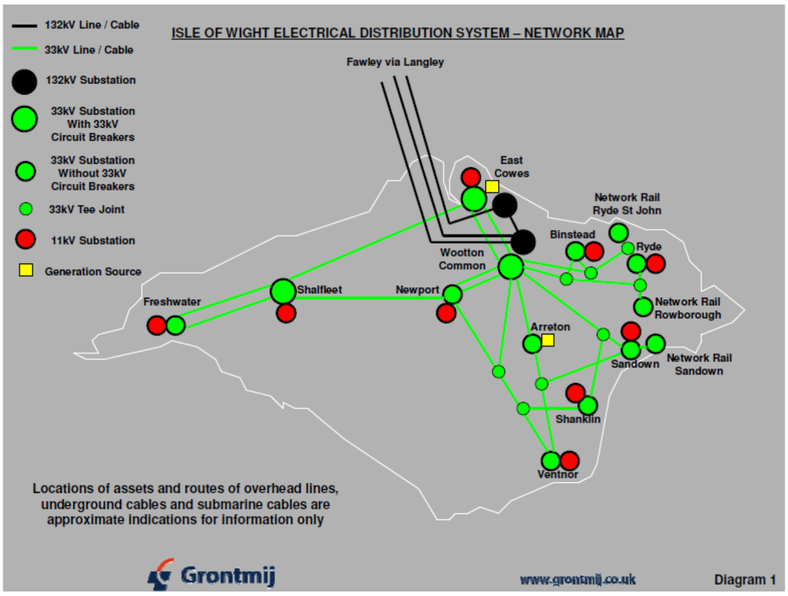

Figure 3. Isle of Wight electrical distribution system map

With the exception of Wootton Common substation and the three Network Rail Substations, 33 kV / 11 kV transformers and 11 kV distribution switchboards are located at all of the remaining 33 kV substation sites, serving the local 11 kV distribution systems via overhead lines and underground cables.

B. Needs and Opportunities

There has been a high penetration of distributed generation on the Island with, on occasions, reverse power flows which trigger thermal constraints on sections of the interconnectors between the Island and the mainland. Over an annual cycle, generation (both planned and implemented) is approximately 35% of total demand, suggesting that load shifting will be a powerful tool to overcome the constraints on generation and allow the Island to move closer to its stated aim of self-sufficiency in electricity from renewable sources.

Table 1. Opportunities and needs of Isle of Wight pilot

Opportunities	Needs
RES (PV, biomass, waste, tidal) availability in the area	A full exploitation of renewables in the area requires an optimal management of the distribution grid to maximise the Hosting Capacity i.e. the capacity to host new generation without curtailment, whilst maintaining system reliability, security and quality of service.
Final user participation to the ancillary market	Technological and regulatory developments to allow the full participation of small and medium scale users in the ancillary market so that they can benefit financially from the opportunities. This contributes to the development of community energy solutions.
Properly exploit energy storage options	Appropriate energy storage solutions – both in terms of size and technology – to be identified as part of a smart grid architecture. Storage solutions to contribute to load balancing, with new commercial models developed to simplify the connection of stand-alone and behind-the-meter storage systems.

Enable further market penetration of EVs	EVs to benefit from lower energy tariffs through price-responsive charging and to help maintain a secure and stable grid through DSR (Demand Side Response) signalling.

2.2 Context of the Architecture Proposed

The Isle of Wight pilot has developed four different architecture descriptions representing the aspects that the project will address.

A. Demand Response

In the Isle of Wight pilot, the demand response aspect is addressed through the deployment of an "Advanced Building Response" system, a multi-layered suite of applications which allow energy reduction, peak management and flexibility management within industrial and commercial buildings.

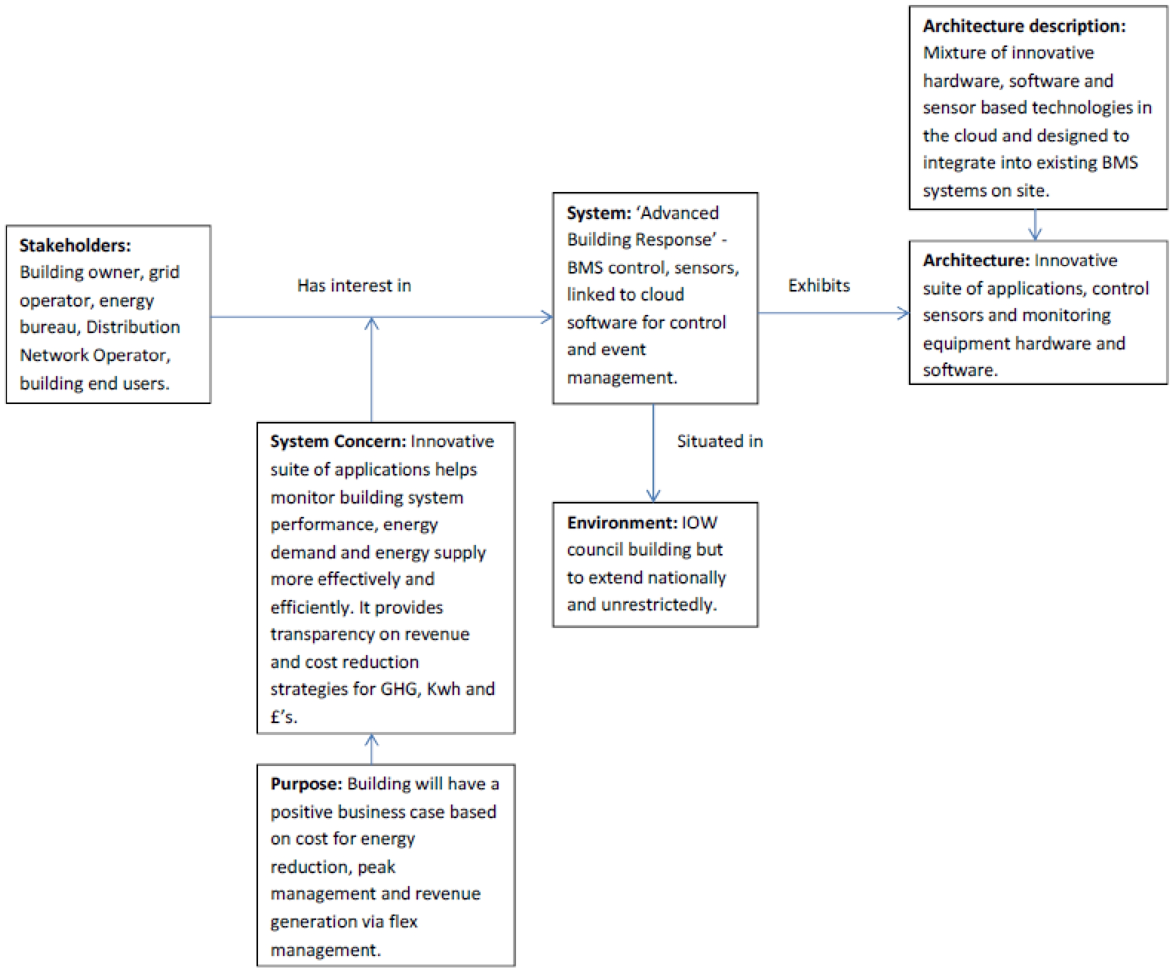

Figure 4. Isle of Wight. Demand Response architecture

Table 2. Isle of Wight. Demand Response architecture description

IEEE 42010 components definition	Description
System	The system provides Advanced Building Response through BMS control and sensors linked to cloud software for control and event

	management.
Environment	The environment will initially be a small number of large commercial buildings on the Isle of Wight.
Stakeholder	Building owners and grid operators are the primary stakeholders at this stage.
Purpose	The main purpose of this activity is to provide a positive business case for DSR.
System Concern	The system provides transparency on revenue and cost reduction strategies for GHG, consumption (kWh) and cost (£).
Architecture	Innovative suite of applications, control sensors, monitoring equipment hardware and software.
Architecture Description	Innovative mixture of hardware, software and sensor-based technologies designed to integrate into existing BMS.

B. Smartening the Distribution Grid

Smartening the grid requires an Island-wide solution which identifies and overcomes thermal, voltage and frequency constraints to new low carbon generation. It proposes and defines new infrastructure and smart service solutions, including load shifting, which will allow the local distribution network to accommodate a larger capacity of renewable generation through a combination of storage solutions and DSR.

Table 3. Isle of Wight. Smartening the Distribution Grid architecture description

IEEE 42010 components definition	Description
System	The system is a model, based on current network data and forecasting, which analyses the effects on network constraints and security of smart grid components and services.
Environment	This is a simulation environment for multi-purpose scenarios.
Stakeholder	The local public authority (Isle of Wight Council), Network Operator, generators and those providing storage infrastructure and DSR services.
Purpose	The main purpose of this activity is to model and therefore help to implement a range of load shifting components so that the area can maximise the local use of generation and traditional reinforcement costs are minimised.
System concern	Appropriate representation of network constraints and capacities, forecasting of future load.
Architecture	Power system simulation environment.
Architecture description	A flexible power system model which considers flow, capacities and constraints. It uses current and predicted network data and contributes to a Constraints Tool which predicts the curtailment of future generation capacity due to network constraints.

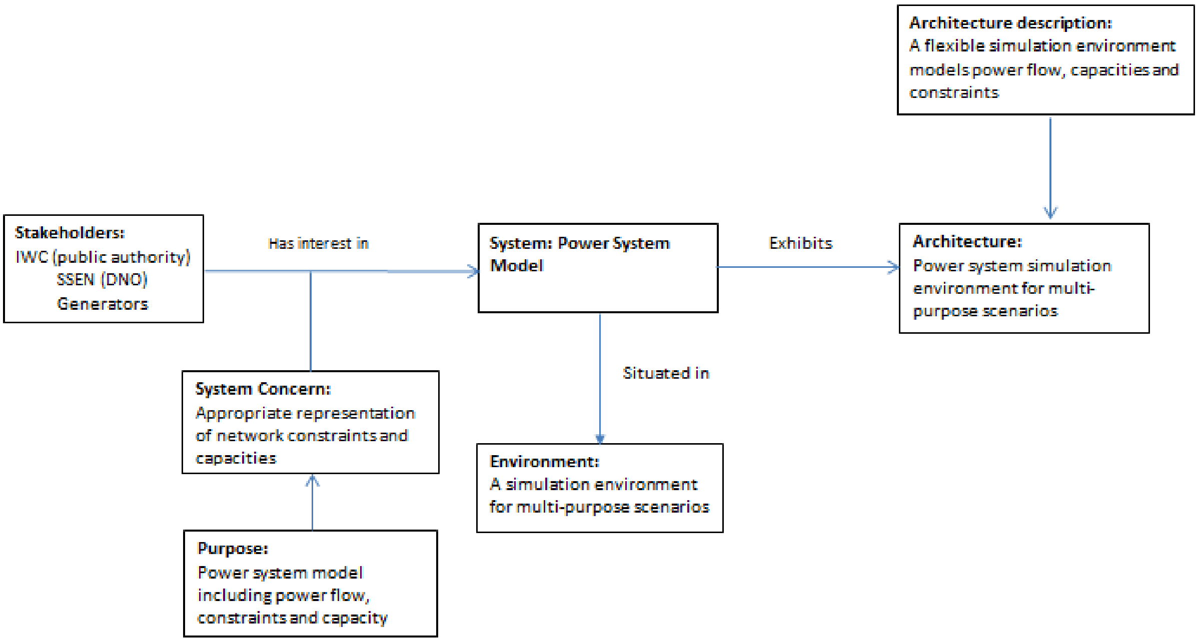

Figure 5. Isle of Wight. Smartening the Distribution Grid system architecture

C. Energy Storage Technologies

Energy storage will be achieved through a domestic heating system which charges a hot water storage tank through solar collectors or at times when grid electricity is cheap and has the capability to reduce load on the network during peak consumption.

Table 4. Isle of Wight. Energy Storage Technologies architecture description

IEEE 42010 components definition	Description
System	The system is a heat pump and thermal store with DSR capability.
Environment	The system will be installed in residential properties in the social housing sector.
Stakeholder	Stakeholders are the property owners, residents (owner-occupiers or tenants), the energy supplier and the network operator.
Purpose	The purpose of the demonstration is to manage the use of the heat pump and thermal store to reduce the cost of grid electricity.
System Concern	Combining a network of residential properties through a central hub to demonstrate the potential for aggregated DSR and flexibility services.
Architecture	Heat pump, thermal store and grid interface, with possible integration of PV in some cases.
Architecture description	Solar thermal energy provision via a large thermal store, controlled by a heat pump and grid command.

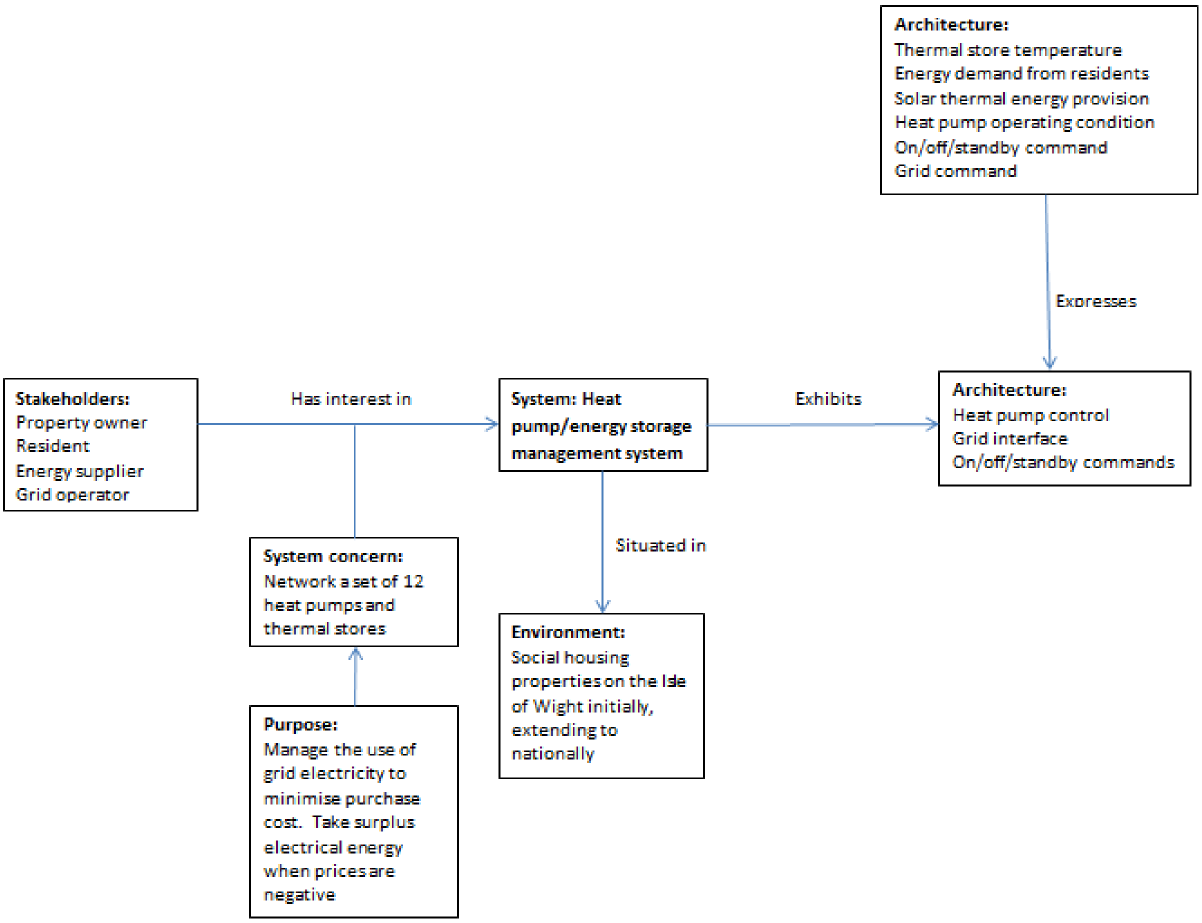

Figure 6. Isle of Wight. Energy Storage Technologies system architecture

D. Smart Integration of Grid Users from Transport

The Isle of Wight pilot will demonstrate an EV charging system which also has the capability to provide energy storage and power control operation to perform DSR, peak shaving and UPS functionality.

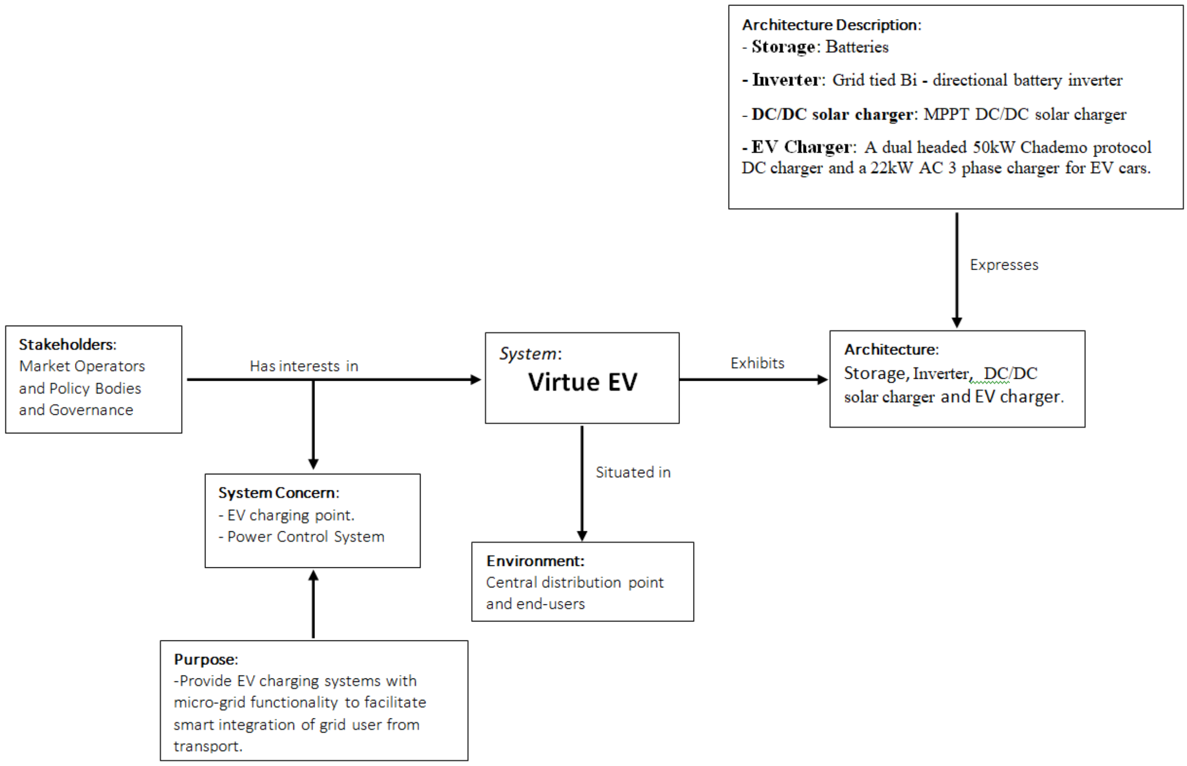

Figure 7. Isle of Wight. Smart Integration of Grid Users from Transport system architecture

Table 5. Isle of Wight. Smart Integration of Grid Users from Transport architecture description

IEEE 42010 components definition	Description
System	This system (Virtue EV) is an innovatively new energy platform that provides EV charging functionality with Energy storage and power control operation. The EV charger comes with two modes that include fast and rapid charging.
Environment	The main environmental factor that has impact on the system includes central distribution points and final end-users.
Stakeholder	The primary stakeholders of the system are Market operators (British Telecom). Policy Bodies and Governance (Isle of Wight council) also are interested in this pilot's aspect.
Purpose	The main purpose of this action is to provide charging point for EV vehicles (including rapid charging). The system targets also the integration of renewable energy generation in the form of solar system. This would be able to forecast and control renewable energy. The complete system would then provide microgrid functionality (perform DSR, peak shaving and provide UPS functionality) to the end-user.
System concern	EV charging point: a standalone system will be implemented to provide rapid and fast EV charging point. Power Control System: the ability of using smart control systems (SCADA) to provide Power Control, including solar energy generation

	and energy storage, will be observed.
Architecture	Storage, Inverter, DC/DC solar charger and EV charger in order to provide smart integration of grid user from transport.
Architecture description	**Storage**: NMC battery rack with in-built active balancing rack and module BMS to provide storage. This also aid in energy control and system management. **Inverter**: Grid tied bidirectional battery inverter which would facilitate the charging and discharging of Batteries. **DC/DC solar charger**: MPPT DC/DC solar charger to integrate renewable energy generation (solar energy generation system). **EV Charger**: A dual headed 50 kW Chademo protocol DC charger and a 22kW AC 3 phase charger for EV cars. This would provide fast and rapid changing modes.

2.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The Isle of Wight has an objective to be self-sufficient in electricity produced from local renewable energy sources. This will require an installed RES capacity of approximately 170 MW, supplying over 540 GWh per year. To date, approximately 80 MW has been installed, but the Island is now subject to a grid constraint caused by the large amount of Distributed Generation.

To combat this, the Distribution Network Operator (DNO), Scottish & Southern Electricity Networks (SSEN), has installed an Active Network Management (ANM) system and plans reinforcements to the 132 kV network in 2017. However, the solutions add cost and complexity, with impacts on the economy and environmental targets. Further reinforcement through an additional interconnector is costly and potentially unachievable.

The Isle of Wight pilot will investigate and demonstrate alternative solutions through a combination of modelling, technology demonstration and the development of business propositions to deliver an optimum smart gird architecture. It will have a focus on maximising community benefit through both investment opportunities and new models for community-led DSR delivery.

The Isle of Wight Council (IWC) will coordinate local actions and stakeholders for the duration of the pilot and will work with the DNO on the provision of data, legal and commercial issues for smart grid integration and the development a solution which provides optimum value. The University of Newcastle Upon Tyne (UNEW) will produce the Power Systems Model including current energy flows, constraints on generation and load, modelling future scenarios for RES generation and electrification of heating and transport, identifying future bottlenecks and capacity requirements. They will also produce a Constraints Tool for generation project developers. Minus 7 Ltd (M7) will demonstrate grid optimisation with balancing elements of its zero-carbon home heating system through a field trial in 12 properties to test the technical and commercial application of the system. EMS (UK) Ltd (EMS) will work with BT Fleet to trial 15 units of its Electric Vehicle Charger and storage system. Siemens (SIE) will install its Advanced Building Response system in at least one large public building to demonstrate its functionality and potential cost savings. AT Kearney (ATK) will undertake business modelling for an aggregation/grid balancing service focused on community ownership issues, commercial opportunities and regulatory barriers.

B. Use Cases

- Demand Response

Demand Side Response (DSR) will be demonstrated through an Advanced Building Response system, a collection of software applications which optimise BMS and facilitate peak and flexibility management.

Table 6. Isle of Wight. Use Case IOW_UC01

USE CASE: Demand Response	
ID	IOW_UC01
Name	Building optimisation to maximise efficiency and demand flexibility, minimise costs and reduce environmental impact across the enterprise.
Storyline	Building will have a positive business case based on cost for energy reduction, peak management and revenue generation via flex management.
Goal(s)	Innovative suite of applications helps monitor building system performance, energy demand and energy supply more effectively and efficiently. It provides transparency on revenue and cost reduction strategies for GHG, kWh and £'s.
Actors	Building owner, grid operator, energy bureau, Distribution Network Operator, building end users.
Preconditions	Building BMS control access and associated asset reprogramming granted. Various event lead interruption or load control requests are initiated and live data receivable.
Postconditions	Ongoing maintenance and improvement is based on lower cost to serve, lower overall consumption, load curve flattening and flexibility for revenue generation contract agreed with various actors.
Trigger events	N2EX, OTC, Building owner, grid operator, energy bureau, Distribution Network Operator.

- Smartening the Distribution Grid

Smartening the Distribution Grid is an area-wide approach which aims to design an optimal smart grid architecture for the Island at full DG capacity and compare the costs and effects of this, including return on investment, with traditional reinforcement through a new interconnector. The proposed smart grid architecture will include energy storage systems (ESS) and demand side response (DSR). ESS and DSR will be used for minimising the net import/export of the Island through the interconnector and also take into consideration of power flow and voltage constraints. The use of ESS, DSR and other smart grid technologies and techniques can also increase the rating of DG connected to the distribution network and avoid or delay network reinforcement. A full simulation model of the Island's power system will be developed, allowing the evaluation of various demand and generation scenarios and designing a "virtual" power plant based on the overall energy balance at the network.

Table 7. Isle of Wight. Use Case IOW_UC02

USE CASE: Smartening the Distribution Grid	
ID	IOW_UC02
Name	Smartening the distribution grid.
Storyline	Design a smart grid architecture for the Isle of Wight distribution network to minimise energy import/export with respect to network power flow and voltage constraints.
Goal(s)	Minimise energy import and export to realise self-sufficient supply of electricity on Isle of Wight.
Actors	DNO, ESS owner/operator, DSR enabled customers.
Preconditions	Modelling of the electrical network, DG and demand. Identify areas in the network where constraints are likely to be violated. Identify potential DG connection capacity.
Postconditions	Self-sufficient in electricity supply.
Trigger events	N/A

- Energy Storage Technologies

Heat storage options at residential level will be explored through the retrofitting of an electrically-powered thermal store to produce zero carbon dwellings. The development and optimisation of Control Hubs will allow the monitoring, control and aggregation of properties to provide grid balancing services.

Table 8. Isle of Wight. Use Case IOW_UC03

USE CASE: Energy Storage Technologies	
ID	IOW_UC03
Name	Minus 7 Energy Storage System.
Storyline	Install a set of proven low carbon technologies which, when deployed at scale, provide demand modulated heat and power to residential properties.
Goal(s)	Integration of multiple heat pumps, thermal stores, optional PV generation and possible electrical storage into an energy system with a single ‘entry point’ to the distribution network.
Actors	Residents, property owners (including Housing Associations), DNO.
Preconditions	Retrofitting of system at 12 sites. Resident involvement in DSR events. Development of Control Hub functionality. Selection of energy optimiser.

Postconditions	Virtual power plant topology capable of peak shaving and network balancing. Reduced utility bills for residents.
Trigger events	Resident heat demand, thermal store temperature, network signals.

- Smart Integration of Grid Users from Transport

The smart integration of transport will be evaluated through the energy management methods of the EV charging solution which stores energy in batteries to provide rapid charging on demand. The system also offers grid balancing solutions through the ability to provide flexibility in DSR and, in the case of the EV charging unit, returning power to the grid at peak network demand.

Table 9. Isle of Wight. Use Case IOW_UC04

USE CASE: Smart Integration of Grid Users from Transport	
ID	IOW_UC04
Name	Transport Smart Integration of Virtue EV charging systems.
Storyline	With an increasing need to integrate EV in order to promote zero carbon emission, British Telecom (BT) required rapid charging systems without increasing any network capacity. BT consulted EMS in order to deploy their Virtue EV technology to mitigate this demand and promote zero carbon energy usage.
Goal(s)	Evaluate the energy management methods to the EV charging solution which stores energy in batteries to provide rapid charging on demand without increasing network capacity of the end-user.
Actors	Market Operators, System Operators, Policy. Bodies and Governance.
Preconditions	The entire system must go through the necessary processes (e.g. electrical standards approval) for obtaining standards for public and commercial implementation in the global market (e.g. the European market). 15 Virtue EV systems based at BT Exchanges serving entire BT fleet and available for public use by EMS (UK) Ltd. Integration of renewable energy generation in the form of solar system to be combined with the storage system in order to provide microgrid functionality.
Postconditions	Displaying the system capability to provide on demand EV rapid charging by utilising stored energy on battery to reduce the amount of energy pulled from the grid during the event. Offer grid balancing solutions through the ability to provide flexibility in DSR, UPS and peak shaving functionality.
Trigger events	Once system is fully designed and installed, continuous smooth running will be provided.

2.4 Regulatory Framework

The role of DSR is changing, as a concept it has been established previously as a (reasonably) predictable means of delivering balancing services and avoiding network constraints either on a time or location basis. In other words, if peak loadings are predicted due to established load profiles or due to localised constraints then in line with pre-agreed contractual arrangements, DSR services can be called upon to ameliorate these events. This has worked well until now, but this is still living in the old paradigm of centralised generation, single direction flow and without much consideration of the changes brought about by the inexorable shift towards Smart Grids.

Distributed Generation (Embedded Generation) is already bringing major changes to the electricity flows at the distribution level and this ripples up into the transmission system as unpredictable changes to demand requirement. In future, predicted growth in electrification of heating and mobility may additionally bring further changes to flows and demand. These changes will not be easily predictable, particularly at the distribution level, and may not provide the luxury of hours or even minutes of warning to permit current 'Dispatch Notice' practice to be applied. In terms of renewable embedded generation, and assuming this to mean either wind power or solar PV generation, then there seem to be two distinctly different profiles, wind power fluctuating with lower rates of change in output over a 24-hour day – and meteorological data being developed that is capable of reasonably predicting these changes in output – compared to Solar PV with a defined curve between dawn and dusk, but suffering from rapid changes in output due to cloud cover. DSR measures can potentially be used to counter both of these profiles, but different approaches are needed, in fact wind generation could probably be managed using the 'DSR service requirement' of DNO (pre-fault dynamic) with dispatch notice times of between ½ and 4 hours and a 2 to 4-hour duration. However, the need to meet the challenge of increasing PV generation should drive a review of the whole DSR service requirement model and hence possibly during this process a better service could be developed for both wind and PV embedded generation matching.

Also, current DSR models tend to consider load reduction and/or standby generator operation to meet contractual requirements, while not implicitly stated it seems to be generally accepted that standby generation will be delivered from diesel generators or similar. In future, the ability to both sink and source power through load and generation management will increase and in these terms an electrical energy storage system could play a valuable part in meeting the more dynamic fluctuations that may occur on the distribution network. The alignment and asset sharing paths appear to be a good reflection of how DSR can be managed between two parties – Network Operator and System Operator - and are a good start point for the development of DSR to meet more flexible requirements. As to how an ESCO or perhaps residential aggregator might respond to this is less certain; they might have their own requirements for the DSR resource, but provided these can be met without affecting the contracted service requirement of the pathway model – and are not specifically excluded by the shared service framework – then this may not be an issue.

OFGEM is the UK regulator for gas and electricity markets. The regulation of DSR is enabled through Licence Condition C16(1) which includes the following requirements:

- C16 1(g) Ensuring the procurement of balancing services is transparent
- C16 1(h) Ensuring that the technical requirements of balancing services do not restrict new and existing balancing service providers from competing in those services
- C16 1(i) Anticipating future national electricity transmission system requirements by using and developing competitive approaches to procuring balancing services wherever this is in the best interests of current and future consumers
- C16 1(e) Publishing information which the licensee holds to enable electricity market participants to make efficient operational and investment decisions

- C16 1(i) Anticipating future national electricity transmission system requirements by using and developing competitive approaches to procuring balancing services wherever this is in the best interests of current and future consumers

In July 2017, OFGEM published a Working Paper on the Future Regulatory Framework for System Operators which requires the SO to carry out a detailed analysis of whole system needs to derive an optimal performance strategy for balancing and ancillary services. This will be implemented from April 2018.

Also in July 2017, National Grid published its “Future of Balancing Services” consultation which seeks to simplify the market for balancing services and ensure a level playing field for providers. Further information is available at [NGR17].

In the UK, energy storage is not currently recognised as either an activity or an asset class. The absence of a regulatory definition of energy storage has led to its classification as a generation asset. Generation assets have a very broad definition in the Electricity Act 1989 as “the generation of electricity at a relevant place”, and EU Directive 2009/72/EC similarly refers to generation as “assets that produce electricity”. The Electricity Order 2001 expands on these definitions by stating that the technology “generates or is capable of generating electricity”. Energy storage technologies can generate electricity so are undoubtedly described in the most literal sense by these broad definitions. However, energy storage cannot generate a net positive flow of electricity to the system, and classification as generation does not recognise the potential contribution of storage to moving electricity from periods of low demand to meet peak demands. A new definition that differentiated storage from generation would facilitate the removal of barriers to the deployment of storage by treating it as an integral part of the electricity system. Actually, the way in which storage is treated under the Climate Change Levy (CCL) framework remains unclear. The CCL is an energy tax aimed at energy consumed by commercial and industrial users. Renewable technologies and electricity derived from renewable generation qualify for an exemption from this levy via Levy Exempt Certificates (LECs). This statutory instrument requires the renewable-derived electricity to be calculated at the point where electricity is delivered from generation to a UK distribution or transmission system. However, if export of electricity from a storage device relies on the import of electricity (from a LEC-owning generator) and then the export of this electricity, the issuing of a new LEC at the point of export (since storage is considered a generator) implies a double LEC. Therefore, it could be argued that storage should not be eligible for LECs, which currently represents a considerable barrier to the optimal deployment of storage resources.

Similarly, the UK’s Climate Change Act and commitment to Carbon Budgets has set a strong environmental framework that requires an ambitious shift in transport technology towards ultra-low carbon alternatives. As set out in the UK Automotive Council’s technology roadmap, the UK Government recognises that in the future there will be a portfolio of low emission technologies for different transport applications – including plug-in vehicles, hydrogen fuel cells, sustainable biofuels and ultra-efficient internal combustion engines. The UK Government is taking an integrated and pragmatic approach to lay robust foundations now that will support continuing market growth in the years ahead through grants to reduce the upfront cost of eligible vehicles, a favourable tax regime, capital grants for recharging infrastructure and support for low and ultra-low carbon vehicle research, development and demonstration.

2.5 Technology Bounds

The Isle of Wight Pilot will install low carbon technologies, provided by Minus 7, EMS (UK) and Siemens.

In multiple properties, the heat pumps, thermal stores, optional PV generation and possible electrical storage will be integrated into a single energy system with a single 'entry point' to the national grid. The solution (provided by Minus 7) will be deployed over 12 sites, which is sufficient scale to test the DSM potential. The key innovation is to integrate a network of PV, solar thermal, heat pump, immersion heaters, thermal storage, and electrical storage into a single entity (illustrated above) that minimises grid impact, while providing a seamless energy service to residents. To deliver this innovation requires the remote control and management of individual and networked heat pumps to allow an interface with an energy optimiser. The DSM hub will manage the PV systems to maximise on site use and minimise the demand on the grid from the network of thermal stores/heat pumps.

The Minus 7 solution has a single control system that manages heat delivery to the building and the operation of heat pump in relation to heat contribution from the roof. The control system is entirely proprietary and bounded within the Minus 7 system. The remote operation of the heat pump will therefore be proprietary. However, there is no reason why the approach could not be applied to all heat pump based technologies. Minus 7 have been working with third party utilities to enable them to control the heat pumps; in these instances, Minus 7 can provide an optional interface to their system with open protocols. Similarly, Minus 7 are looking to integrate their heat pump with third party batteries and inverters.

The second technology, Virtue EV, is the integration of EMS's energy storage and power control system with rapid and fast EV chargers, within an entirely new energy platform. The hardware of the system includes a 10 kW MPPT DC/DC solar charger, a 50 kW high efficiency bidirectional battery inverter (PCS), an 80 kWh NMC battery rack with inbuilt active balancing and BMS, a 50 kW modular rapid charging unit and an 11 kW fast charger. The hardware has been tested independently both in operation within the Virtue product (batteries and bidirectional inverter), and separate test beds within the EMS facility. The hardware has also been tested together under basic operations, such as utilising the storage (via the PCS) to inject fixed portions of battery power in parallel with the mains, in order to offset the chargers reliance on the grid (e.g. 50% grid energy and 50% battery energy to provide a total of 50 kW to the EV). The Energy Management System is vital to providing reliable revenues, charging times as well as efficient solar/renewable use. Such a universal software solution does not exist in this sector, and currently the challenge is to reliably charge vehicles on a daily basis as well as providing dynamic grid services. There are chargers that integrate renewables currently being developed by companies that already exist on the market, but a fully integrated solution with storage and DSR capabilities does not.

Finally, Siemens' Advanced Building Response system utilises a multilayered hardware, software and communications approach to optimise the energy of commercial and industrial buildings via monetary, energy consumption and greenhouse gas metrics. The pilot on the Isle of Wight will utilise cloud-based energy and sustainability platforms designed to optimise the performance of building(s). It seamlessly integrates complex sources of data from energy procurement, energy consumption, system performance, and sustainability. With this system, Siemens offers numerous possibilities for connecting machines, plants and building equipment fleets digitally, regardless of the manufacturer. This will be a Plug&Play solution that enables the building user to read out data from building assets and pre-process it for transfer to the Siemens 'Advanced Building Response' simply and reliably. The encrypted data is then transferred securely to the cloud, where it is then available for real time automation and analysis.

2.6 Business Model

The detailed investigations of the Isle of Wight power network are expected to support the evaluation of investment options for smart grid hardware by both the DNO and third parties. It is expected that this will include investment in battery storage and hydrogen production, either standalone or integrated with generation projects, as well as new commercial arrangements for DSR and aggregation. A particular focus will be community investment to ensure that the local population benefits from improvements in the power system.

The M7 system offers considerable savings on energy bills for either owner-occupiers or social landlords where they are responsible for the costs of heating the property. Reducing fuel bills has the additional advantage of alleviating fuel poverty which is a strong driver for Government and the social housing sector. The potential addition of the batteries and DSM software would allow participation in the flexibility market providing an additional income stream for residents.

The Virtue EV system will provide several economic benefits to end-users, the DNO and the implementer (owner of the unit). This is due to several basic benefits:

- Grid balancing services, which benefit the end-user, DNO and the owner - utilising energy storage to perform network balancing allows for several economic benefits to both suppliers of energy and consumers, especially businesses. By contributing to frequency and demand balancing utilising assets such as battery storage, will allow the DNO and national grid to reduce their dependency on expensive back-up generation such as peaking plants and diesel generators.
- Reduced installation and implementation cost - Virtue EV provides rapid EV charging in areas that have limited or restricted network (local) capacity. By incorporating localised storage, dependency on the network decreases, which eases the demand strain and consequently reduces the need for network upgrades.
- The proposed solution can allow for free charging, due to the revenues generated through demand response services - the balancing services provided by storage will also benefit the owner of the asset, as they will be able to generate revenue through demand services. In the case with typical energy storage systems the ROI (Return on Investment) is between 3 – 6 years, which is considered a very good investment for a stakeholder. With regards to operating demand services with an integrated charger, the ROI will decrease due to the need for the system to perform functions outside of the standard windows of demand response; however, the return on investment will still be in the region 5 – 8 years. This will allow stakeholders to install charging stations without needing to charge clients for charging their vehicles or at least reduce the cost of utilising the chargers, which will benefit EV users.
- Renewable integration and associated CO2 savings – through the wider use of renewable energy sources for EV charging and reduced dependency of fossil fuels for transport.

The Siemens system will have a positive business case based on reduced energy costs, peak management and revenue generation through flexibility management. By generating a reliable day ahead and intraday forecast of building demand and supply, the building owner is able to access new revenue streams which were previously unavailable in the N2EX (Nord Pool Spot Market) markets. Additionally, balancing day ahead with real time SPOT prices could enable the building owner to further reduce their electricity bills.

2.7 Replicability/Impact of the Pilot

The process for developing of a smart grid architecture for the Isle of Wight, based on local data and complex modelling, can be replicated throughout the project area. This will enhance the transition to smart power systems through providing the business case for investment based on the identified opportunity and the operability of the inteGRIDy platform. Furthermore, the Constraints Tool being developed in the Pilot will provide a template for third party calculation of potential curtailment in constrained areas.

The Isle of Wight Pilot will pay particular attention to the technologies that are being demonstrated locally to form an understanding of their impact on the power system if the number of installations were expanded considerably.

Although the finished EMS system will be unique to the market, hardware within the system can be replicated. There are numerous vendors of battery systems, power conversion systems, rapid chargers and DC/DC converters in the marketplace. The Energy

Management System will be the unique part of the system, entirely owned by Powerstar (which aims to apply for a patent on the EMS as a milestone in the project). This Energy Management System, therefore, cannot be copied, but companies may produce analogous solutions in the future.

The domestic energy architecture proposed, if installed at scale, can play a significant role in reducing carbon emissions from the domestic sector. It also reduces fuel bills for occupiers and this can be further enhanced by the income-earning potential of a DSR-enabled system. Siemens aims to develop solutions which are replicable at scale both within the Isle of Wight, broader UK, Europe and beyond. Besides the ambitious goal to reduce greenhouse gases, lower cost to serve and generate revenue for building owners, a key challenge is to develop the urban system in a resilient and also socio-economic-sustainable way: to find replicable solutions, minimise first mover risks, create innovative business models, speed up the market roll out of technologies and to create jobs. Each innovation deployed will follow an individual way to achieve these goals through the exploitation of both cutting edge technology but also new business models. Through strong performance measurements carried out in partnership with universities and ATK, the lessons learned will be analysed and a blueprint will be developed that can be used by other districts and the follower cities within the consortia. Siemens also aims to develop new modules for existing vendor agnostic BMS systems and retrofitting of older buildings to be able to support the new technologies therein.

For those areas with Community Energy Managers or Community ESCOs, the modelling for community participation and investment in DSR aggregation services will provide useful guidance on investment requirements and risks for similar schemes in other areas, subject to regulatory compliance.

2.8 Miscellaneous

IWC, the Pilot Lead, is a public-sector organization and therefore has a focus on ensuring all residents, especially the more vulnerable, benefit from the smart grid transition. A more efficient and resilient power network has the ability to benefit all through greater security of supply and reduced use of system charges and also reduces constraints on local generation projects in which the community may invest. The Pilot may also identify new investment opportunities for storage, energy conversion and DSR from which the community may benefit and an organization already exists for this purpose.

However, IWC is keen that the work continues to consider disadvantaged consumers to ensure that the benefits of smart grids are widely dispersed to willing participants as well as providing an appropriate level of service to those not able to navigate the new market. Vulnerable consumers should be protected from any negative impacts of DSR tariffs and offers and from the use of smart meter load control switches by DNOs.

3.Survey on the Terni Pilot

3.1 Pilot Area Description

ASM TERNI S.p.A. is an Italian multi-utility company, established in 1960 and fully owned by the Terni municipality, specialised in water, gas, electricity and environmental services. Terni is located in Central Italy (Umbria Region) and counts about 230,000 inhabitants. ASM owns and operates the local power distribution network, covering a surface of 211 km^2 and delivering about 400 GWh to 65,100 customers annually. The ASM distribution network acquires electricity at High Voltage (HV) level through 3 primary substations and supplies electricity to residential and business customers through 60 Medium Voltage (MV) feeders (10 kV to 20 kV) and 700 secondary substations. The peak power is about 70 MW and the overall length of the power lines in the grid is about 2,350 kilometres, of which 587 km at MV level and 1762 km at low voltage (LV) level.

Nowadays the ASM electric grid is characterised by a large number of distributed renewable energy sources embedded in MV and LV distribution networks: 1 biomass plant, 5 hydro power generators and 1,234 solar photovoltaic (PV) units are currently connected directly to the MV and LV distribution networks, reaching an overall installed capacity of about 70 MW. It is worth pointing out that, based on the energy mix, the yearly energy demand is about 380 GWh and 196 GWh are produced by DER systems connected to the MV/LV grid of ASM, of which 26 GWh are from intermittent RES (photovoltaic power plants). The peak power of DER generation is 40 MW.

Terni Pilot is going to be developed on the border between Terni and Rieti municipalities. The pilot site comprises the already existing farm “Il Moggio” and the local energy infrastructures managed by ASM TERNI. A secondary substation is going to be deployed and the necessary HW and SW equipment will be set up in order to monitor and control the microgrid resources. The farm covers an area of 14 hectares, in which 9 buildings are devoted to agricultural and commercial activities (basically primary and tertiary sectors). Closed to the pilot site, there are some important tourist attractions with a high natural and cultural value.

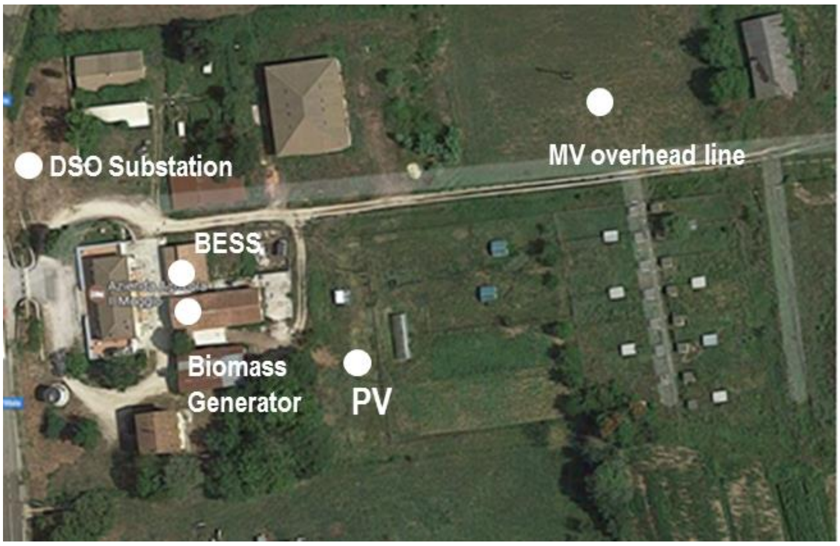

Figure 8. Terni Pilot geographical location

“Il Moggio” farm is at present a stand-alone grid already in operation and represents the pilot site. In accordance with CIGRE definition, Microgrids are electricity distribution systems containing loads and distributed energy resources (such as distributed generators, storage devices, or controllable loads), which can be operated in a controlled, coordinated way either while connected to the main power network or while islanded [CIG12]. This means that “Il

Moggio" microgrid is definitely compliant with this definition, since it comprises a significant amount of distributed generation: a 30 kWp rated PV plant and two 31 kVA – 25 kWt biomass CHP generators. In detail, apart from internal loads due to the agricultural and commercial activities, the generation and energy storage units are as follows:

- The PV power plant is composed of 7 strings; each one has 14 modules (300 W). The PV plant can feed simultaneously both the microgrid load and an electric storage through a static inverter made up of a DC/AC converter, a series-connected transformer and a DC/DC converter.
- Electric storage consists of 50 lead batteries responsible for managing distributed generators without curtailments.
- 2 brushless generators coupled to the network without a static converter, whose fuel is supplied by two gasifiers. They are able to supply fuel for both electrical and thermal uses and require only dry organic materials (as wood chips, walnut shells, agricultural waste) to provide their products and services.

The connection of the "Il Moggio" stand-alone grid to the LV distribution network is under deployment. A secondary substation fed by an existing overhead MV line will be built by ASM. The microgrid will be connected to the DSO monitoring tool, which is basically composed by a SCADA system and a network calculation platform and will be described in detail in the deliverable D1.5, through a communication channel under deployment.

B. Needs and Opportunities

The pilot exploits a rural microgrid and represents a good opportunity in providing higher electric service reliability and better power quality to the end customers. Microgrid can also furnish the local utility with additional benefits by providing dispatchable power to be used in peak load conditions; moreover, there is a benefit also for the DSO related to the possibility to alleviating or postponing distribution system upgrades.

Table 10. Opportunities and needs of Terni Pilot

Opportunities	Needs
RES (Biomass, PV) availability in the rural microgrid	Hardware and Software equipment for monitoring and control of RES resources. Software platform able to dynamically estimate the flexibility of microgrid RES. Deployment of a MV/LV substation for the interconnection of the MG with the distribution network. Smartening the microgrid through the DSO monitoring tool to allow the monitoring and control of microgrid resources by mean of Flexibility Optimized Management Cockpit (FOMC).
Rural microgrid	The rural microgrid needs the deployment of an Energy management system able to dynamically estimate the flexibility of microgrid components, sell flexibility to the DSO through a DR program and managing cooperation in compliance with the internal strategic goals of the microgrid, that are addressed implementing a multi-objective optimisation approach.
EV charging station	A preliminary estimation of the impact of charging stations needs a load forecasting and charging station simulation model DSO needs tools in order to coordinate stations' consumptions, according to the estimated flexibility of the microgrid.

3.2 Context of the Architecture Proposed

Four different architecture descriptions are proposed according to the number of project pillars that have to be addressed in this pilot.

A. Demand Response

The demand response aspect is focused on the definition of a cooperative business model between DSO and rural microgrid owner (local farmer's cooperative), aiming at a technical-economic optimum for both actors. The DSO monitoring tool on DSO side and the Flexibility Optimized Management Cockpit (FOMC) on microgrid side will allow the optimisation of the system. FOMC is a software platform able to dynamically estimate the flexibility of microgrid components, like storage or CHP, sell this flexibility to the DSO and managing this cooperation in compliance with the internal strategic goals of the microgrid. It is the result of the integration and extension of modules (EMS, DSO dashboard, DR Manager) already deployed in previous projects (INGRID [TER01], FINESCE [TER02], GEYSER [TER03]).

Table 11. Terni. Demand Response architecture description

IEEE 42010 components definition	Description
System	In the demand response project pillar, the cooperative business model between DSO and microgrid owner is the system.
Environment	The environment is formed by the Microgrid generators and loads, as well as by the DSO substation.
Stakeholder	DSO and Microgrid owner are stakeholders for this pillar of the pilot.
Purpose	The purpose is to allow the DSO to exploit the microgrid resources, with the constraints of microgrid owner's business operation and energy requirements.
System concern	System concern is the technical-economic optimum of the stakeholders.
Architecture	Cooperative and flexible management of the microgrid in order to support the DSO distribution network and to optimise the microgrid resources (PV plant, storage system, CHP, passive load).
Architecture description	DSO monitoring tool allows measurement acquisition from the microgrid and the distribution network, as well as prediction of generation and load profiles. Automated DR programs access microgrid resources. FOMC optimises and manages the flexibility of the microgrid.

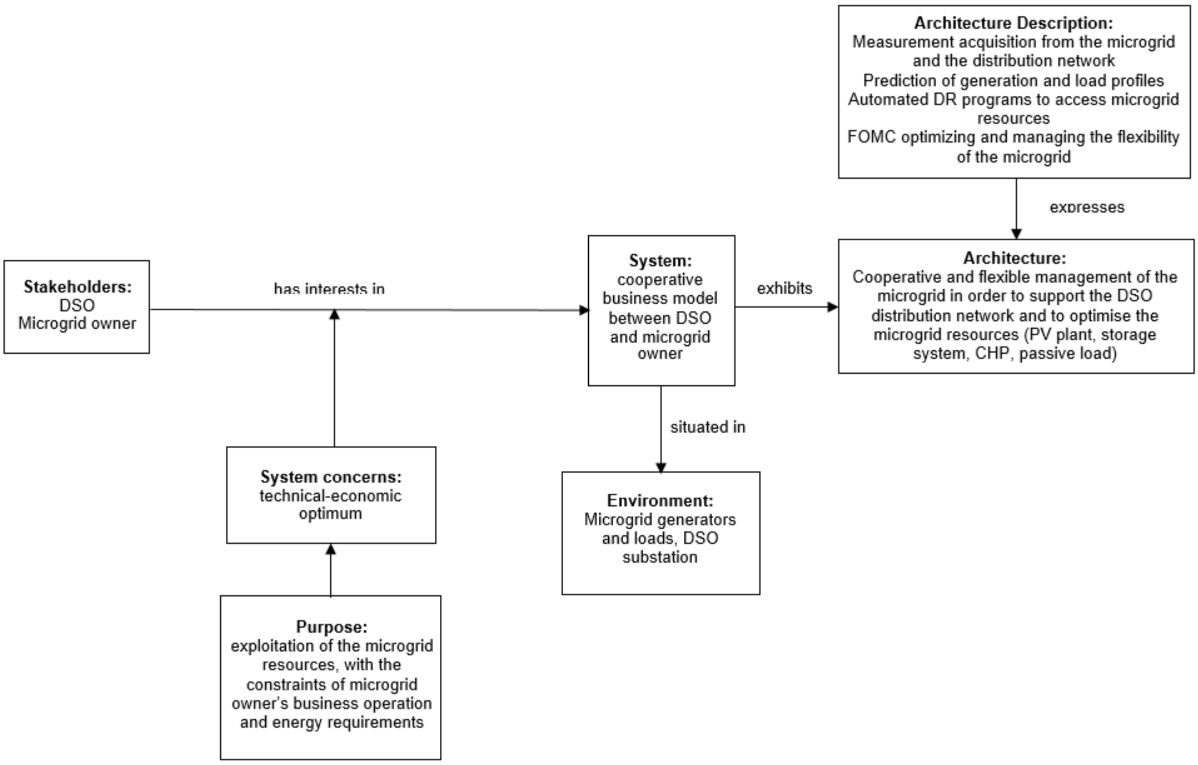

Figure 9. Terni. Demand Response system architecture

B. Smartening the Distribution Grid

The smartening of the distribution grid is centred in the portion of the grid (secondary substation and MV feeder) supplying the microgrid. This project pillar is focused on the improvement of the operation, in terms of service quality, by exploiting the resources (PV plant, storage system, CHP) smartly put at disposal in real time by the microgrid through the Flexibility Optimized Management Cockpit (FOMC) software platform.

Table 12. Terni. Smartening the Distribution Grid architecture description

IEEE 42010 components definition	Description
System	In this project pillar, the system involved is the MV feeder and the DSO substation supplying the microgrid.
Environment	The environment is the distribution network surrounding the system, as well as the microgrid.
Stakeholder	DSO is interested in this pilot's aspect.
Purpose	The main purpose of this activity is to improve the MV network operation by means of the flexibility of the resources of the microgrid.
System concern	System concern is the optimisation of the MV network operation.
Architecture	Flexible management of the microgrid generation resources to support the DSO distribution network
Architecture description	DSO monitoring tool allows measurements acquisition from the microgrid and the distribution network, as well as prediction of

	generation and load profiles. Automated DR programs access microgrid resources. FOMC optimises and manages the flexibility of the microgrid.

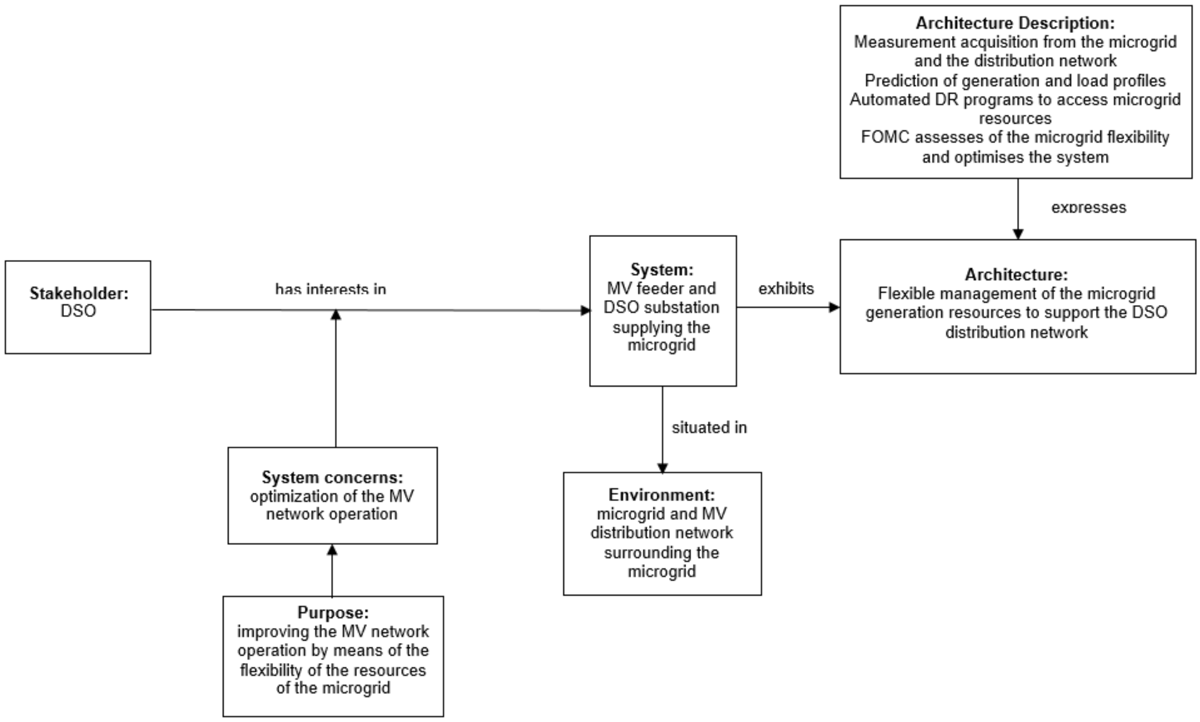

Figure 10. Terni. Smartening the Distribution Grid system architecture

C. Energy Storage Technologies

In this pilot, the Energy Storage pillar is focused on the optimisation of the microgrid distributed generation (PV and CHP) by means of a battery storage system. The optimisation aims both at maximising microgrid self-consumption during normal operation of the MV grid and at supporting the MV grid in case of surplus of power or local congestions.

Table 13. Terni. Energy Storage Technologies architecture description

IEEE 42010 Components definition	Description
System	The distributed generators in the microgrid are mainly involved in this project pillar.
Environment	The environment is the distribution network surrounding the system, as well as the microgrid.
Stakeholder	DSO and microgrid owner are stakeholders for this aspect of the pilot.
Purpose	The main purposes are maximising microgrid self-consumption during normal operation and supporting the MV grid in case of surplus of power or local congestions.
System concern	System concern is the technical-economic optimum of the stakeholders.
Architecture	Management of the storage system of the microgrid in order to support the DSO distribution network and to optimise the operation of the

	microgrid generators.
Architecture description	DSO monitoring tool allows measurements acquisition from the microgrid and the distribution network, as well as prediction of generation and load profiles. Automated DR programs access microgrid resources. FOMC asses the flexibility of the microgrid and optimises the system.

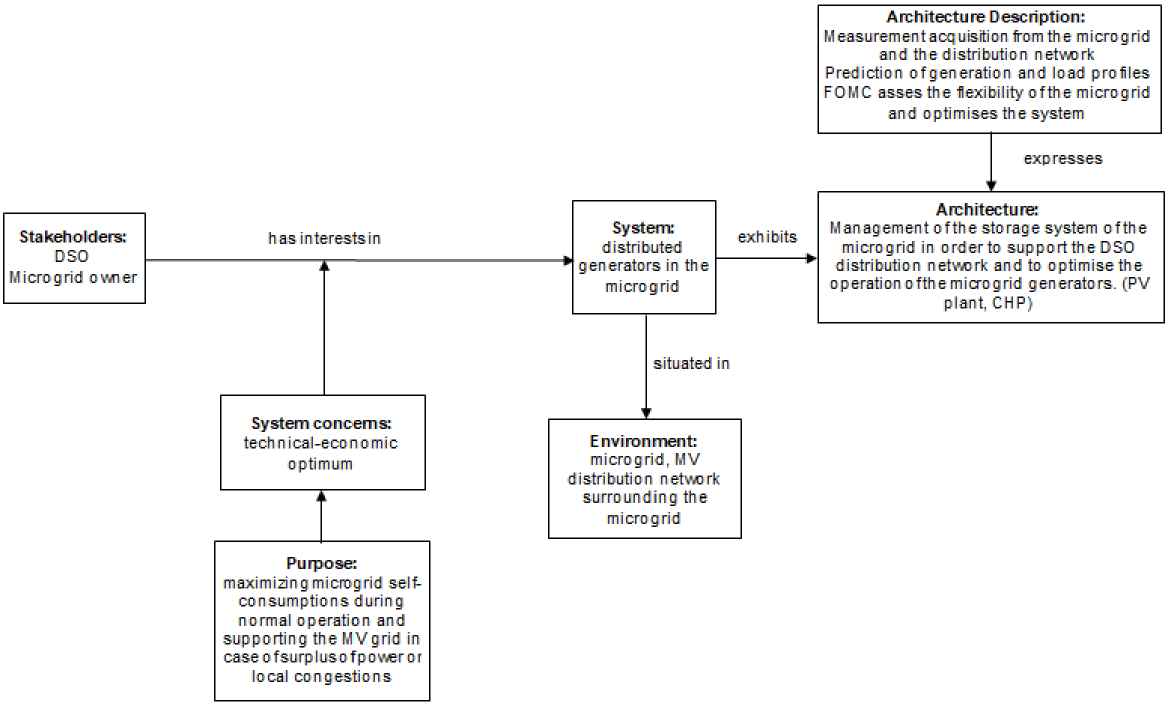

Figure 11. Terni. Energy Storage Technologies system architecture

D. Smart Integration of Grid Users from Transport

This pillar is focused on the evaluation on how EV recharging points can contribute to the MV grid reliability and stability, in cooperation with the flexible microgrid resources SCADA, FOMC and load forecast. It will allow evaluating how the management of EV recharging points improves the MV grid operation, according to the estimated flexibility of the microgrid.

Table 14. Terni. Smart Integration of Grid Users from Transport architecture description

IEEE 42010 components definition	Description
System	In this project pillar, the EV recharging points are involved.
Environment	The environment is the distribution network surrounding the system.
Stakeholder	DSO is interested in this pilot's aspect.
Purpose	The main purpose is of this activity is improving the MV grid operation, according to the estimated flexibility of the microgrid.
System concern	Technical optimum of the MV grid operation.
Architecture	Optimising load profiles of EV recharging points in order to improve

	the MV grid operation, in accordance to the microgrid flexibility.
Architecture description	DSO monitoring tool coordinates operation of EV recharging points, taking into account the flexibility of the surrounding microgrid estimated by FOMC, in order to optimise the MV grid operation.

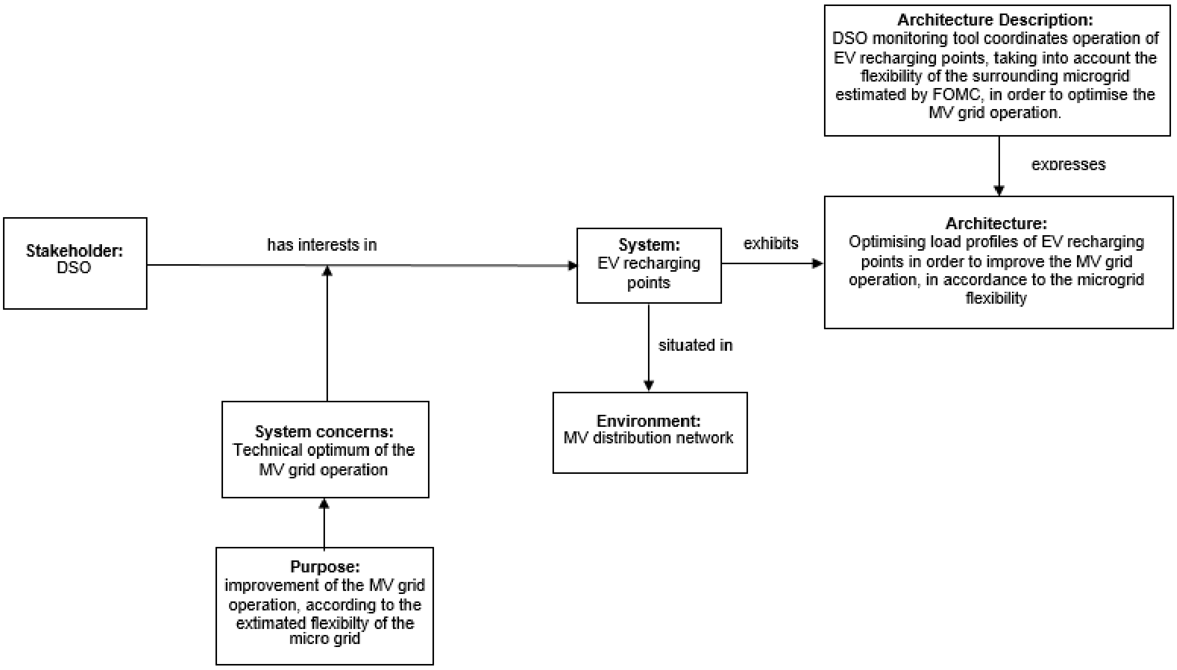

Figure 12. Terni. Smart Integration of Grid Users from Transport system architecture

3.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The flexibility of the microgrid will be exploited with the aim to find a trade-off between the DSO needs and the rural microgrid economic and technical constraints. By means of hardware equipment (e.g. sensing infrastructure) and software tools that the inteGRIDy technology providers will make available in the pilot site, it will be possible to demonstrate the application of a hybrid cooperative business model between the DSO and the microgrid's actors. Indeed, the DSO will be able to exploit the microgrid flexibility to improve stability and reliability of the distribution network without ignoring the needs of microgrid owner in terms of business operation and energy requirements (electric and thermal needs).

Therefore, the overall goals of the Terni Pilot can be summarised as follows:

- Enabling DSO to exploit the flexibility offered by microgrid components through automated DR Programs: this will be possible through the functionality offered by the FOMC software platform. The latter will support DSO in managing the microgrid resources in order to improve the grid power quality through the maximisation of DER cluster.
- To prove environmental, economic and social sustainability of the hybrid business model. From an environmental point of view, it will be evaluated how a proper energy management can increase green energy consumption. From an economic point of view, an improvement of savings due to flexibility's supply is expected. At this level, a proper flexibility assessment will be established.

To accomplish these goals, some use cases have been identified as crucial for reaching the expected results. Data flow and electric equipment in the Pilot are represented in the figure below.

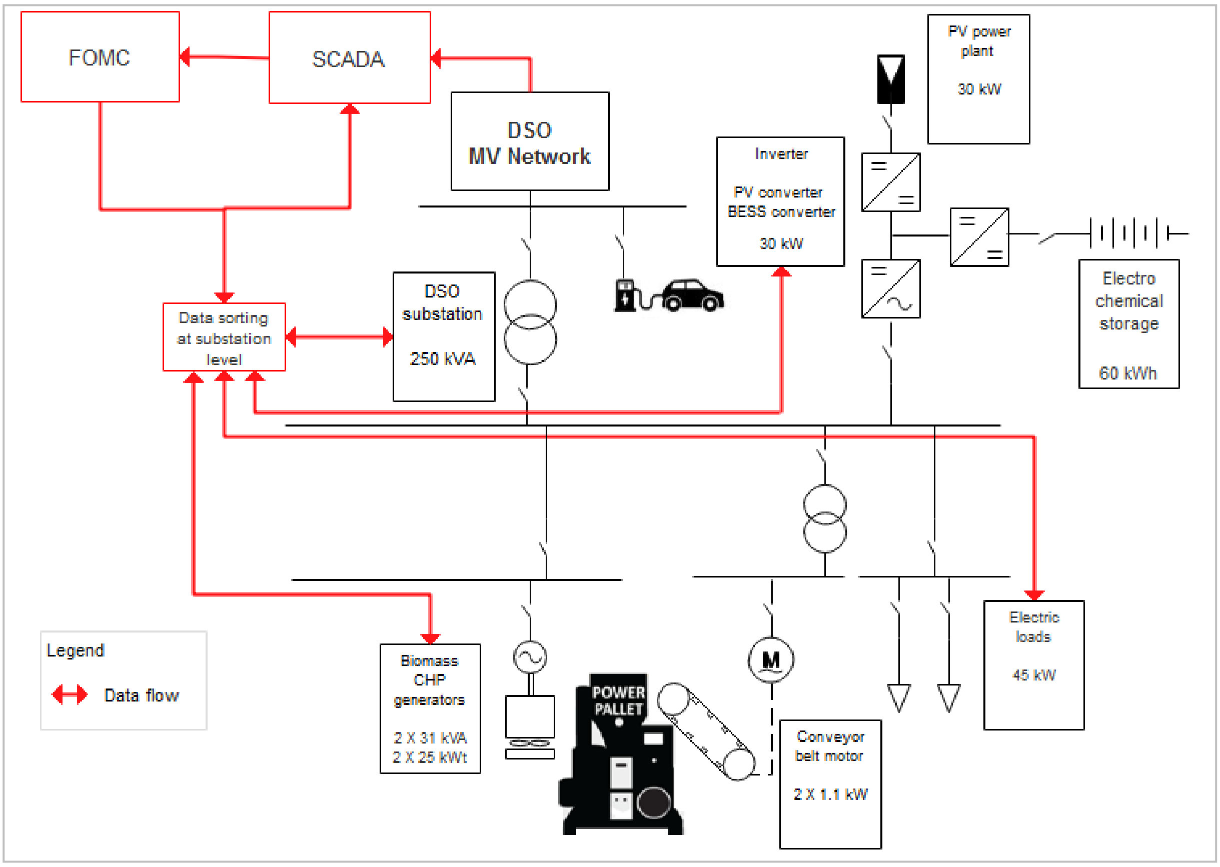

Figure 13. Overall scheme of the Terni Pilot

B. Use Cases

Actually, the use cases investigated in the project could be classified as listed in the following.

- Demand Response

Proper Automated DR programs will be defined and deployed to allow DSO distribution network manager to access microgrid resources (especially storage and CHP) with the aim of maximising savings and economic benefits in normal operation by optimising flexibility management. Individual components of the microgrid will be connected to DSO monitoring tool, which measures relevant quantities (i.e. generated active and reactive power, load consumptions, battery state of charge) and stores them in a historical data storage.

Every pre-fixed time interval, DSO monitoring tool will estimate power flow and voltage profile along the MV feeder connecting the microgrid by means of the network calculation platform, able to perform network state estimation. FOMC is then activated in order to assess the microgrid flexibility by means both of data provided by the SCADA and of a forecast analysis based on historical data. Subsequently, FOMC performs Optimal Power Flow calculations with the aim to minimise active losses along the MV feeder by exploiting the microgrid flexibility, i.e. by modifying the power exchange between microgrid and MV grid at the point of delivery by means of previously agreed automated DR Programs. OPF results are then provided as input to each microgrid component through a telecommunication network.

Several advantages are expected:

- the resource management improves green energy consumptions calling properly the flexibility resources of the microgrid;
- microgrid self-consumption is maximised, thus entailing economic benefits for the microgrid;
- energy and money savings are expected for the DSO, since energy losses along the MV feeder are reduced;
- a model will be tested, where DSO is the provider of a management service as technical aggregator, allowing the DER cluster in the microgrid to achieve economic sustainability.

Table 15. Terni. Use case ASM_UC01

USE CASE: Demand Response	
ID	ASM_UC01
Name	Maximising savings and economic benefits in normal operation by optimising flexibility management.
Storyline	The DSO monitoring tool periodically performs the state estimation of the distribution grid and consults FOMC in order to improve power quality in normal operation by optimising microgrid resources. FOMC evaluates and manages flexibility resources, deploying DR Program, compliant with the constraints imposed by the running farm processes. Furthermore, the analysis will define the requirements (i.e. minimum size conditions and essential equipment) so that MG owner can effectively participate to a hybrid business model.
Goal(s)	Exploiting and optimising the flexibility of microgrid resources to improve the MV grid operation by minimising energy losses.
Actors	DSO, Microgrid operator.
Preconditions	DSO can automatically perform the state estimation. Microgrid operator is registered to the DSO Demand Response program. Components of the MG are monitored and controlled through the ASM Terni sensing infrastructure and DSO monitoring tool. The FOMC component can access to the historical data storage in order to evaluate the dynamic flexibility of the microgrid and to offer proper services to the DSO.
Postconditions	The MV grid operation is improved by reducing energy losses.
Trigger events	Every pre-fixed time interval, the DSO monitoring tool performs state estimation of the distribution grid.

In addition, Terni pilot aims at defining an equipment ranking, in order to set up the requirements of the hybrid model and the priorities about DSO's technical needs (e.g., MV network requirements, software deployment, data transmission and distribution), DER cluster composition (e.g., primary energy sources, storage, load) and stakeholders' concerns (e.g., energy savings, power quality improvement, ancillary services deployment), checking the replicability of the proposed solution. Cyclical analyses with different availabilities of resources will be performed, leading to a global definition of the requirements for a microgrid which can offer flexibility resources and in terms of DR program may improve power quality during normal operation.

- Smartening the Distribution Grid

Flexibility resources are exploited with the aim of improving power quality in degraded operation by optimising flexibility management.

Feeder loadings are monitored by an ASM sensing infrastructure suitably deployed in the grid. Monitored data are then sent to the DSO monitoring tool through a TLC network. DSO monitoring tool can automatically estimate the state of the whole MV grid and, in the case of interest, voltage and loading profiles of the feeder supplying the microgrid by means of the network calculation platform, and thus it can identify potentially degraded state of the network (e.g. overloads, overvoltage and outages). Regarding the feeder supplying the microgrid, a preliminary analysis is carried out in order to assess a target range of feeder loadings: the maximum allowed loading must not violate security requirements provided by DSO.

If an abnormal condition is identified, DSO consults FOMC (Flexibility Optimized Management Cockpit) in order to estimate the MG flexibility. MG components are monitored and controlled by the ASM Terni sensing infrastructure and the DSO monitoring tool; collected data are properly stored into a historical data storage so that can be accessible by FOMC. The latter uses historical data to estimate the flexibility of microgrid components, estimates the microgrid state by means of the data provided by the DSO monitoring tool, and performs forecast analysis based on historical data and background analysis. Based on the Microgrid flexibility, FOMC carries out Optimal Power Flow calculation and exploits flexibility resources with the aim to improve the grid reliability. OPF results then are provided as new set points to each microgrid component through the deployed telecommunication network.

The proper management of the flexible resources of the microgrid improves the distribution network reliability, reducing feeder overloads. Flexibility consists of the ensemble of energy resources (both electrical and thermal) that can be managed by FOMC in order to satisfy the DSO requests of improving power quality.

In addition, Terni pilot aims at defining an equipment ranking, in order to set up the requirements of the hybrid model and the priorities about DSO’s technical needs (e.g., MV network requirements, software deployment, data transmission and distribution), DER cluster composition (e.g., primary energy sources, storage, load) and stakeholders’ concerns (e.g., energy savings, power quality improvement, ancillary services deployment), checking the replicability of the proposed solution. Cyclical analyses with different availabilities of resources will be performed, leading to a global definition of the requirements for a MG which can offer flexibility resources and whose management may supply to DSO ancillary services in order to smartening the distribution grid and to provide economic benefits to MG owner.

From the DSO’s point of view, avoiding and preventing abnormal conditions whose evolution can lead to interruptions, energy and money savings are expected, since the power quality improvement reduces SAIDI and SAIFI indices; furthermore, additional money savings are obtained by avoiding lack of supply, which are charged to the DSO and submitted to a regulatory regime. Regarding the microgrid economic involvement, the flexibility-as-a-service model can be tested.

Table 16. Terni. Use Case ASM_UC02

USE CASE: Smartening the Distribution Grid	
ID	ASM_UC02
Name	Power quality improvement in degraded operation by optimising flexibility management of microgrid resources.
Storyline	The DSO identifies abnormal condition in the distribution grid and consults FOMC in order to deploy automated DR Programs to access microgrid resources and to improve the grid power quality.

	Furthermore, analyses will define the requirements (i.e. minimum size conditions and essential equipment) so that MG owner can effectively participate to a hybrid business model.
Goal(s)	Exploiting and optimising the flexibility of microgrid resources to improve the distribution grid reliability.
Actors	DSO, Microgrid operator.
Preconditions	DSO can estimate automatically the load profile. Microgrid operator is registered to the DSO Demand Response program. Components of the MG are monitored and controlled through the ASM Terni sensing infrastructure and DSO monitoring tool. The FOMC component can access to the historical data storage in order to evaluate the dynamic flexibility of the microgrid and to offer proper services to the DSO.
Postconditions	The grid reliability is improved and both SAIDI and SAIFI indices are reduced.
Trigger events	The DSO identifies abnormal condition in the distribution grid.

- Energy Storage Technologies

Two different aspects will be addressed regarding the MV distribution network. During normal operation, historical data and measurements collected by DSO monitoring tool are sent to FOMC, which estimates microgrid flexibility. Based on the forecast of local energy generation, FOMC provides new set points to energy storage technology, aiming at increasing self-consumption. In degraded operation, DSO monitoring tool asks FOMC to manage energy storage system in order to support the distribution network, for instance by discharging or charging the ESS with the aim to improve power quality.

From the DSO's point of view, energy and money savings are expected, since the power quality improvement reduces SAIDI and SAIFI indices; furthermore, additional money savings are obtained by avoiding lack of supply, which are charged to the DSO and submitted to a regulatory regime. Regarding the microgrid economic involvement, the flexibility-as-a-service model can be tested.

Table 17. Terni. Use case ASM_UC03

USE CASE: Energy Storage Technologies	
ID	ASM_UC03
Name	Energy storage technologies.
Storyline	During normal operation, FOMC provide new set points to energy storage technology, aiming at increase self-consumption. In degraded operation, DSO monitoring tool asks to FOMC to manage energy storage system in order to support the distribution network.
Goal(s)	Increasing of MG self-consumption. Improving reliability of MV network.
Actors	DSO, Microgrid operator.

Preconditions	DSO can estimate automatically the load profile. Microgrid operator is registered to the DSO Demand Response program. Components of the MG are monitored and controlled through the ASM Terni sensing infrastructure and SCADA system. The FOMC component can access to the historical data storage in order to evaluate the dynamic flexibility of the microgrid and to offer proper services to the DSO.
Postconditions	The grid reliability is improved and both SAIDI and SAIFI indices are reduced.
Trigger events	N/A

- Smart Integration of Grid Users from Transport

Not far from the microgrid, the installation of some EV recharging points is expected, so that a theoretical study is going to be developed in order to efficiently manage the network. They will be supplied by the same MV feeder. A preliminary estimation of the EV charging points impact on the network will be performed by simulation models and taking into account historical data from the DSO monitoring tool, checking the microgrid contribution to the optimised management of the whole system. Through FOMC and load forecast, DSO coordinates stations' consumptions, according to the estimated flexibility of the microgrid. At the end, an evaluation of the contribution to this load to the network reliability and stability will be performed.

Table 18. Terni. Use Case ASM_UC04

USE CASE: Smart Integration of Grid Users from Transport	
ID	ASM_UC04
Name	Microgrid flexibility exploited for eventual EV recharging stations.
Storyline	Taking into account historical data from the DSO monitoring tool and through FOMC and load forecast, DSO coordinates stations' consumption, according to the estimated flexibility of the microgrid. It follows an evaluation of the contribution of the microgrid to the management optimisation for the network branch.
Goal(s)	Preliminary impact estimation of the EV charging positions on the network.
Actors	DSO, Microgrid operator.
Preconditions	Components of the MG are monitored and controlled through the ASM Terni sensing infrastructure and SCADA system. The FOMC component can access to the historical data storage in order to evaluate the dynamic flexibility of the microgrid and to offer proper services to the DSO. FOMC can estimate flexibility during off-line simulations.
Postconditions	Demonstrating system's availability to supply energy to EV recharging stations, by managing flexibility.
Trigger events	N/A

3.4 Regulatory Framework

Up to now, the Italian regulatory framework of energy market is essentially based on a centralised electric generation model and does not consider flexibility as a service, as the Terni pilot aims to test. The national Entity in charge of setting the regulatory framework is the Authority for Electricity Gas and Water: as reported in the web site, “the Authority core regulatory competences refer mainly to the definition and maintenance of a reliable and transparent tariff system - reconciling the economic goals of operators with general social objectives and promoting environmental protection and the efficient use of energy - the setting quality of service standards and the definition of a framework aimed at the protection and empowerment of consumers in competitive market” [AEN16].

Regarding the hybrid business model to be demonstrated in the Terni pilot, the Authority does not provide any definition of the microgrid for an urban, rural or industrial cluster. Therefore, the pilot site has to manage the trial in compliance with the legislation laid down for non-domestic prosumers having several production plants connected to the electrical distribution network.

In particular, the existing regulatory framework regards prosumers who require the connection to the distribution network, establishing the contractual power that the prosumer may absorb from / supply to the grid. The remuneration for plants, generating from renewable sources, is entrusted to the GSE, the state-owned company which promotes and supports renewable energy sources in Italy. There are two distinct options available:

- Net metering service: under the service, the electricity generated by a consumer/producer in an eligible on-site plant and injected into the grid can be used to offset the electricity withdrawn from the grid. GSE pays a contribution to the customer based on injections and withdrawals of electricity in a given calendar year and on their respective market values. Therefore, for a prosumer choosing this regulatory regime, only the amount of generated energy equal to the amount of energy absorbed from the grid may be remunerated [GSE17].
- Resale arrangements: purchases and resells the electricity to be fed into the grid at the zonal price or at a minimum guaranteed price; moreover, on behalf of the producer, transfers the fees for the use of the grid (transmission and dispatch fees) to distributors and to the TSO. [GSI17]

As for the energy drawn from the grid, the customer buys the necessary resources in the open market or in the safeguard market. In the first case, the energy is supplied by a retailer that buys energy in the electric market; in the second case, energy price is defined by the Authority.

In general, there is neither a regulation nor a remuneration of the DR practice, although a regulatory framework begins to arise according to the authority’s resolution 39/10, that incentivised DR testing, and resolution 114/2015, which promoted research about integrated ICT system for DR applied to small users through flexible pricing, load shedding or remote power supply with distributed generation [AEI16], [AEN10].

The definition of a new regulatory framework is thus expected. On the one hand, it should allow DSO or other stakeholders to become technical or economic aggregator for prosumers’ clusters; on the other hand, Authority should define new opportunities for customers, as DR mechanisms or flexibility services.

3.5 Technology Bounds

Terni Pilot site aims at demonstrating a new cooperative and efficient cooperative model between a microgrid and a DSO. Therefore, advanced equipment is required. In Italy standards are already in place in order to prescribe the requirements for active users connected to the LV network. Actually, the main standard is CEI 0-21, which regards the technical connection for active and passive customers to the DSO’s LV networks. According to the standard, PV power plant and/or conventional generator equipped with storage system must give DSO some ancillary services, even if with a limited impact. The foreseen actions in Terni pilot site aim at improving the effect of DERs on the power quality and distribution network efficiency, by means of voltage regulation, peak shaving, load shifting, reverse power flow mitigation, power losses reduction and recovery from outage.

Moreover, a proper data exchange system is deployed. In the pilot site, data are collected by Remote Terminal Units (RTUs) and processed by the DSO monitoring tool, able to show the current state of the distribution network. Standard IEC 61850, which is the International Standard related to the configuration of Intelligent Electronic Devices for electrical substation automation systems, is used as communication protocol.

According to a distribution smartening, potential of DSO monitoring tool are yet unexplored and data will be used by innovative software tools, such as OpenADR, which will allow the communication between DSO and FOMC. They are able to define DR programs, analyse and optimise the flexibility resources in the Microgrid. These operations need tools for the forecast of flexibility, as results of modelling of user behaviour, economic needs, state of equipment.

3.6 Business Model

ASM (the DSO) has to sustain costs in order to connect the microgrid lo the LV network. Connection requirements are substation, cable line, TLC network. Project development requires analysers in order to measure generation and consumptions. Also, the microgrid owner has to sustain costs for the adjustments of its equipment.

Main savings concern microgrid resources optimisation (e.g. increasing of self-consumption, internal losses reduction), green energy consumption maximisation, network reliability and resilience improvement. Furthermore, on the distribution network loss reduction is expected, as well as power quality improvement. In particular, ASM aims at reducing SAIDI and SAIFI, reducing voltage fluctuations.

Regarding the pilot site, ASM aims at increasing both efficiency and sustainability, from an environmental point of view. Environmental improvement involves CO_2 emission reduction and self-consumption increase. From an economic point of view, these improvements can be considered as revenues. In actual fact, green certificates can be obtained by GSE.

3.7 Replicability/Impact of the Pilot

Due to the increasingly amount of distributed generation, many independent and private microgrids similar to the one involved in this Pilot are envisaged in the near future. Therefore, the Terni Pilot may be taken as a benchmark for the management of similar DER clusters connected to the distribution network.

The FOMC software, able to assess and exploit the flexibility of a microgrid taking into account both DSO and microgrid constraints, will be integrated and extended in order to define a modular solution for the management of a microgrid and its integration in DSO's distribution network. Moreover, the software will allow applying a "flexibility-as-a-service" business model, based on the cooperation between the DSO and the microgrid owner.

Such solution is easily scalable and replicable, and therefore could be implemented at a large scale for the effective management of microgrids connected to the DSO's distribution network.

4.Survey on the San Severino Pilot

4.1 Pilot Area Description

A. Area and Geographical Overview

The pilot project is related to the distribution grid of San Severino Marche which is managed by the local distribution system operator A.S.SE.M. SpA. San Severino Marche is a small town in the Macerata province, in the Centre of Italy. The total area of the municipality of San Severino Marche is around 193 km^2 and counts as population 13 thousand inhabitants. The territory is composed by the main town and the surrounding rural hilly area. The total length of MV grid, operated at 20 kV, is 182 km. In 2016 the number of users connected to the grid was 7958 with a peak demand of 39.69 MW. In the same year, the number of generators connected was 387 with a capacity of 27.4 MW. The main technologies of generators are solar and run-of-the-river hydro. The primary substation of the grid is located in Colotto, a hamlet of San Severino Marche. Two transformers are placed in the primary substation and five feeders are connected to each of them. The peculiar topology of the area in some cases makes it difficult to properly reach users far from the main town (e.g. communication channels are typically based on radio technologies).

Figure 14. San Severino Marche geographical location

B. Needs and Opportunities

In the past, the area reported a hydro resources exploitation while, recently, photovoltaic generation penetration has been rising year after year. Moreover, due to the agricultural activities, good opportunities are also related to biomasses. Vice-versa, the energy needs of the loads are quite limited, consequently a reverse power flow regularly occurs, especially during summertime. One of the main already existing components in this area is the communication system developed in a previous project, which is based on fibre optic, Wi-Fi bridges, and mobile network (LTE). It allows exchanging real-time signals/data between the DSO's control Centre, the protection equipment distributed on the MV network and the users.

In such a scenario, with high DG penetration but also high communication level among the components, the MV grid of San Severino Marche is particularly suitable for a pilot to investigate the effective management of the DG and the maximisation of the hosting capacity.

Table 19. Opportunities and needs of San Severino Pilot

Opportunities	Needs
RES (Hydro, Biomass, PV) availability in a rural area	Maximising distribution grid Hosting Capacity (HC, i.e. the capacity to host new generation): a proper exploitation of renewable in a rural area (i.e. an area with a limited energy needs) require an optimal management of the distribution grid devoted to maximise the HC, the system reliability and the quality of service.
Final user participation to the ancillary market	Small-medium users could have in the ancillary market participation an economic opportunity; similarly, the electric grid could benefit of the exploitation of new regulation resources. In order to have a feasible integration in the market, small and medium users have to be aggregated and properly managed.
Properly exploit energy storage options	Energy Storage is a new quite promising option, nevertheless communication protocols need to be standardised in order to monitor and control such new resources. Similarly, in the end-user perspective, there is the need of a clear identification of pros and cons of these technologies.

4.2 Context of the Architecture Proposed

Three different architecture descriptions are proposed according to the number of project pillars which have to be addressed in this pilot.

A. Demand Response

In this pilot, the demand response topic is centred in the market pool, where market operators and aggregators are interested in increase their revenues, but there is also a strong need to limit end-users costs by a greater competitiveness. Thanks to the storage, real-time meters, ICT and energy management systems, market flexibility and efficiency will be achieved.

Table 20. San Severino. Demand response architecture description

IEEE 42010 components definition	Description
System	In the demand response project pillar, the market pool is the system, where market operators and aggregators operate.
Environment	The surrounding area of the main system which have an influence on that are power plants, final users (passive) and the electric grid.
Stakeholder	Market operators and aggregators are interested in this pilot's pillar.
Purpose	The main purpose of this activity is having an efficient and flexible market in order to improve the supply side.
System Concern	Stakeholders concerns in the event of this purpose is concluded in optimum economy.
Architecture	The architecture is based on storage, meters, ICT and energy management systems in order to monitor, control and optimise the

	performance of the system by using innovative technologies.
Architecture Description	Ancillary services market will be simulated in order to interact with final users and distributed ESS apparatuses. The architecture is based on an advanced interaction with final user meters. Passive users will be properly informed (adopting standard media) about their energy behaviour in order to improve their awareness.

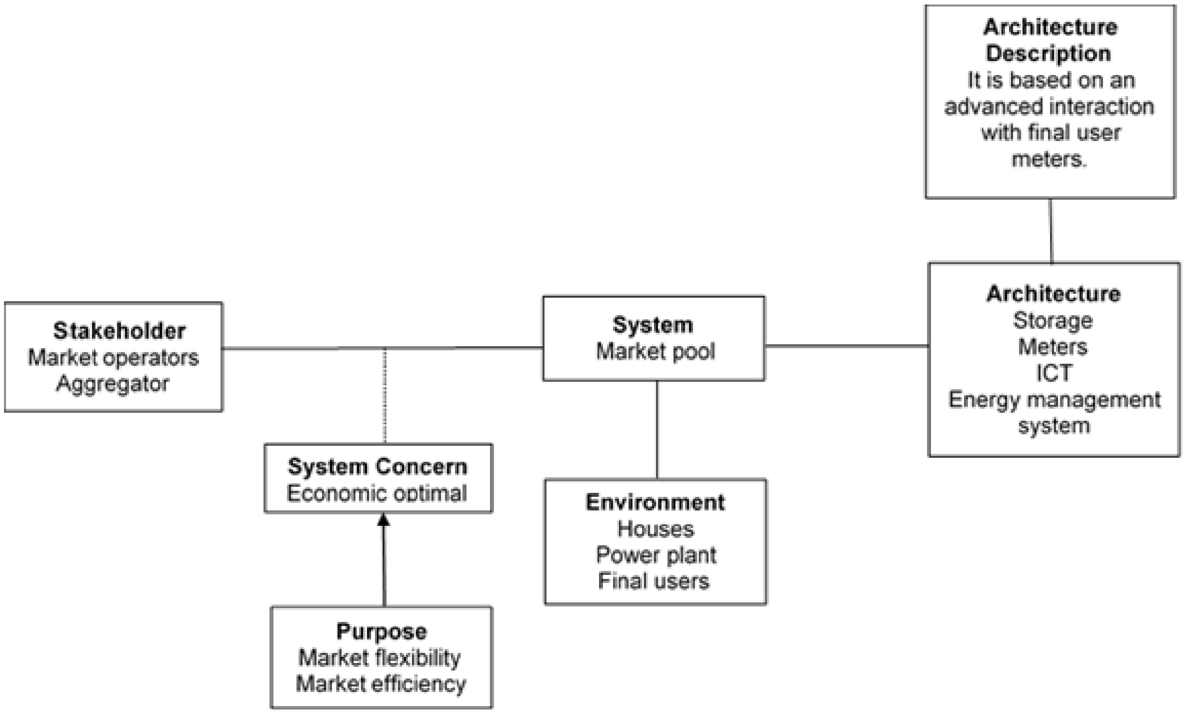

Figure 15. San Severino. Demand Response system architecture

B. Smartening the Distribution Grid

This project pillar is focused on the distribution grid. Thus, the distribution system operator who have service quality, losses reduction, reliability and hosting capacity as purposes should achieve them with respect to grid's technical constraints. To this purpose, SCADA, RTU, meters, switches and ESS are distributed on the MV/LV network.

Table 21. San Severino. Smartening the Distribution Grid architecture description

IEEE 42010 components definition	Description
System	Distribution network is the system where the smartening of the distribution grid is conducted.
Environment	The surrounding area of the main system which has an influence on that is medium voltage grid where the final users are connected.
Stakeholder	The main party who has the interest in smartening the distribution grid in this pilot is DSO.
Purpose	The main purposes of this activity are providing service quality, losses reduction and distribution grid hosting capacity improvement, which bring system reliability.

System Concern	DSO concerns in the event grid's technical constraints obstruct the achievement of the over-mentioned purposes.
Architecture	SCADA, meters, ICT, RTU, Energy storage, weather forecast and switchers are used to monitor, control and optimise the performance of the system by using innovative technologies.
Architecture Description	The architecture will be based on the DSO SCADA, improved with a DIgSILENT Power Factory based Distribution Management System. Sensors over the distribution grid and sectionalising switches will be linked thanks to a mobile (LTE) network.

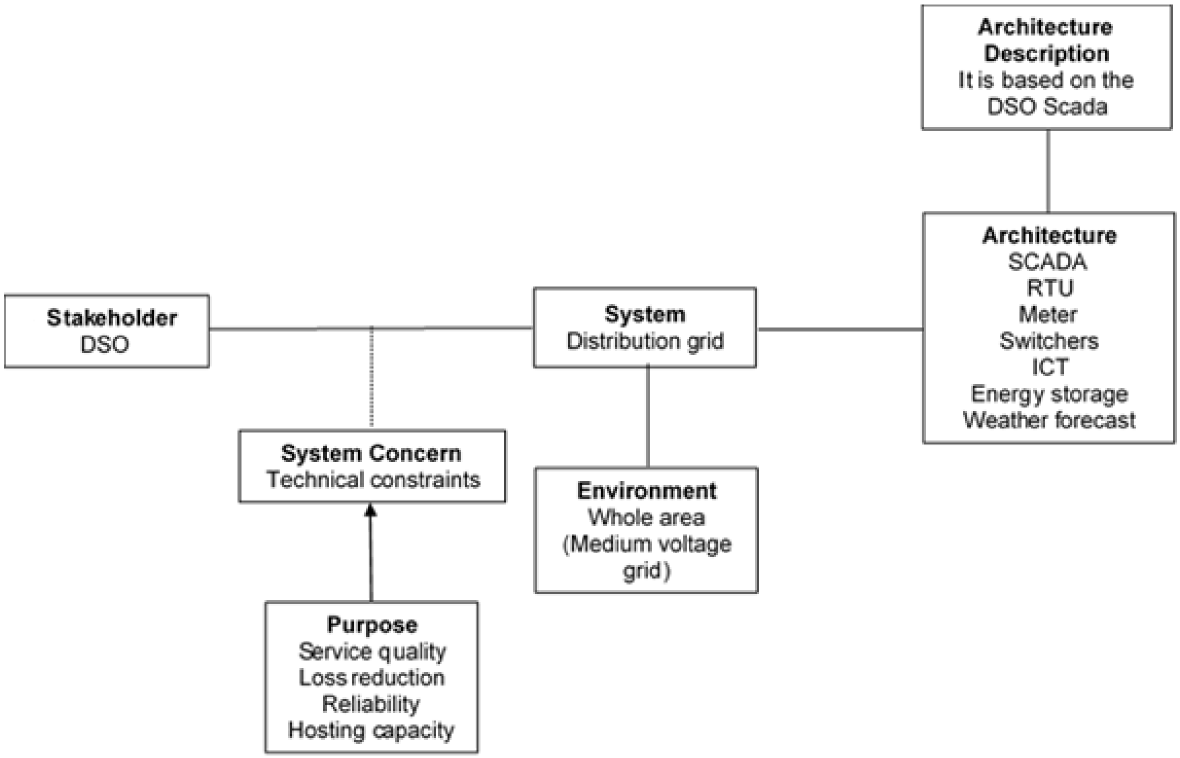

Figure 16. San Severino. Smartening the Distribution Grid system architecture

C. Energy Storage Technologies

In this pilot, energy storage systems are exploited together with meters, ICT and energy management system technologies to optimise the energy behaviour optimisation of end-users, reducing their absorption peaks, increasing self-consumption and supporting the power system operation.

Table 22. San Severino. Energy Storage Technologies architecture description

IEEE 42010 components definition	Description
System	User power plant is the centre of activity and the main system involved in the energy storage technologies pillar.
Environment	The surrounding area of the main system which have an influence on that is residential and industry sectors.
Stakeholder	Final users in distribution grid and market operators (including

	aggregators) are the main stakeholders of this system.
Purpose	Energy behaviour optimisation will be achieved in order to reduce peaks and consumption.
System Concern	Stakeholders concerns are for an economic viability.
Architecture	ESS, meters, ICT and Energy management systems are used to monitor, control and optimise the performance of the system.
Architecture Description	Energy Storage will be controlled by a local PLC (devoted to control each apparatus) in order to provide behind-of-the-meter services. Moreover, a web-service will be activated in order to coordinate several apparatuses in providing front-of-the-meter regulations.

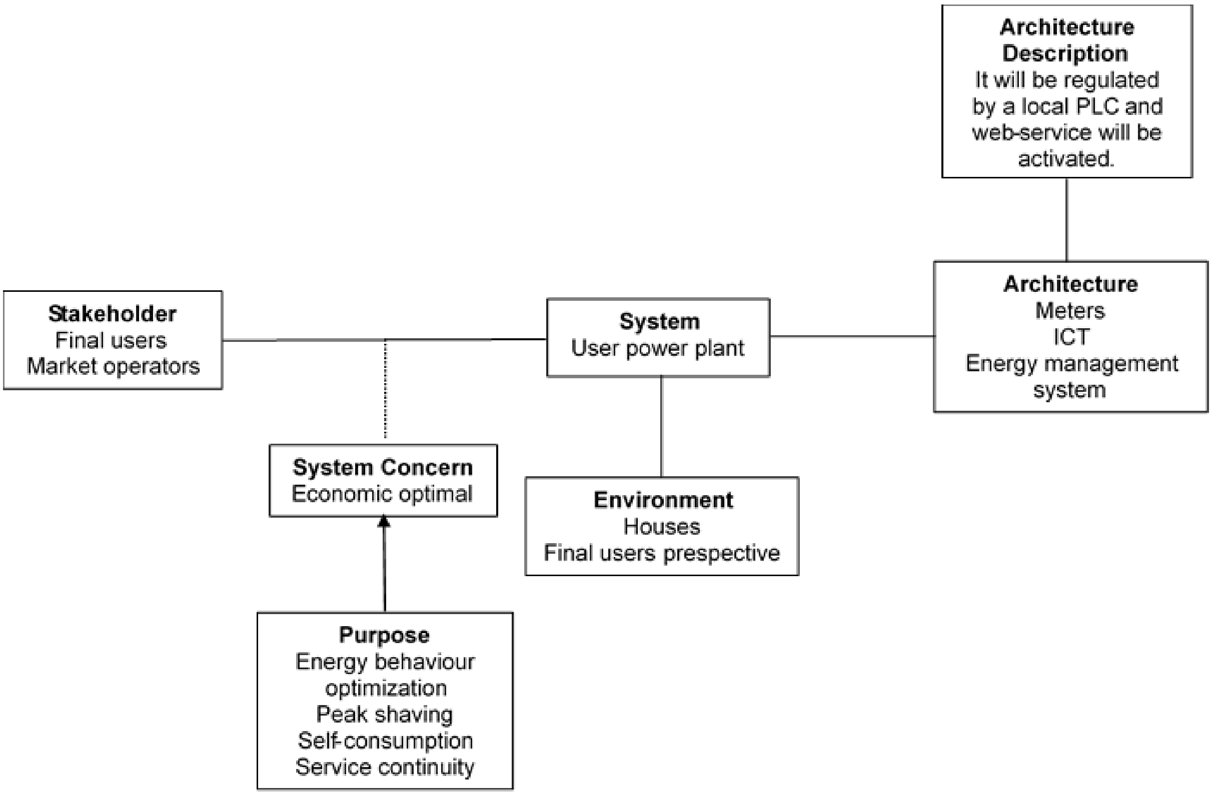

Figure 17. San Severino. Energy Storage Technologies system architecture

4.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The goals of the pilot are related to the advanced monitoring of the grid, the forecast of the power flows and, consequently, the day ahead topology optimisation of the grid.

Actually, distribution networks are built as radial systems, but with the possibility of back-feeding during contingencies. They have some advantages over meshed networks, such as lower short-circuit currents and simpler switching and protecting equipment. On the other hand, the radial structure provides less overall reliability. Nowadays, DSOs have the opportunity to change the topology of their grids in order to obtain an optimal configuration, in terms of losses or other operational indicators (Quality of Service, Hosting Capacity, etc.).

To this purpose, it is pivotal to perform an accurate estimation of the state of network, in real time, but also on a predictive base in order to support DSOs in operating networks with great penetration of DG. To implement this predictive approach, the forecast of the power flows and advanced monitoring of the grid need to be developed. The information obtained from these mentioned partial goals can be used in advance to find the optimal grid topology.

Generators will be consequently managed by the electric protection and remote-control system of the DSO and exploited in order to optimise the grid reliability and efficiency. Moreover, an innovative platform will be activated to evaluate the effectiveness of a coordinated control of MV generators performed by the DSO in order to provide ancillary services to the main grid.

Moreover, new technologies are now getting involved in the picture, with one of the most promising being the energy storage. In the pilot, a coordinated management of distributed energy storage will be tested both in a final user perspective (improving the energy behaviour of LV users) and in the grid perspective (provide ancillary service to the local grid or to the national one).

A.S.SE.M. SpA will coordinate all the activities and will be in charge of the apparatuses deployment, the data gathering and the effective management of the test. Politecnico di Milano (POLIMI), a technical university, will develop the innovative algorithms devoted to optimise the grid topology and the energy storage management in order to monitor users' behaviour and provide forecast of the power injections. Moreover, a SME, UNE s.r.l., will develop the innovative energy storage system.

B. Use Cases

- Demand Response

In the new energy market, Demand Response (DR) is supposed to be a very important service in order to provide effective regulation resources to the market, improving both the economic efficiency of the market itself and the economics of the final users.

Moreover, in the new scenarios with increasing renewable penetration, criticalities could eventually be generated on the distribution grid due to fluctuant production. This will consequently results in investigating new grid services devoted to improve the grid management.

The ASSEM pilot data, both from passive final users and storage apparatuses, will be collected by a new platform (in perspective, managed by an aggregator), in order to quantify in real-time the resource available. This will aid in simulating a virtual market aiming at generating price signals and to evaluate the aggregator response, in particular investigating the capacity to coordinate several resources distributed in the grid.

Actually, energy storage apparatuses will be controlled in real time thanks to a dedicated TLC channel, while passive users will be properly informed about their energy behaviour (i.e. the goal is to improve their energy behaviour while no real-time control will be tested).

Table 23. San Severino. Use Case ASS_UC01

USE CASE: Demand Response	
ID	ASS_UC01
Name	Demand Response
Storyline	Renewals growing penetration ask for new regulation resources. Nevertheless, ancillary services market is nowadays closed to dispersed generation and storage. The need is to aggregate several small/medium resources (RES and conventional generators, flexible loads, etc.) in order to play on the ancillary services market.

Goal(s)	Evaluate the effectiveness of a resources aggregation in order to provide grid services.
Actors	Loads, Energy Storage, DSO.
Preconditions	Resources (Loads and Energy Storage) will be collected in the Aggregator platform. The Platform will evaluate the regulation margin of each resource. A market platform will be activated in order to simulate realistic market signals. Congestions/violations on the MV grid will be detected and a new market signal will be defined in order to properly manage regulation on the distribution grid.
Postconditions	Energy Storage apparatuses will be controlled according to the Aggregator needs. Passive loads will be informed about their energy behaviour in order to improve awareness for effective energy behaviour (effective also with respect to the grid needs). Measure of the energy flows and evaluation of the effective contribution to the grid services will be carried out.
Trigger events	The procedure is periodically scheduled.

- Smarting the Distribution Grid

Time series approaches and an advanced weather forecast infrastructure will be adopted in order to predict renewables production and load consumption.

A metering infrastructure deployed in the MV grid will provide data to the ASSEM control Centre thanks to a TLC network, realised by mobile technology (LTE), and the already in place Wi-Fi and Fibre Optic (FO) communication channels. Data will be processed thanks to the MV Distribution Networks Management Tools (based on DIgSILENT PowerFactory software) in order to identify the optimal topology of the MV grid in terms of losses or other operational indicators (Quality of Service, Hosting Capacity, etc.).

The output of the procedure will be reported to the grid operator for validation and eventual adoption in the grid; in particular, the procedure will perform both "day ahead optimisation" and "real time (post contingency) identification" of the optimal topology.

Users will benefit a better energy supply (both in terms of quality and reliability), while DSO will obtain better economics (power quality revenues, power losses saving, grid reinforcement postponement).

Table 24. San Severino. Use Case ASS_UC02

USE CASE: Smartening the Distribution Grid	
ID	ASS_UC02
Name	Smartening the Distribution Grid
Storyline	The DSO identifies optimal topology of the grid in order to host dispersed generation, to minimise losses and to maximise grid resilience (providing a better quality of supply to the final users).

Goal(s)	Exploit the real time monitoring of the grid and weather/loads forecast in order to identify the optimal grid topology.
Actors	DSO
Preconditions	Weather forecast is adopted to predict production and consumption patterns. DSO acquires grid information (voltage levels, currents, etc.) thanks to a dedicated monitoring infrastructure on the MV grid (linked with the SCADA). In the DSO control centre, a "Grid State Estimation" procedure is adopted in order to model the grid behaviour.
Postconditions	Grid efficiency and reliability result optimised.
Trigger events	The procedure is periodically scheduled, eventually it is activated in case of critical changes (significant mismatch between measures and grid state estimation).

- Energy Storage Technologies

Generally speaking, energy storage services can either be located in front-of-the-meter or behind-the-meter. Front-of-the-meter applications are those utilised by utilities and grid operators; they include frequency regulation, capacity reserve, etc. Behind-the-meter applications are customer-sited and perform functions directly beneficial to the end-user, such as demand reduction/peak shaving, power backup, energy time shifting, etc. On a different perspective, energy storage could be deployed adopting different spatial approaches. To minimise as much as possible the capital costs, assets could be centralised in big storage plants or, in order to provide regulation closer to the edge of the grid (closer to the end users), assets could be decentralised in many (small) storage units.

In the ASSEM pilot a distributed management of storage units will be tested. Apparatuses will be deployed on the LV grid and will be coordinated by a TLC system in order to cooperate in providing front-of-the-meter services. Moreover, behind-the-meter services will also be tested evaluating a more classical final user's perspective.

Table 25. San Severino. Use Case ASS_UC03

USE CASE: Energy Storage	
ID	ASS_UC03
Name	Energy Storage Technologies
Storyline	Renewable growing asks for more regulating resources; Energy Storage is a very promising resource due to the capability for a fast and accurate energy flow regulation (i.e. contribution to frequency control, voltage control, etc.). Similarly, in the final user perspective, Energy Storage could be an effective resource in order to better shape the load profile (i.e. energy arbitrage, peak shaving) and to better exploit local generation (i.e. increase self-consumption).
Goal(s)	Coordinate several Energy Storage apparatuses in order to provide front-of-the meter services. Locally manage an energy storage apparatus in order to provide behind-

	the-meter services.
Actors	Loads, DSO.
Preconditions	Measures will be taken both on the distribution grid and in the users' point of common coupling. Measures will be taken on the distribution grid (e.g. in order to detect congestions, frequency perturbations, etc.).
Postconditions	Energy Storage Systems will be controlled in absorbing/injecting power
Trigger events	Front-of-the-meter regulation: threshold on measurements on the distribution grid (current, voltage amplitude and frequency). Behind-the-meter regulations: threshold on local measures (current, voltage amplitude) at point of common coupling of the end-user .

4.4 Regulatory Framework

The regulatory framework in place in Italy for the electric power systems is given by the combination of national laws (primary legislation) and resolutions of the Italian Energy Authority (AEEGSI); in this section, a brief description of the main regulatory aspects relevant to the San Severino Pilot developed in the inteGRIDy project is reported.

With reference to the electricity distribution service regulation in place in Italy, in recent years AEEGSI put in force a rewards/penalties scheme devoted to promote an improvement of the quality levels of the service supplied to final users. To this purpose, Res. 646/15/R/eel applied economic rewards (revenues) or penalties (fees) to system operators, according to the value, with respect to reference thresholds, assumed by some indexes, measuring the continuity of service and voltage quality provided to MV/LV users (frequency and duration of supply interruptions, SAIFI and SAIDI, and depth and duration of voltage dips). Driven by this mechanism, DSOs are motivated to invest more and better on their grids, in the direction to improve the reliability and resilience of lines and electrical equipment, and increase the network's automation. In addition, a more efficient planning is also fostered, to limit the stress of grid's components and the number of users involved in fault events. Res. 646/15/R/eel takes as reference the European standard EN 50160, which defines proper metrics for the evaluation of the technical quality of service supplied to users (continuity of services and voltage quality indexes).

A better efficiency of the service of electricity supply to final users is another aspect promoted by the Italian Energy Authority. To this purpose, Res. 301/2012/R/eel defines, on a conventional basis, the loss factors for HV, MV and LV networks. According to these factors, energy losses are refunded to system operators (TSO and DSOs). Therefore, if a TSO/DSO is able to manage the distribution grid performing losses lower than the conventional one, the difference between refunded and actual losses is an income for the network operator; otherwise, it incurs in new costs.

Moreover, according to the developments expected in the national regulatory framework, an evolution of the DSOs' role is also envisaged in the medium-short term. In fact, in the next years, the involvement of DSOs in the dispatching of load and generation connected to MV/LV network is foreseen. In this picture, which represents the reference scenario for the San Severino Marche pilot project, on the one hand, the DSOs will be able to collect ancillary services on active/passive users useful to improve the standards of quality of the distribution service; on the other hand, they will be asked to supervise the provision of ancillary services by MV/LV users to the HV system, in order to check the compliance of the services supplied with the distribution grid's technical constraints.

To allow the effective involvement of MV/LV users in the power system's operation, also in this pilot the introduction of a new subject with specific objectives and competences is required: the aggregator. It will have in charge the trading activities related to the LV/MV user bids for ancillary services, while the data gathering (metering, etc.) and the delivery of the regulation set-points, which require infrastructural investments, will remain in charge to the DSO.

In the outlined scenario, the technical connection requirements (Italian standards CEI 0-16 and CEI 0-21) applied to MV/LV users represent another aspect requiring a proper evolution. In fact, in order to enable the real-time exchange of information and commands with the DSO/Aggregator, the user will have to install suitable monitoring and control devices by its premises. A first step in this direction has been made recently by the Annex O of standard CEI 0-16, which includes, by May 2017, a preliminary specification of this interface.

Consequently, the San Severino Marche Pilot is focused on the optimal management of the distribution grid (improving the overalls electric system performance and, thanks to the regulatory framework in place in Italy, the DSO economics) but also on the aggregation of the final users energy flows in order to participate to the new ancillary services market (this will require final users to be able to manage their power consumption/generation flows).

Actually, the final users participation to the ancillary market is still not in place in Italy and the regulatory framework is under evolution. inteGRIDy project results to be absolutely on-time and relevant to investigate the feasibility and effectiveness of the approach.

4.5 Technology Bounds

The San Severino Marche pilot adopts a set of innovative technologies, having the purpose to support the grid operation and to exploit the flexibility provided by small users equipped with energy storage systems.

In particular, concerning the technological solutions devoted to the implementation of new control logics/strategies, the following software tools are exploited in the pilot:

- tools for the data gathering from the metering apparatuses and for the grid state estimation;
- artificial intelligence tools for the forecast of user behaviour (both for generators and loads);
- tools for the optimisation of the grid topology in order to maximise efficiency and reliability of supply, and the grid hosting capacity (capacity to effectively integrate into the grid new generators);
- tools for the grid-oriented management of centralised/dispersed energy storage solutions.

Moreover, the pilot makes use of energy storage technologies (molten-salt sodium-nickel batteries) in order to improve the flexibility of load and generation profiles of LV users, and consequently support the grid operation. The state-of-the-art of electrochemical storages (in terms of both technological readiness and related costs) is a key point for the implementation of the experiment and its future replicability.

In the San Severino Marche demonstrator, communication systems are also used extensively in order to connect all the monitoring and control devices deployed on the MV and LV network to the DSO's control centre (and to possible other external subjects, e.g. market operators). On the contrary of "standard" power systems applications, where, at least at MV/LV level, not-binding requirements exist for TLC technologies (usually GPRS and PLC transmission vectors are used), in this pilot the data transfer rate, reliability and latency of the communication are all factors to properly take into account. To this purpose, an always-on data-exchange infrastructure is adopted, based on both wired and mobile TLC technologies (fibre optic, Wi-Fi, LTE).

Given the need in the project to establish a communication among all the systems and apparatuses involved, the adoption of proper technical standards providing a specification of the data exchange profile is pivotal. In this context, standard IEC 60870-5-104 provides a communication profile used for remote control (supervisory control and data acquisition) in electrical engineering and power system automation applications. Standard IEC 61850 represents a more advanced alternative of the former one, which is being increasingly exploited for LAN and WAN applications on electricity distribution networks.

Many devices and systems used by the DSO natively manage the just mentioned protocols. In the other cases, further devices are required (e.g. RTU) to interface the apparatuses communicating with proprietary protocols, such as Modbus, and to perform the necessary protocol conversion. This problem is more relevant when a communication with the final user is required. Although the existing technical standards (CEI 0-16 and CEI 0-21) prescribe, in some cases, that the user's generator or energy storage system has to be able to exchange data with the DSO, as for now a clear definition of the content of the datum to be exchanged does not exist. Therefore, a protocol profile specific for each product needs to be adopted (with an obvious impact on the replicability of the solutions developed).

4.6 Business Model

The San Severino Marche Pilot is arranged with respect to two different perspectives: the DSO one and the final user one (mainly domestic users).

The first one is devoted to an improvement of the distribution grid efficiency and quality of supply. Such goals drive to economic income of the DSO thanks to the regulatory framework in place in Italy (Res. 646/15/R/eel, Res. 301/2012/R/eel, as detailed in Section 5.5).

Moreover, thanks to an optimal management of the distribution grid, the DSO will be able to increase the Hosting Capacity (capability of the grid to connect new generators) and will minimise grid congestions (thanks to the adoption of energy storage solutions and to the Demand Response platform). This will consequently induce an economic gain thanks to the postponement of the investments for network reinforcement.

On the other side, the end-user will have economic benefits thanks to an effective participation to the Demand Response logic, providing services to the local grid or to the ancillary market. These functions are nowadays under evaluation in the Italian framework, nevertheless the regulatory framework is still not completely defined, consequently emphasising need of the project results to be particularly on-time in order to provide useful on-filed results.

Eventually, thanks to ESS, the end-users will be able to better manage its energy needs in (increasing self-consumption), and consequently minimise the energy bill.

4.7 Replicability/Impact of the Pilot

The Pilot in San Severino Marche is carried out on the distribution grid of San Severino Marche, supplied by the Primary Substation managed by ASSEM.

Actually, in Italy 2500 primary Substations with a very similar architecture are in place. This realistically lead to suppose that the solutions investigated in the Pilot could be easily duplicated at national level. In particular, one of the main outcome of the project will be on the communication protocols; these protocols are directly related to the feasibility of an effective cross-operation of the apparatuses tested. Assuming to obtain positive outcomes from this project, this would be replicated easily at a large scale.

Similarly, Demand Response and ESS integration tests performed in the project will provide on-field data useful to validate the approach proposed and to estimate the technical and the economic benefits at a national level.

4.8 Miscellaneous

San Severino Marche is geographically located in a place subject to seismic and hydrogeological risk (an example is represented by the earthquakes that unfortunately happened tragically in late 2016 and beginning 2017). Thus, the electric grid could be influenced by this natural impact which could cause system reliability reductions.

Although these events are inevitable, their damage to the electrical infrastructure through research and development, demonstration and implementation could be controlled. Hence, the impact of nature is the other issue in this pilot which should be considered in order to provide a reliable and safe electrical grid for dwellers.

5.Survey on the Barcelona Pilot

5.1 Pilot Area Description

A. Area and Geographical Overview

The Spanish demonstration site is placed in Barcelona. It is a sport Centre, which is being currently refurbished under energy efficiency criteria as part of the GrowSmarter project. A number of passive and active refurbishment measures are to be implemented at the Sport Centre finalising in June 2017. Among others, detailed monitoring and energy control system are being implemented.

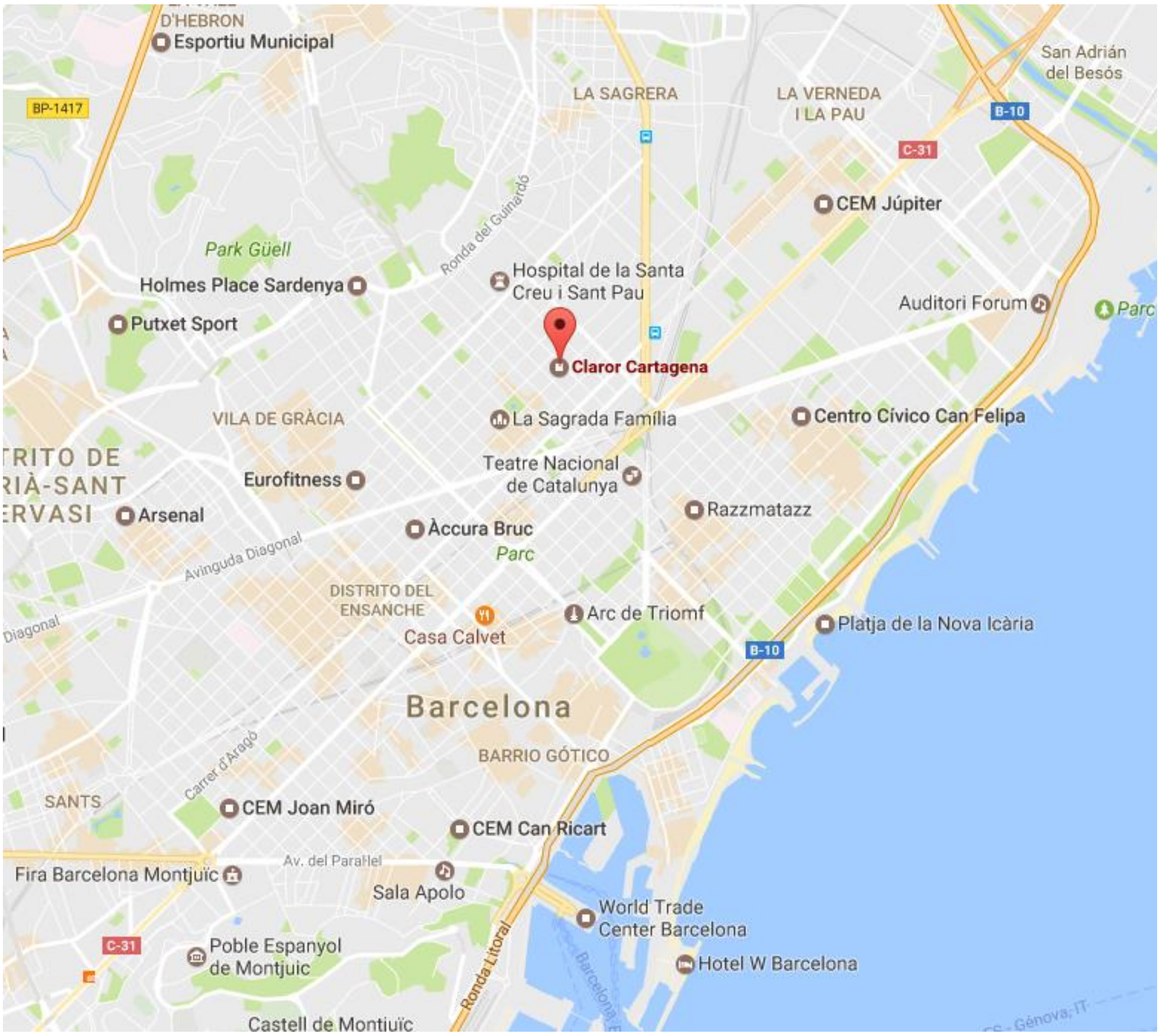

Figure 18. Barcelona Pilot. Sports Centre Claror pilot geographical location

At this moment, gas boilers are being replaced by electrical heat pumps of 240 kW, a new dehumidifier with heat recovery has been installed, and a detailed BEMS system, is being implemented in the Sports Centre. This BEMS system is being designed to be integrated with the inteGRIDy concept.

B. Needs and Opportunities

Energy flexibility and demand response are essential for modern energy markets with the need to manage demand in order to use energy more sustainably and to integrate increasing levels of intermittent renewable energies. In terms of power system IT architecture, it brings with it the need for a new market role, the flexibility aggregator, who in essence bundles volumes of generation or load, or ‘flex’, into tradeable volumes whose value can be maximised.

The main goals of the Spanish pilot site are:

- Support the implementation of the European Third Energy Package and influence on the future regulation design for the aggregator roles and demand response market at national scale.
- Develop internal know-how on the potential services that flexible resources can provide to the Spanish balancing market through the aggregator role. Develop the coordination schemes between DSO and TSO suitable for the Spanish context. Support the development of European standards for smart grid components and demand response in order to ensure European interoperability.

The expected outcomes for GNF is to assess the tools, develop the know-how and validate them on an end-user in order to deploy the aggregator figure in the Spanish Market.

Specific expected outcomes by GNF are the following:

- Deployment, integration and validation of the Cross-functional modular platform developed within the inteGRIDy project, enabling the integration of smart grid technologies, including storage.
- Elaborate a set of recommendations for policy makers in order to contribute to the transformation of the energy market.
- Integrate the tools developed at the inteGRIDy project into the corporate platform in order to deploy and replicate those services to GNF customers.

The partners that will participate in the Barcelona pilot project will be:

Gas Natural Fenosa, as the ESCO that is currently managing the sports Centre, and who is willing to integrate all the potentialities of the inteGRIDy tool, given its role as energy generator (wind parks) and energy trader, in the Spanish market.

Aiguasol, as the engineering consultancy that will develop the demand response models for the sports centre and contribute to integrate electricity and thermal response to the forecasting model that will be used in the inteGRIDy tool.

Table 26. Opportunities and needs of Barcelona Pilot

Opportunities	Needs
Viability to exploit a very big thermal storage using the temperature set-point of the swimming pool	Optimising the cost of heating the pool, in a trade-off between the reducing the electricity cost, shaving peak demands of the heat pumps and profiting from the residual heat from the chiller operating in the gym.
100 kWh Li-Ion batteries	Cost reduction via arbitrage and peak shaving of the grid.
Demand Response from the Centre	The flexibility that the sport Centre can offer, in exchange for lower energy prices, can be of interest, to be able to understand the potential of these type of systems.
Excess electricity available from wind parks	Refurbished wind parks can produce excess energy, which should be taken advantage of.

5.2 Context of the Architecture Proposed

Three different architecture descriptions were developed according to the number of project pillars addressed in this pilot.

A. Demand Response

Table 27. Barcelona. Demand Response architecture description

IEEE 42010 Components definition	Description
System	Spanish market pool, specifically the energy consumption for the Claror Sports Centre.
Environment	Barcelona electricity grid and the HVAC consumption from the Claror Sports Centre in Barcelona.
Stakeholder	Gas Natural Fenosa as ESCO and potential aggregator will make use of the demand response strategies to optimise the cost of energy.
Purpose	Peak shaving. Energy cost reduction. Increase wind parks electricity delivery.
System concern	ESCO reduction in energy cost and increase of R.E. fraction.
Architecture	Thermal storage, electrical storage, W+H meters, detailed SCADA system integration with the operation of the HVAC system, so as to be able to make flexible HVAC set-points. Energy management existing system (following IPMVP for a previous Smart Cities project). PV local production (5 kWp).
Architecture description	Control the HVAC System with the following priorities: • Set-points (with ranges). • Electricity market (arbitration).

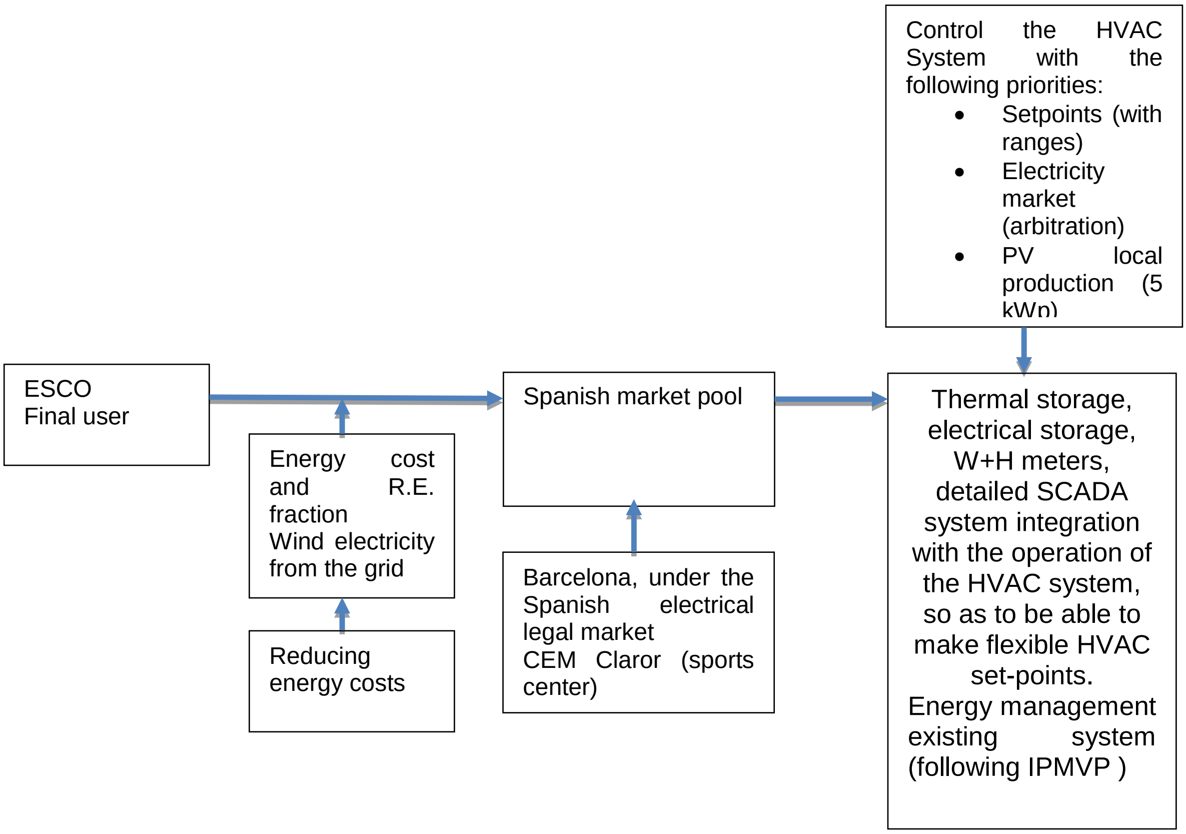

Figure 19. Barcelona. Demand Response system architecture

B: Smartening the Distribution Grid

Table 28. Barcelona. Smartening the Distribution Grid architecture description

IEEE 42010 components definition	Description
System	Electrical aggregated consumptions of tertiary consumers, residential consumers and prosumers.
Environment	Spanish electrical market/wind generators.
Stakeholder	Gas Natural Fenosa as energy generator (wind parks) and energy trader (aggregator).
Purpose	Reducing energy costs and improving % of clean energy. Avoiding grid congestion.
System concern	Energy cost. Congestion of the grid.
Architecture	Electrical meters. Local demand response strategies. Virtual Storage Strategies.
Architecture description	Control the different consumers (DR) and provide energy forecast, in order to:

	• Foresee day-ahead consumption of accumulated users. • Demand Response strategies. • Wind Parks generation forecast.

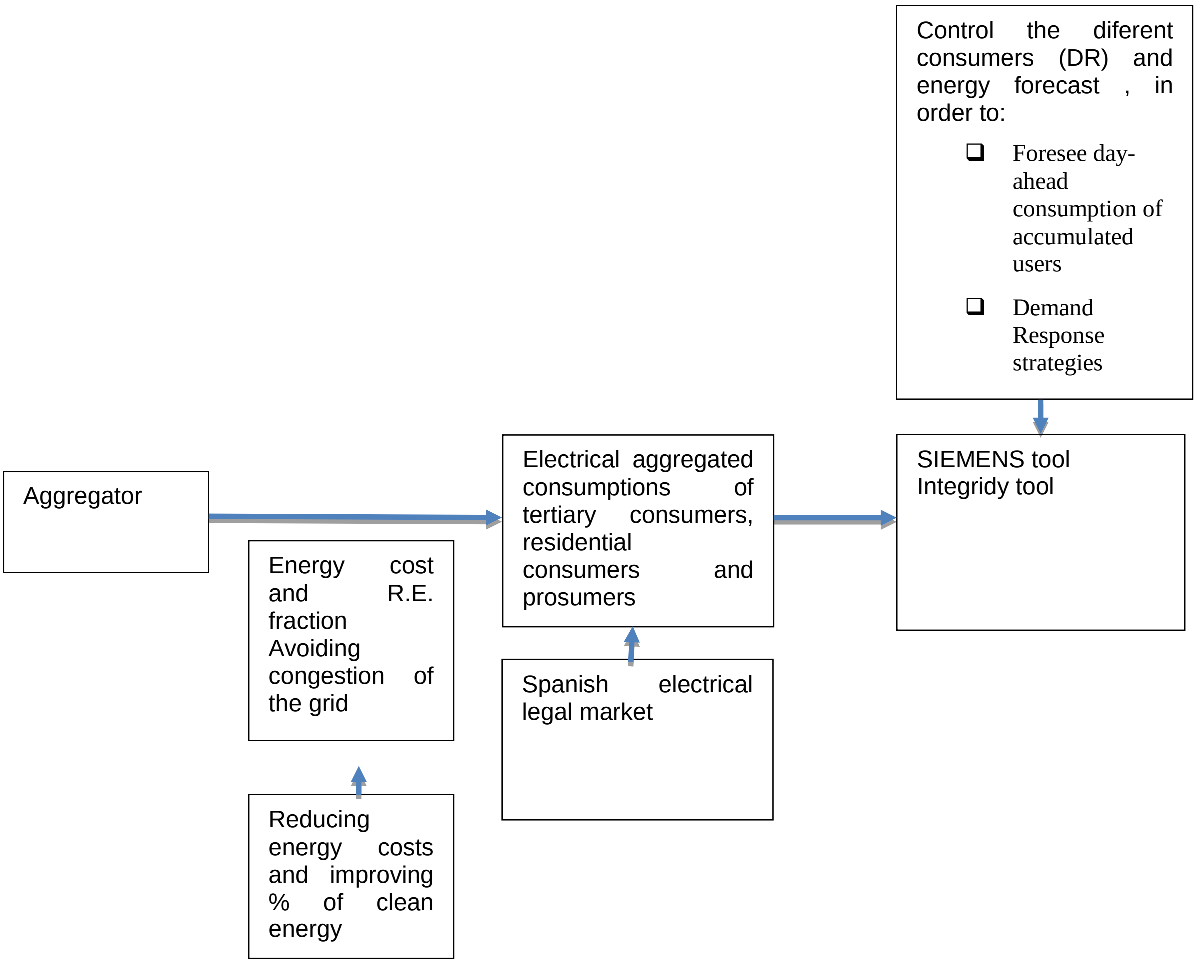

Figure 20. Barcelona. Smartening the Distribution Grid system architecture

C. Energy Storage Technologies

Table 29. Barcelona. Energy Storage Technologies architecture description

IEEE 42010 components definition	Description
System	Thermal and electrical storage.
Environment	CEM Claror (sports Centre).
Stakeholder	Gas Natural Fenosa as ESCO company.
Purpose	Reducing fix and variable energy costs.
System concern	Peak shaving. Energy cost reduction.
Architecture	Thermal storage, electrical storage, W+H meters, detailed SCADA system integration with the operation of the HVAC system, so as to

	be able to make flexible HVAC set-points. Energy management existing system (following IPMVP for a previous Smart Cities project). PV local production (5 kWp).
Architecture description	Control the HVAC System with the following priorities: • Set-points (with ranges). • Electricity market (arbitration). • Peak shaving.

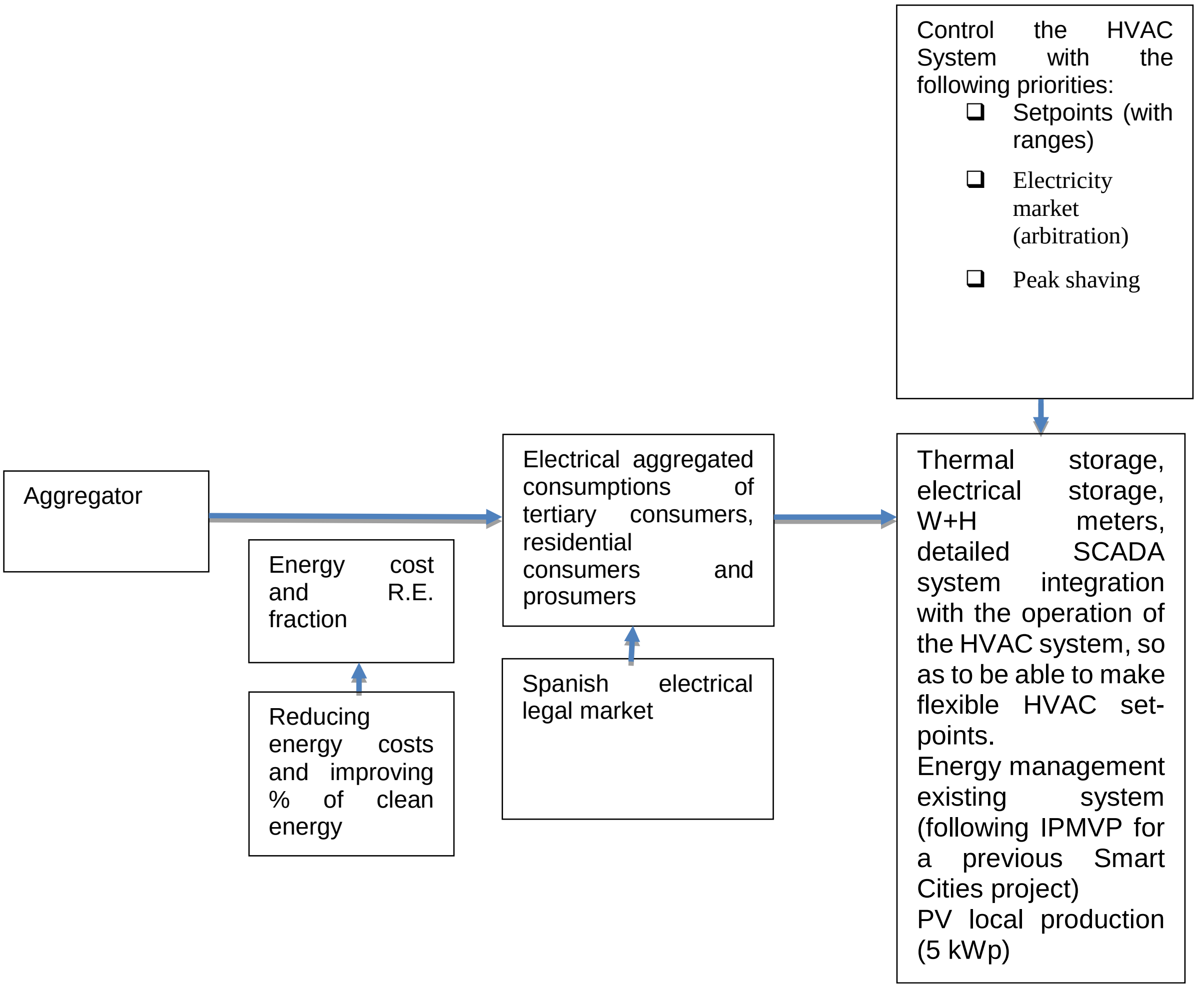

Figure 21. Barcelona. Energy Storage Technologies system architecture

5.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The main goal of the pilot site at Barcelona is to validate the tools developed within the inteGRIDy project, oriented to demonstrate aggregation of a wide variety of load types and products leveraging emerging technologies that are connected and provide a better customer experience. It includes designing, developing, testing and validating operational strategies for load management using the Cross Mutual Platform developed during the project.

On this pilot, the realization of the developed architecture will be deployed in order to demonstrate its feasibility. So, a proof of concept demonstrating the use of the tools developed within the inteGRIDy project will be performed to assess the viability of the platform.

In addition, local optimisation algorithms for optimal management of the building, including the distributed generation and ESS and the Thermal and Electric Synergies, will be tested.

Regarding the market needs, traditionally, the RES shares in electricity generation were low in many European countries. Thus, the markets were not designed with their specific characteristics in mind (variable, non-controllable output), and were focused on day-ahead market. Enhanced market rules might be designed not to interfere with short-term price signals, allowing RES operators/aggregator actors to be subject to efficient short-term prices.

Thanks to the pilot, implementing/simulating the new market mechanisms developed within the inteGRIDy project for the support of renewable generation and storage will be useful to assess the viability of the new market schemas and to influence on the future regulation design for the aggregator roles and demand response market at national scale.

B. Use Cases

- Thermal and Electric Synergies

Temperatures set point modulation for heat pumps and dehumidifiers will be allowed without compromising comfort given the continuous learning algorithms feeding the electric/thermal models of the building. Optimisation of the heat pumps, AC splits and boilers will be done based on energy prices (i.e. gas and electricity) and on the flexibility in the comfort criteria by the final user, as well as demand forecasts.

Moreover, aggregator services will be simulated by means of the simulation module of the inteGRIDy Cross Mutual Platform. Since the current regulation framework does not allow yet in Spain the aggregation of flexibility or demand management processes, a flexibility and demand response simulator tool is needed in order to validate the inteGRIDy ecosystem.

Actually, the "*Flexibility Optimized Management Scenario-based Dynamic Simulation tool*" is intended to be used by the aggregator actor (Energy Service Company, ESCo, within GNF in our specific cases studies) for estimating the effect of aggregation programs, flexibility programs and demand response programs.

Table 30. Barcelona. Use Case BCN_UC01

USE CASE: Thermal and Electric Synergies	
ID	BCN_UC01
Name	Thermal and electrical synergies.
Storyline	Temperatures set point modulation for heat pumps and dehumidifiers will be allowed without compromising comfort given the continuous learning algorithms feeding the electric/thermal models of the building. The use of a swimming pool with a huge inertia will be analysed.
Goal(s)	Optimisation of the effective energy costs.
Actors	Sports Centre. ESCO company.
Preconditions	Heat for the pools is supplied by heat pumps. Set-points are modular.
Postconditions	Heating and cooling set-points vary between some margins to be able to fit inside the comfort criteria.

Trigger events	Variable energy costs between hours.

- Photovoltaic and Electric Storage Optimisation

The following strategies will be tested: peak shaving, load shifting and maximising self-consumption. This will be done based on machine learning algorithms that will learn on consumption demand, photovoltaic generation forecast and energy prices forecast.

Table 31. Barcelona. Use Case BCN_UC02

USE CASE: Photovoltaics and Electric Storage Optimisation	
ID	BCN_UC02
Name	Photovoltaic and Electric Storage Optimisation.
Storyline	The following strategies will be tested: peak shaving, load shifting and maximising self-consumption. This will be done based on machine learning algorithms that will learn on consumption demand, photovoltaics generation forecast and energy prices forecast.
Goal(s)	Optimisation of the use of the PV captured energy.
Actors	ESCO company.
Preconditions	PV system is correctly installed. LI Ion battery is correctly installed.
Postconditions	PV electricity is used when more necessary for cost saving. Day-ahead PV production is foreseen.
Trigger events	Variable energy costs between hours. PV production depending on the hour.

- Uninterruptible Power Supply

Controlled islanding during grid outages. This service depends on the grid's reliability as well as on the potential damage of a grid outage to the specific client. In this case, it will feed a critical demand at the Sport Centre (e.g. emergency lighting, Data Centres, and others to be determined by sport facility managers).

Table 32. Barcelona. Use Case BCN_UC03

USE CASE: Uninterruptible Power Supply	
ID	BCN_UC3
Name	Uninterruptible Power Supply.
Storyline	Controlled islanding during grid outages. This service is dependent on the grid's reliability as well as the potential damage of a grid outage to the specific client. In this case, it will feed a critical demand at the Sport Centre (e.g. emergency lighting, Data Centres, others to be determined by sport facility managers).
Goal(s)	Controlled islanding during grid outages. Energy security of supply.
Actors	ESCO company.

	Sports Centre.
Preconditions	Li-Ion battery and safety system is installed.
Postconditions	Critical demands are fed.
Trigger events	Electricity outage.

5.4 Regulatory Framework

Today, Spain relies mostly on hydro and gas for its flexibility needs. As Spain is evolving towards more distributed energy generation, the need for flexibility is expected to increase in the coming years.

In Spain, demand-side resources are not allowed to participate in the markets, or they are allowed to participate just in one programme. For example, loads can only participate in one specific scheme (interruptible contracts), which is rarely triggered. The rest of the balancing and ancillary services can only be accessed by generation. So, the current flexibility of the Spanish electricity market is low.

Aggregation is not legal in the Spanish electricity system and there is only one scheme allowing Explicit Demand Response: The Interruptible Load programme. The scheme, which is reserved only for large consumers, is managed by the TSO, Red Eléctrica de España. The programme acts as an emergency action, in case the system is lacking generation and the balance resources are not enough. Though annual tests are conducted, this programme has not been called for consecutive years, raising questions whether it is a genuine interruptible load programme or a form of subsidy to the national industry. Proposals to open balancing services to Demand Response could lead to changes in 2016- 2018, especially given that a full smart meter roll-out is expected by 2018.

The legislation should include common rules for the internal market in electricity, in order to reflect the right value of flexibility and enhance participation of generators (conventional and RES), storage and demand response.

The legislation should include, also, the promotion of the use of energy from renewable sources, including storage. For example, In Spain, the present Royal Decree RD900/2016 does not consider net metering, does not promote the storage, and include the “solar tax", which means that consumers (with PV installation) will pay more tolls for system maintenance than other consumers, and also they have least use of grid.

RES should be incentivised to obtain revenues based on participation in markets that would increase RES operational flexibility. RES should have full balancing responsibility and full participation in the provision of balancing and reserve services. RES support mechanisms should become more market compatible.

5.5 Technology Bounds

The main technology innovation to be achieved during the inteGRIDy project will be the development of a platform to harvest the flexibility provided by the distributed energy resources (DERs) in order to provide services to the grid (TSO, DSO and BRP).

The technologies to be used in the pilot case, to exploit the potentialities of the inteGRIDy concept will be:

- Detailed metering of heat and electricity of the pilot case, thanks to a previous SmartCity project.
- Detailed control of all the parameters of the HVAC plant of the Sports Centre, for the previously mentioned concept.
- Li-Ion battery, to be able to act as arbitration agent and peak shaving element.

- PV system, 5 kWp, and its integration in the self-consumption criteria of the sports Centre (management of the non-occupancy hours, given the fact that the Spanish legislation does not facilitate to inject in the main grid PV extra-generation).
- Demand Response criteria, using flexibility supplied by the final user.

At our specific case study, the tools in the platform should be able to optimise battery operation, optimisation of the electric and thermal loads if this is the option selected by the end-user.

The tool for the aggregator will exploit flexibility and maximise the value of flexibility for its customers. Aggregators bundle small flex assets into a flexibility volume.

The tool for the prosumer and the provider of flexibility will have the main features:

- Local optimisation algorithms including operation of the storage, generation, HVAC, lighting.
- Quantification of the baselining to be sent to the aggregator.
- Quantification of the flexibility criteria to be sent to the aggregator.

The tool for the local market evaluates the amount of power and the offer matching for an effective participation to the ancillary services market.

The technological bounds of the pilot project will be related to the integration of the inteGRIDy platform through:

- The fully developed SCADA system integrated in the currently operating HVAC system for the Claror project. It is a tailor-made SCADA platform, based on KNX, that can integrate all BACNET protocols, and KNX protocols, as well as Modbus.
- The current energy benchmarking platform (Dexma) to be installed in the CEM Claror project, integrated with the electrical and heat meters installed.
- The electrical meters.
- The heat meters.

5.6 Business Model

One of the main goals of the Spanish pilot site will be implementing/simulating the new market mechanisms (including the new market role: aggregator) developed within the inteGRIDy project. In our pilot site, the main actors will be:

- Flexibility aggregator → Energy Service Company (ESCo) within GNF.
- Flexibility provider → Claror Sport Centre.
- Flexibility user → DSO Unión Fenosa Distribución.

Changes of regulation design at the Spanish electricity market, availability of the simulation tool developed to be delivered by the inteGRIDy consortium, improvement of internal capabilities and the needed external permits to carry out aggregator services are some requisites to introduce an aggregator role in the Spanish electricity market.

So, an enhanced distribution business model might be designed, taking into account:

- RES, through aggregator actors, should have full balancing responsibility and full participation in the provision of balancing and reserve services.
- DSOs, should be able to send flexibility requests to the aggregator actor, and operate the network considering the flexibility provided by the aggregator.

Thanks to the pilot, it will be possible to analyse the viability of the Energy Service Company (ESCo) within GNF to have an aggregator role in the electric market.

The investment costs of the implementation will be basically the development and integration of the inteGRIDy platform with the existing flexibility providers' tools (BEMs for tertiary users, HEMS for residential).

The revenues from the implementation of the strategies will be different for the various users. The aggregator will obtain economic benefits from a reduced energy price thanks to the displacement of heat demands to hours of lower grid consumption and thus lower prices, the same as the Sports Centre.

The DSO will benefit from a very clear forecast of electric demand from the Centre thanks to the weather forecast implemented together with the models, and the flexibility that the Claror Sports Centre can provide. Costs referring to the flexibility revenues have to be analysed.

5.7 Replicability/Impact of the Pilot

A proof of concept demonstrating the use of the inteGRIDy architecture for network operation, including aggregator services will be performed to assess the viability of the Cross Mutual Platform.

Once the technology is validated through the pilot, the integrated platform developed to the pilot case will be included in the ESCo services portfolio in order to replicate it to all suitable clients.

The solutions to be tested in our pilot site will be replicable to any ESCo or DSO company. Critical requirements will be based on the future design of Spanish electric market regulation.

The local optimisation algorithms developed will be replicable at any other facility with similar loads and thermal/electric demands. Critical requirements to go further and deploy as well as aggregator services will be based on the future design of Spanish electric market regulation.

The result of the implementation of flexibility using the platform will allow the aggregators to improve the market operation, as well as obtaining singular benefits from this closer approximation to demand estimation techniques.

6.Survey on the St. Jean Pilot

6.1 Pilot Area Description

A. Area and Geographical Overview

The pilot St Jean is situated in St Jean de Maurienne, between Lyon, FR and Torino, IT, in a distribution grid managed by INNED (a 100% subsidiary of SOREA, which is a French DSO in the Maurienne valley in the French Alps).

La Maurienne is a French Intra-Alpine valley located in the department of Savoie in Auvergne-Rhône-Alpes region. With a length of 125 km, it is crossed by the Arc river.

Figure 22. St Jean Pilot geographical location

This region is a mountain region where tourism is then particularly developed in winter with ski resorts. 3 ski resorts have their electricity distributed by the INNED grid: Valloire, Valmeinier and Les Karellis.

The grid is divided in 2 sub-grids: the main one is supplying 14.000 yearly customers. The second sub grid is supplying the ski resorts and few (1000) yearly customers. The peak power in winter results around 3pm (ski lifts in ski resorts) and 10pm (electrical heating in ski resorts)

The 2 sub-grids are interconnected and supplied by 2 stations (63 kV - 20 kV) and have 309 substations (20 kV - 400 V) along with the on-grid PV and hydro plants. The hydro production is located in the Maurienne Valley with a part of PV production (40 systems from 9 kWp to 250 kWp).

The following graphs show the production and consumption for a typical day in January and May on the grid in Maurienne.

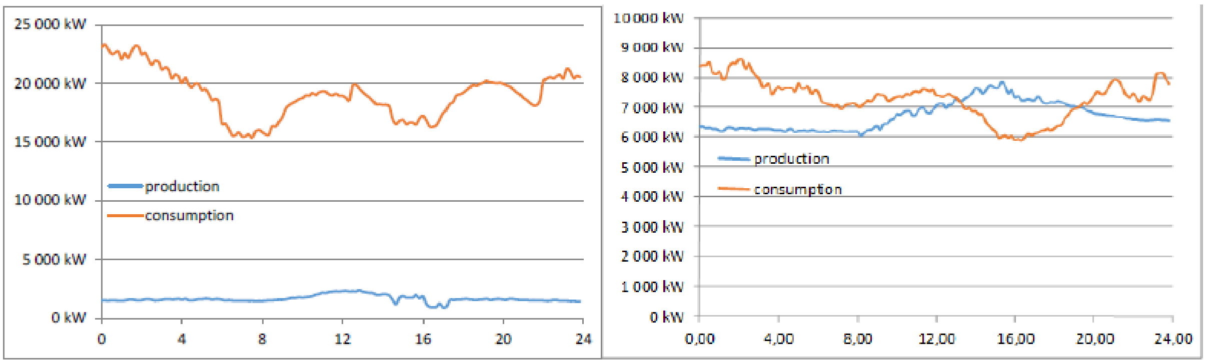

Figure 23. St. Jean. Consumption and renewable production.
Left: on January 1st 2015, Right: May 1st 2015

B. Needs and Opportunities

Addressing the role of INNED (acting as a local DSO with connection points to the rest of national network), we are highlighting the needs and objectives of the pilot site.

The main objective is to reduce network charges of local DSO, by better balancing energy imports and exports at the different connection points of the network. Larger variability of network flows increases peak demand for network capacity and lowers average network utilization, making network investments less profitable and requiring flexibility to keep network operation in control. For the same reason, network congestion occurs more frequently at a wider variety of locations and at different times. Lower predictability of power supply increases demand for system balancing as well as demand for ancillary services, such as voltage control.

Towards this direction, we have to take into account the particularities of demand in the Pilot site, and enable the deployment of a demand side management framework. With the advent of intermittent generation, whereby production varies with weather conditions such as wind power and solar irradiation, there is a further increasing need for flexibility in the power system value chain to maintain competitiveness and security of supply.

Therefore, unlike the practice was before, DSOs may deploy flexibility services for congestion management in day-to-day network operation in order to save on network reinforcements that would be used only occasionally or to a very limited extent. Moreover, DSOs may need flexibility services to fulfil some system operation tasks at the distribution network level such as balancing, which are currently only performed at the transmission level without the active participation of demand and generation facilities connected at the distribution level.

Regarding the pilot general architecture, although distributed sources allow the delivering of energy from renewables, the grid is connected to the upstream national distribution grid managed by ENEDIS through seven delivery points and to the national transport grid managed by RTE through one delivery point. Thus, these 8 delivery points get for each one some contract characteristics, which are mainly:

- The subscription rate for a registered power with a special rate when the consumption goes beyond this power.
- The tariff of public use of electricity TURPE depending on the voltage at the point of connection, as described in the diagram.

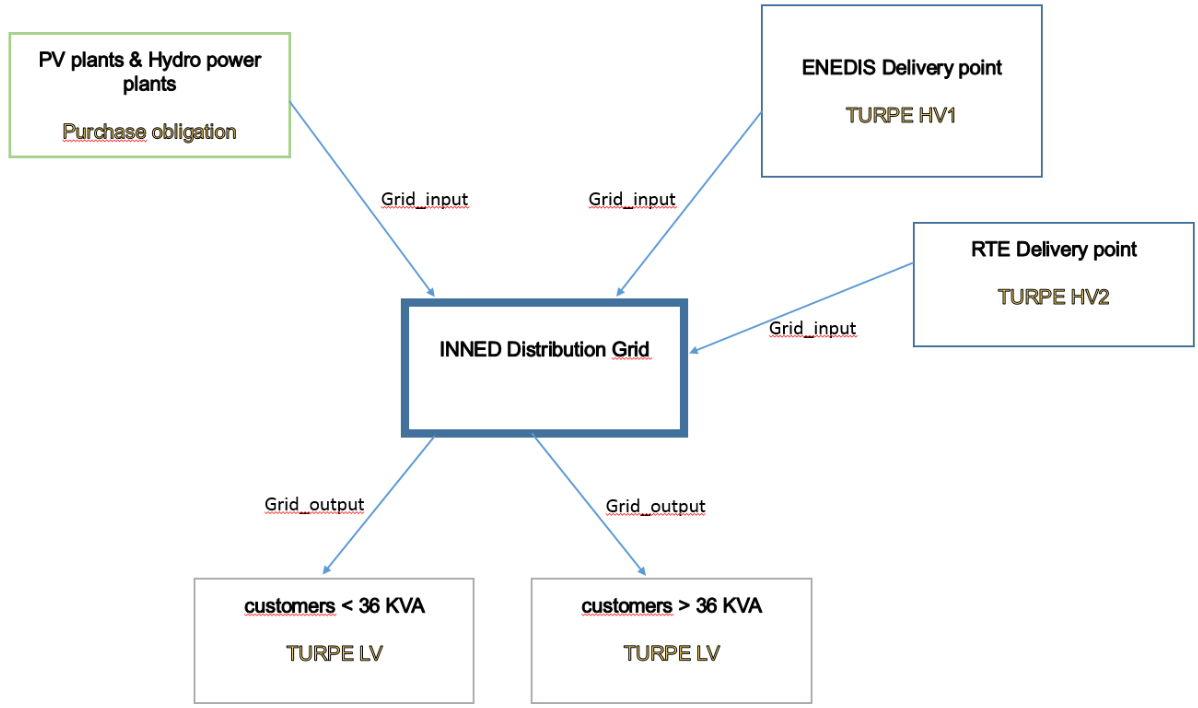

Figure 24. St. Jean. Overall scheme of the electric grid in the area of the St. Jean Pilot

On the diagram above, it is shown public tariffs relative to the use and distribution that are to be paid to the upstream grid (TURPE High Voltage 1 High Voltage 2) and tariffs paid by INNED customers (TURPE Low Voltage).

Moreover, energy from RES doesn't require any distribution tariff to pay as it is by nature a production source geographically present on the grid. Nevertheless, it has to be taken in account that all these production sources need grid reinforcement regularly and could require a substation construction in the future.

Table 33. St. Jean. Opportunities and needs of St. Jean Pilot

Opportunities	Needs
Demand Response to address grid network constrains	As highlighted above, the goal is to enable the implementation of Demand Side Management strategies towards addressing grid constrains due to the structure of the network managed by INNED in FR pilot site.
RES (Hydro, Biomass, Photovoltaic) availability in a rural area	In addition to the need for optimal grid management as presented above, the pilot case has to face with the issues of renewables sources already available on the grid → Demand Side Management to enable a better balancing between production and consumption for the different types of demand (depending on the season's periods).
End user participation to the ancillary market	End user profiles will be extracted to preserve end users' needs and preferences. Demand Response strategy will take into account demand capability relative to weather conditions and occupant comfort preferences.
Properly exploit energy storage options	In order to ensure objective, the potential of the building should be used with devices such as HVAC and water heaters to address virtual energy storage. This is one of the main innovations of the

	project, to incorporate in the decision-making process the potential of the buildings to act as batteries.

6.2 Context of the Architecture Proposed

Different pillars for demonstration in the pilot site could be summarised as listed in the following:

Demand Response

- Accurate prosumers' energy behaviour and comfort modelling towards the extraction of context-aware demand flexibility profiles.
- Prosumers' flexibility clustering, classification and prioritization for the provision of different services to the distribution grid (balancing, ancillary services).
- Demonstration of Automated (Human-Centric) DR Schemes.

Smartening the Distribution Grid

- Tools and methods for analysing and forecasting demand flexibility even in the short-term.
- Tools for optimal VPP configuration based on evolving requirements of the distribution grid and available flexibility sources and their characteristics.
- Tools and techniques for internal optimisation and dispatching between different flexibility sources at various spatial/temporal granularity.

Energy Storage Technologies

- Modelling the thermal behaviour of buildings to identify thermal mass and inertia characteristics and assess their capabilities to virtually storage energy and provide flexibility.
- Demonstration of innovative power-to-heat solutions resulting from the project for VES in buildings through optimised HVAC and water heaters control.
- Coordination with DR solutions to optimise Smart Grid operations and minimise intrusiveness in occupants' premises and compromises in their comfort.

By taking into account the aforementioned high-level functionalities, we are defining the context of the architecture for the pilot site.

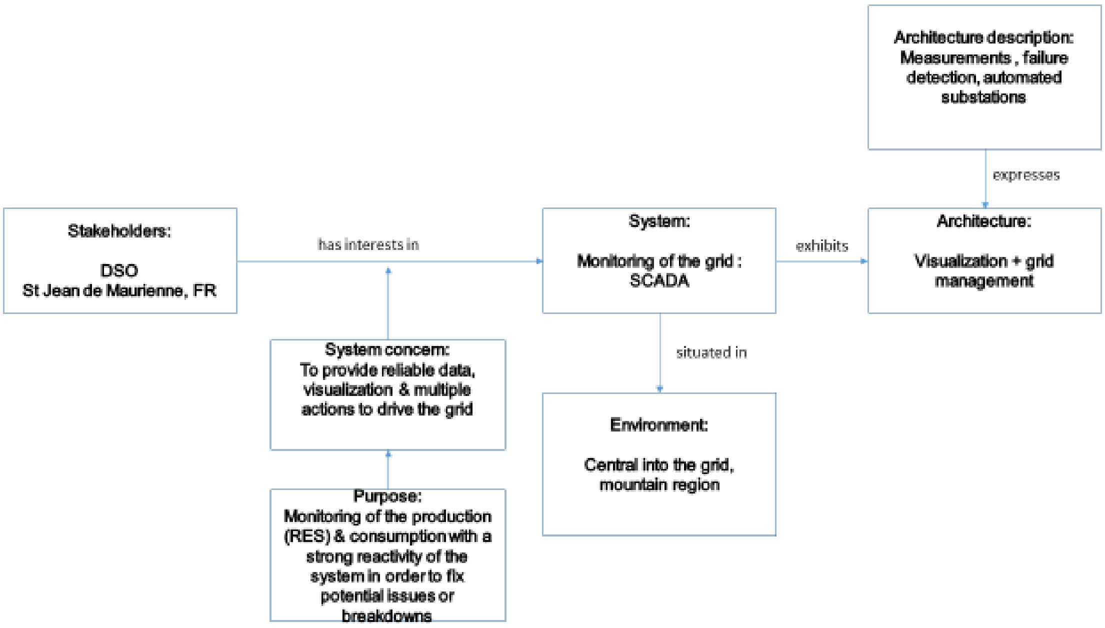

Figure 25. St Jean Pilot system architecture

Table 34. St. Jean. Demand Response architecture description

IEEE 42010 components definition	Description
System	Accurate customer and demand profiling towards the extraction of context based flexibility profiles that will facilitate the implementation of DSM strategies.
Environment	Portfolio management with potential of demand flexibility to enable the implementation of DSM strategies.
Stakeholder	DSO acting as DR aggregator towards optimally managing the portfolio of consumers/prosumers (and final users).
Purpose	The purpose is to enable a better management of demand flexibility, fully preserving end users' needs and requirements.
System concern	Through the extraction of accurate customer and demand profiles, we enable a better portfolio management exploiting the potential demand flexibility.
Architecture	Extraction of comfort profiles and context based demand flexibility profiles towards optimal portfolio management.
Architecture description	Sensors, actuators and metering devices to enable monitoring and control at sub-metering level (special focus on monitoring HVAC and lighting devices operation).

Table 35. St. Jean. Smartening the Distribution Grid architecture description

IEEE 42010 components definition	Description
System	Optimal VPP configuration and operation by taking into account grid requirements and constrains.
Environment	Portfolio of prosumers with demand flexibility potential, DSM by taking into account DSO business objectives and needs.
Stakeholder	DSO (and final users).
Purpose	The purpose is to enable the implementation of DSM strategies towards addressing DSO business needs and objectives.
System concern	To enable the establishment of a coordinated framework towards better managing the potential of demand flexibility of customers to meet grid constrains.
Architecture	Tools and methods for 1) analysing and forecasting demand flexibility that will further 2) facilitate the coordinated management of groups of prosumers by taking into account DSO business objectives 3) towards triggering the associated DSM strategies in an automated way.
Architecture	By taking into account the extraction of context based flexibility profiles

description	in previous use case, we incorporate them in the DSO business framework. More specifically, we consider the pilot specific business needs and requirements towards enabling an optimal management of prosumers (with flexibility potential) through the implementation of automated DR strategies to meet the business scenarios examined in FR pilot site.

Table 36. St. Jean. Energy Storage Technologies architecture description

IEEE 42010 components definition	Description
System	Accurate customer and demand profiling towards the extraction of context based flexibility profiles with special focus on VES device operation.
Environment	Special focus to devices with thermal inertia (HVAC and water storage).
Stakeholder	DR aggregators with special interest to VES device monitoring and control (end users).
Purpose	Introduce VES concept towards enabling the implementation of demand shifting strategies.
System concern	HVAC, Building Thermal mass and Water Heaters with potential of VES.
Architecture	Modelling of thermal behaviour of buildings to identify thermal mass and inertia characteristics and assess their capabilities to virtually energy storage.
Architecture description	Monitoring and accurate modelling of HVAC and water heaters (with focus on demand shifting potential) towards integrating these devices as part of a holistic DSM framework.

6.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The main goal of the pilot at St Jean is to evaluate the impact of demand response strategies in real-use conditions. The pilot site will give the chance to stakeholders to examine carefully the performance of individual, structural components of the scheme, but also its overall behaviour. Furthermore, the pilot will give a chance to validate a concrete business model that will be taking in to consideration the actual French regulatory framework and the operational needs (as defined above) of INNED as a business stakeholder (DSO).

Taking into account the different business objectives of the pilot site, special interest is delivered on the evaluation of Explicit Demand Response schemas, through the establishment of a direct load control mechanism.

In Explicit Demand Response schemes, consumers receive payments to change their consumption patterns upon request, triggered by, for example, the activation of balancing energy or a constraint on the network. To achieve the establishment of this framework, it is necessary to set in place a Demand Side Energy Behaviour Profiling Mechanism, that will allow for the assessment of occupants' general behaviour under given ambient conditions and consequently carve out an appropriate DR strategy.

The main innovation of the proposed framework is the incorporation of occupants comfort boundaries in the decision making process. Every demand shifting/shedding/curtailing action (as part of DR) causes discomfort. So, we need to somehow quantify the comfort/discomfort boundaries, to further quantify how much we can change demand ensuring the minimum of end users discomfort. Towards this direction, models and tools will be developed for the extraction of an automated comfort profiling framework. The activity will focus on the definition of accurate context-aware prosumer profiles, utilising data from ambience sensors (humidity, temperature, etc.) and control actions of occupants over major building loads.

By incorporating prosumers profiles with accurate load profiles, we can further estimate the potential of demand flexibility of occupants under specific ambient conditions thus deciding on optimal (context aware) demand response strategies. Such profiles will be introduced in the DR optimisation DSS, so as to enable the deployment of human-centric demand response control strategies over HVAC and lighting loads, that allow for the utmost exploitation of consumers' flexibility (individual and aggregated) to address critical grid conditions, without compromising occupants' comfort. Demand flexibility profiling models will be configured during the project to address dynamic occupancy contexts and evolving weather conditions in the pilot sites.

Partners involved in pilot 5 are:

- INNED (France): in charge of the pilot implementation and evaluation of the technical solution in premises.
- TREK (Greece): as the technical partners in charge of the technology provided to the pilot site towards testing the innovative demand side management framework introduced in the project.

B. Use Cases

Table 37. St. Jean. Use Case INN_UC01

USE CASE: Demand Response	
ID	INN_UC01
Name	Explicit Demand Response in residential and commercial premises.
Storyline	The main objective of this use case is to enable the implementation of automated Demand Response strategies in a seamless way. The main innovation of the proposed framework is the incorporation of occupants comfort boundaries in the decision making process towards establishing a demand side management framework fully preserving end users' needs and preferences.
Goal(s)	Accurate prosumers' energy behaviour and comfort modelling towards the extraction of context-aware demand flexibility profiles to facilitate end-users participation in DSO triggered DR campaigns.
Actors	Consumers/Prosumers. DSO acting also as the DR aggregator.
Preconditions	Monitoring and control equipment installed in premises. Integration of equipment to the inteGRIDy platform. Context Based Demand Flexibility profiling engine available.

Post-conditions	Demand flexibility profiling models that will be configured to address dynamic occupancy contexts and evolving weather conditions in the pilot sites.
Trigger events	DSO triggering DR campaigns to address specific business objectives. The selection of best fitted DR strategies takes into account the extraction of context-aware demand flexibility profiles.

Table 38. St. Jean. Use Case INN_UC02

USE CASE: Smartening the Distribution Grid	
ID	INN_UC02
Name	Demand flexibility analysis and forecasting.
Storyline	Based on the consumers' profiling extracted from previous use cases, a set of algorithms will combine load models and their behaviour when subject to demand response events towards enabling a better management of portfolio. This use case is about the daily operation of DR aggregators towards better managing portfolio performance.
Goal(s)	To provide a tool that enables a better management of portfolio performance and facilitates the implementation of DR strategies.
Actors	DSO acting also as the DR aggregator.
Preconditions	Monitoring and control equipment installed in premises. Integration of equipment to the inteGRIDy platform. Context Based Demand Flexibility profiling engine available. Demand Flexibility Analysis and forecasting engine available.
Post-conditions	Analytics engine to facilitate decision making under different market and building operational conditions.
Trigger events	The business stakeholders access the system to perform analytics over portfolio data.

Table 39. St. Jean. Use Case INN_UC03

USE CASE: Energy Storage Technologies	
ID	INN_UC03
Name	VES in Buildings through optimised HVAC and water heaters control.
Storyline	This is a vertical use case examined in FR pilot site to evaluate the impact of energy storage as an inherent component of future grids. Using the thermal models (previously generated) in combination with other data sources, we will infer the thermal properties and the heating dynamics of the building. The resulting profiles are used for the demonstration of innovative power-to-heat solutions resulting VES in buildings through optimised HVAC and water heaters control.
Goal(s)	To examine the potential of controllability of thermal inertial devices under

	demand side management strategies (demand shifting potential).
Actors	Consumers/Prosumers. DSO acting also as the DR aggregator
Preconditions	Monitoring and control equipment installed in premises for managing devices with thermal inertia. Integration of equipment to the inteGRIDy platform. Context Based Demand Flexibility profiling engine available.
Post-conditions	Demand flexibility profiling models that will facilitate the implementation of demand shifting strategies in an automated way by exploiting thermal inertia of specific devices in premises.
Trigger events	DSO triggering demand shifting strategies towards exploiting the potential of inertial devices in premises.

6.4 Regulatory Framework

In France, the connection consists of linking a production or consumption installation to the public electricity grid. It is a prerequisite for access to the network, whose transparency and non-discriminatory nature are guaranteed by the Energy Regulatory Commission (CRE).

RES must be connected to a public or private electricity grid so that the electricity they produce can be sold, on the markets or on a contractual basis, in particular through mandatory purchasing or tendering mechanisms, in order to have this energy used by consumers connected to the grid.

Regarding regulation and financing, there is currently in the French context a specific means: the Tariff of Use of the Public Electricity Networks (TURPE). This tariff must cover the R&D expenses of the network operators, as well as the experimental cost of new smart meters.

However, as R&D is a fundamental preliminary step in the development of smart grids, it must be consider if additional incentives are needed. For instance, England has set up an investment fund dedicated to innovative projects to reduce greenhouse gas emissions.

Today, the CRE gives a particular importance to the modernization of networks and tries to control the technological and economic risks associated with investments in smart grids by framing experiments. It aims at covering then the deployment costs of new meters with the TURPE. Moreover, the deployment is submitted on the CRE approval and the final approval of the Energy Minister.

In this context, the French regulatory system must progress to create favourable conditions for the development of smart grids. This is why a specific tariff has been set up from 2017 to 2021 (called "TURPE 5"), so that network operators can have the resources to support the research and development and deployment costs of smart grids.

Regarding smart meters and Demand Response regulatory framework, the implementation of these metering systems by public DSOs is framed by several laws and regulations coming from EU directives (2006/32/CE and 2009/72/CE) that set general objectives for these systems and define tasks entrusted to network operators.

In particular, the order of 4 January 2012 issued from Article 4 of Decree No 2010-1022 of 31 August 2010 states that “The metering devices used by public DSO at points for connecting users to low-voltage (LV) public networks and from powers less than or equal to 36 kVA shall be capable of measuring and recording the three times: time, half-hourly, ten minutes and the maximum value of the power consumption. In the event of an injection, the counting devices also measure and record the measurement curve, as well as the maximum value of the power injected."

The metering devices put in place by the operators of public electricity networks must be interoperable and must allow in particular:

- downstream of the meter, energy suppliers, service operators or equipment to provide network users communication equipment that is identical throughout the country, allowing direct access to the data via the local communication interface;
- upstream of the information systems of the network operators, where energy providers can recover the customer's metering data through standardised data exchanges throughout the national territory.

Cooperation between the countries is essential. The lessons of current and future demonstrators, in France and abroad, will allow refining the regulatory and cost-benefit analyses decisive for the deployment of smart technologies.

6.5 Technology Bounds

By having defined the list of use cases to be examined in FR pilot site, we are briefly describing the list of technological components that consist of the pilot specific inteGRIDy framework.

- Prosumer Profiling Models and Mechanism

The extraction of thermal and visual comfort profiles will be achieved through the real-time monitoring of environmental (temperature, humidity, luminance) and operational (HVAC, water heater, lighting devices) conditions within the selected buildings. This will be possible with the use of wireless, internal climate measurement devices.

The occupants will not have to explicitly define specific operational profiles, instead these will be defined by continuously monitoring user control actions and also reactions (corrective control actions) to specific automated control operations.

Basic operational profiles will be initially defined and then fine-tuned and continuously calibrated by monitoring occupant control activities under specific environmental conditions or other demand response related triggers).

Towards the extraction of prosumers profiles, environmental sensing (temperature, humidity and luminance) and control (users' interaction with lighting and HVAC devices) equipment needs to be installed in premises. The equipment will be further integrated in the inteGRIDy platform towards enabling the extraction of operational profiles.

- Demand Flexibility Analysis and Forecasting Module

The focus of this module is on the incorporation of the user behaviour models (Prosumer Profiling Models and Mechanism), towards defining robust and dynamic demand profiles, which will lead to the delivery of Context-Aware Load Flexibility Profiles, reflecting real-time demand flexibility as a function of multiple parameters, such as time, device operational characteristics, environmental context/conditions and individual/group occupant comfort preferences. The main idea behind this modelling framework is the extraction of Demand Flexibility Profiles (real time analysis and short-term demand flexibility forecasting) as a function of contextual conditions.

Apart from the extraction of prosumer profiles, prerequisite is the installation of energy monitoring equipment towards the extraction of semantically enhanced device profiles that will further enable the calculation of Context-Aware Load Flexibility Profiles

- Dynamic Thermal Building Modelling Component

The role of this component is to take into account time series of indoor/outdoor environmental conditions associated with HVAC device operation towards modelling in a dynamic way for the thermal parameters of the building.

In addition, the role of this component is to act as the simulation engine that will facilitate the real-time analysis of building thermal conditions, enabling the accurate forecasting of thermal losses/gains of the building.

Towards the extraction of accurate Thermal Building Modelling, sensing equipment needs to be installed in premises, further integrated in inteGRIDy platform. In addition, knowledge of building static information (size, structure etc.) is considered as a main prerequisite.

- DR Optimisation and Signal Dispatch Module

There are two core services offered by this module:

DR Strategies Optimisation. This service is performed by taking into account the demand flexibility potential of the portfolio and the DR needs from external stakeholders.

Signal Dispatch Module. By having defined the optimal DR strategy, the role of this component is to trigger the associated signals and further accurately monitor the active enrolment of prosumers/consumers in DR campaigns.

Complementary to real time decision making, data analytics will be performed over streams of data from different end points. Enriched visualization techniques will present the outcomes of the analytics process in a visually appealing way allowing for quick and accurate decision making. The role of this module is to act as the front-end and DSS tool for the pilot site. Towards this direction, access on raw (device level) and processed (as extracted from the aforementioned model components) is required to enable business analytics and decision making towards the implementation of best fitted demand side management strategies.

Essentially, interoperability of apparatuses could be a technological bound in the Pilot, e.g. it will be necessary to adopt electric devices such as HVAC, water heating and lighting that can be further controlled through the installation of a building automation equipment in premises.

6.6 Business Model

The energy provider revenues are related to the sales of the energy directly to end-users. Actually, the following points should be considered for this pilot economics in the framework of the project in order to constitute the new business model:

- Get the best energy level possible for critical demand peaks avoidance (Demand Response strategy in buildings is one of the solution chosen to be implemented in this pilot).
- Smart meters to have a better understanding of the grid breakdowns and to be able to fix the issues faster. This point could be considered to improve the quality of the service provided to customers. It should be the way of being more flexible and faster to answer easily to users' recovery after breakdowns or any subscription change request.
- Fraud: Smart meters could determine in a precise way the consumptions at each point of the distribution. This function will contribute to limit frauds (nowadays in France frauds impact for about 3% of the total amount of electricity).

Furthermore, thanks to previous experimentations, it should be noted that the economic benefit is mainly concentrated on DSO activities, especially with the use of Demand Response which is the main asset of the pilot. However, several functionalities will then be provided to the final users with smart meters and will allow that ones to be more involved in their consumptions with the capability to optimise day by day users' behaviour.

6.7 Replicability/Impact of the Pilot

The use cases examined in this specific pilot are specific, about real time monitoring of load devices and contextual conditions in premises; therefore, replicability in other pilot sites is not doable, because specific equipment is required.

In general terms and beyond the inteGRIDy project limits, to fulfil Europe's energy goals and political promises, it will not be sufficient to engage just one group of consumers, in one programme type, for one market. The full range of demand-side resources available must be engaged, and the full range of consumers must have the ability to benefit from their flexibility. This will require both Explicit and Implicit Demand Response.

7.Survey on the Nicosia Pilot

7.1 Pilot Area Description

A. Area and Geographical Overview

The Cyprus pilot will test two different pilot cases. The first one regards the microgrid within the campus of University of Cyprus (UCY) in Nicosia city, while the second one regards dispersed prosumers within the Cyprus island. The selected prosumers will have a photovoltaic (PV) installation with two separate smart metering infrastructures, in order to have access both to production and consumption data. They will be selected to be in the district area of Nicosia and Larnaca. These two different sites have been proposed for reasons of having different weather conditions, while being close to UCY. Furthermore, the selected prosumers will not be supplied by the same distribution feeder. The impact of the proposed solutions to a single feeder of the electrical grid will be examined within the university microgrid test case.

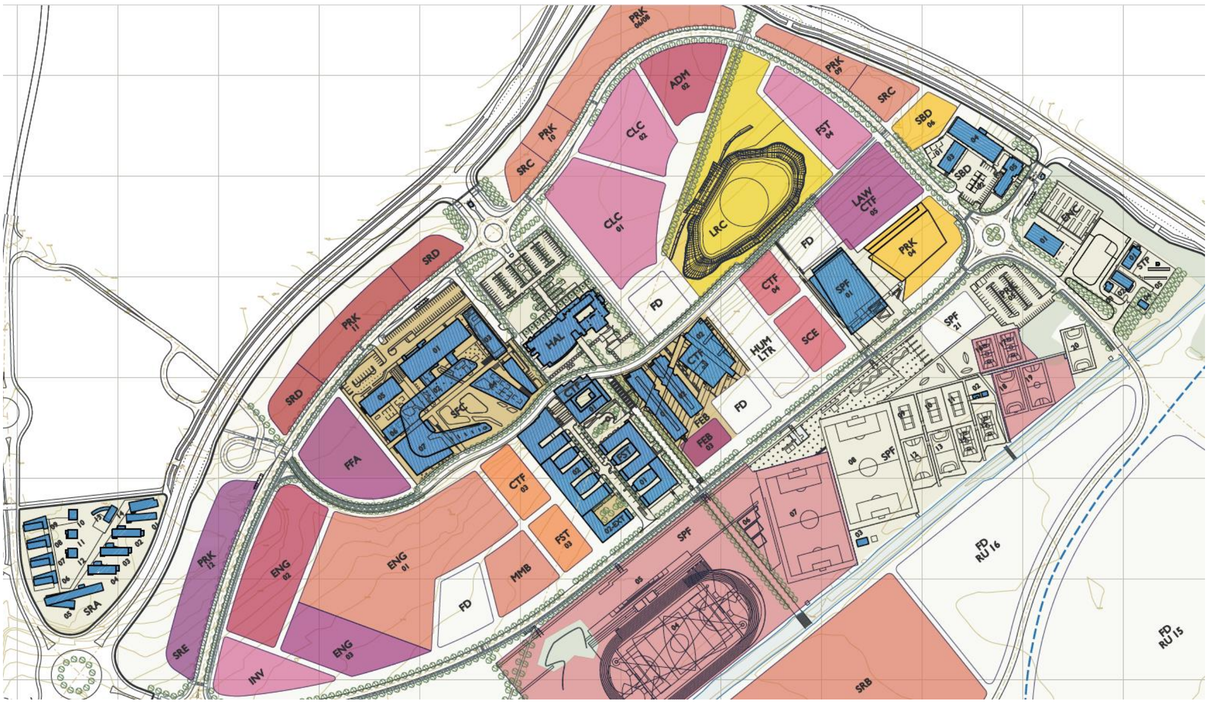

Figure 26. Nicosia Pilot. UCY master plan

B. Needs and Opportunities

The electrical grid of Cyprus is not interconnected with other electrical grids and is operated islanded. Therefore, it can be regarded as a weak one. For this reason, the increased penetration level of renewable energy sources (RES) has caused serious issues, such as power system stability problems, grid congestions, increase of the spinning and non-spinning reserves, frequency deviations, voltage profile violations, high-order harmonic pollution, voltage unbalance etc. In order to alleviate these problems and further promote the renewable energy production, the current and new RES installations should adopt a more grid-friendly nature. The distribution grid operator (DSO) of Cyprus (named Electricity Authority of Cyprus, EAC) is also a partner in inteGRIDy project and will support all these actions. EAC has also installed several weather stations within Cyprus (17 weather stations) in order to acquire information and support analysis work, the functionality of a forecasting tool for PV generation and intraday operation. The weather forecast is used for providing information about the intraday energy forecast of the PV installations and help the DSO to schedule better its resources and optimise generation availability. This forecast information can be utilised by the local energy management system of the microgrid and the prosumers, in order to become more efficient. Furthermore, these microgrid and prosumer installations can send feedbacks from the sensors installed at their premises, in order to increase the reliability of the forecasting tool.

The University of Cyprus is selected as a pilot site, since it is in the transformation phase to become a “living lab”. Currently, more than 400 kWp PV are installed both on rooftops and in terrain. Furthermore, many buildings within the university campus have Building Energy Management Systems (BEMS) for controlling the heating/cooling needs. For the next years, a large PV park (10 MWp) and a battery storage bank (1 MWh) are going to be installed within the university campus, enabling the microgrid operation. The monitoring of the microgrid will be carried out through sensors and advanced smart metering infrastructure, placed in several nodes within the campus. A single point of collecting the measurements and take the respective control decisions is needed.

Furthermore, the increased usage of electrical vehicles (EV) is on the rise in Cyprus. Currently, there are 15 EV public charging stations, where 8 of them are located in Nicosia. Within the university campus a charging station is going to be installed next to FOSS premises.

Concerning the prosumer case, many domestic consumers in Cyprus have installed rooftop PV systems in order to reduce their total cost of electricity. The nominal power of the PV system is usually around 3 kWp. Therefore, 20 prosumers with 3 kWp PV installation will participate in collaboration with UCY in inteGRIDy project.

All the aforementioned issues make the Cyprus electricity grid ideal for testing the advanced equipment of inteGRIDy project.

Table 40. Opportunities and needs of Nicosia Pilot

Opportunities	Needs
Alleviate the grid problems caused by increased RES penetration	Implement grid-friendly demand response strategies.
Increase the RES penetration (mainly solar)	Give incentives for self-consumption to the domestic prosumers with Time-of-use (ToU) and dynamic pricing tariffs.
Contribute to the grid stability	Create controllable energy entities (e.g. microgrids) which will be able to operate both grid-connected and islanded, while the installed energy storage will provide ancillary services to the grid (power smoothing, frequency support, correction of the voltage violation, harmonic attenuation, etc.).
Create new business models for adopting demand response schemes	Increase the energy storage installations (e.g. electrical vehicles, domestic batteries with PV) and install energy management systems (EMS) for increasing the efficiency of the domestic prosumers.

7.2 Context of the Architecture Proposed

A. Smartening the Distribution Grid

Table 41. Nicosia. Smartening the Distribution Grid architecture

IEEE 42010 components definition	Description
System	In this project pillar, the microgrid is the system, consisting of the controllable (BEMS) and uncontrollable energy consumption, energy production (PV) and energy storage.
Environment	A central microgrid control point will be able to monitor and supervise the energy flow within the microgrid, increasing the overall operational efficiency of the whole microgrid.
Stakeholder	The microgrid will trade ancillary services with the DSO, according to the respective grid requirements, while the University will increase its self-consumption and decrease the total cost of electricity.
Purpose	The main purpose of this activity is the monitoring of the energy production, consumption and storage, while all technical constraints will also be monitored (e.g. voltage magnitude at PCC, frequency, THD, VUF, etc.).
System concern	Stakeholders concerns in maximising the efficiency of the operation of the microgrid, while providing ancillary services to the utility grid.
Architecture	Storage, meters, ICT and energy management in order to monitor, control and optimise the performance of the system by using innovative technology.
Architecture description	Sensors will be placed within specific identified nodes within the microgrid, in order to monitor the respective parameters. Furthermore, at the points of production and consumption, smart meters are going to be installed.

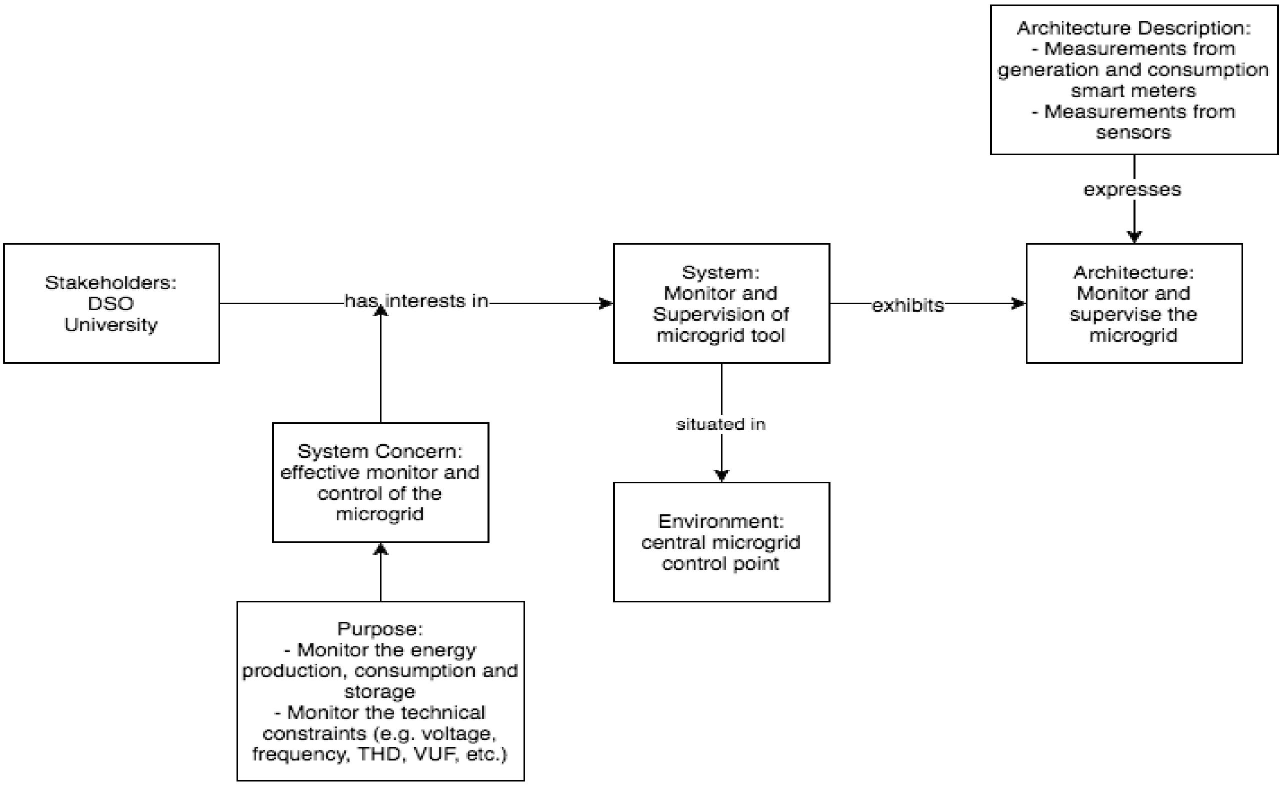

Figure 27. Nicosia. Smartening the Distribution Grid system architecture

B. Microgrid Demand Response

Table 42. Nicosia. Microgrid Demand Response architecture

IEEE 42010 components definition	Description
System	In Demand Response tool, the BEMS of the several buildings will be controlled towards the needs of the microgrid.
Environment	All BEMS will be controlled by the central point of the microgrid control, where a unique integrated control system will be located.
Stakeholder	The microgrid will trade ancillary services with the DSO, according to the respective grid requirements, while the university will increase its self-consumption and decrease the total cost of electricity.
Purpose	The main purpose of this activity is the trading of flexibilities through the microgrid demand. The energy consumption profile of the microgrid will be fully controllable.
System concern	The DSO will have direct access to the demand of the university microgrid, being able to trade the demand flexibility with it. As a result, the peak demand will be decreased, while the microgrid will operate with increased self-consumption.
Architecture	Smart control of the energy production and consumption.
Architecture description	The placed smart meters and sensors will help the demand response tool to activate its control potentials, according to DSO requirements.

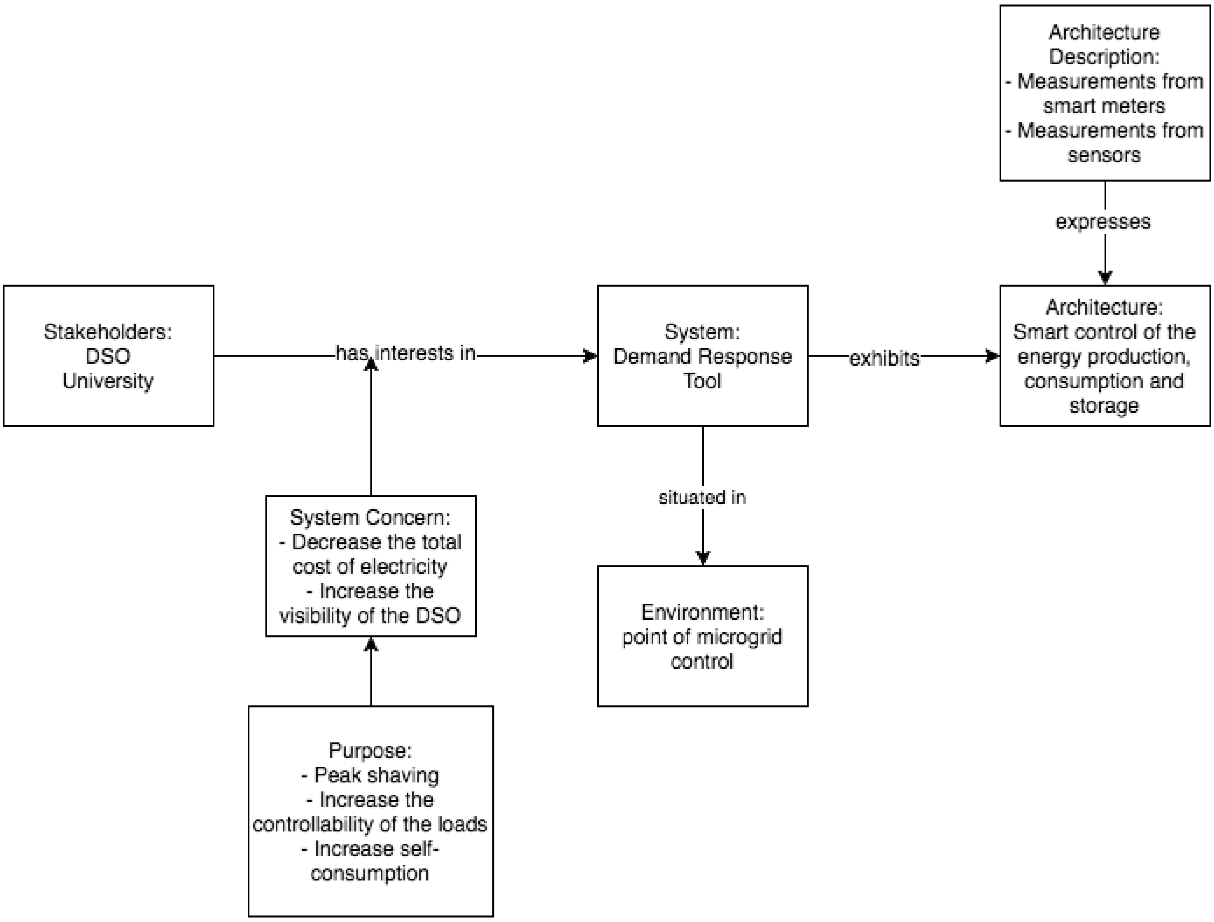

Figure 28. Nicosia. Microgrid Demand Response system architecture

C. Prosumer Demand Response

Table 43. Nicosia. Prosumers Demand Response architecture

IEEE 42010 components definition	Description
System	In demand response tool, the EMS of the prosumers will be activated combining the energy production (from PV), energy consumption and possible energy storage (batteries).
Environment	The prosumer will be able to control its own loads in order to form a controllable demand profile towards the requirements of the utility grid.
Stakeholder	The prosumers will trade the demand flexibility with the DSO, adopting a more grid-friendly demand profile.
Purpose	The main purpose of this activity is the trading of flexibilities through the energy demand of the prosumers.
System concern	The DSO will have direct access to the demand of the prosumers, being able to trade the demand flexibility with them. As a result, the peak demand will be decreased, while the prosumers will operate with increased self-consumption.
Architecture	Smart control of the energy production and consumption.

Architecture description	The placed smart meters and sensors will help the demand response tool to activate its control potentials, according to DSO requirements.

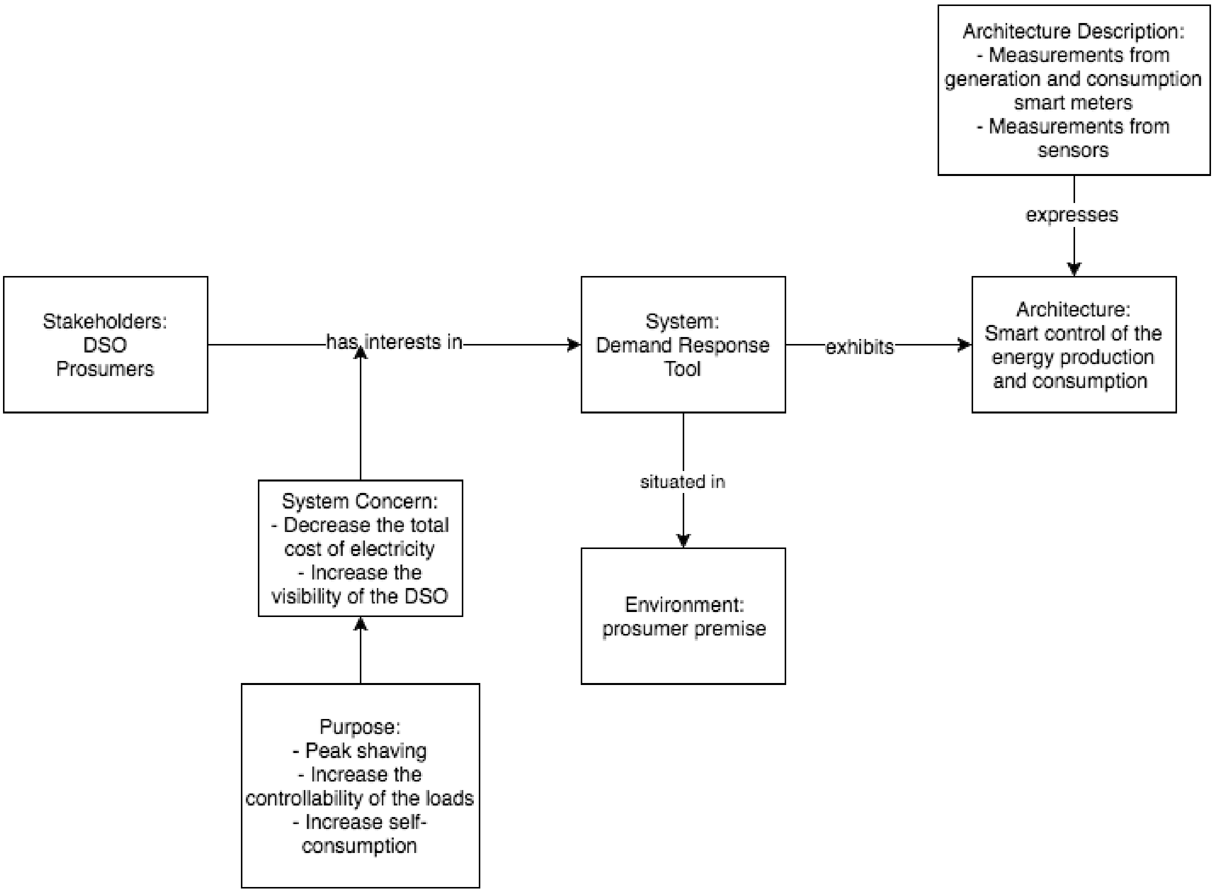

Figure 29. Nicosia. Prosumers Demand Response system architecture

D. Energy Storage Technologies

Table 44. Nicosia. Energy Storage Technologies architecture

IEEE 42010 components definition	Description
System	With reference to ESS technologies, the energy storage systems placed both centrally and distributed within the microgrid will be tested.
Environment	The energy stored in ESS will be controlled by the central microgrid control system, in order to maximise the overall efficiency of the microgrid.
Stakeholder	The microgrid will be able to make a more predictable demand profile, absorbing any power disturbances (i.e. power smoothing control), while it will also be able to provide other ancillary services (such as frequency support, voltage regulation, etc.)
Purpose	The main purpose of this activity is to control the state of charge (SoC) of ESS in order to ensure an extended lifetime, enhance the control among the central and the distributed ESS and monitor specific parameters of the storages and the microgrid (e.g. SoC, SoH, etc.) in

	order to provide ancillary services to the utility grid.
System concern	The stakeholders concern about the effective use of the energy storage systems.
Architecture	Optimise the energy storage among the central and the distributed ESS.
Architecture description	The placed smart meters and sensors will help the demand response tool to activate its control potentials, according to DSO requirements.

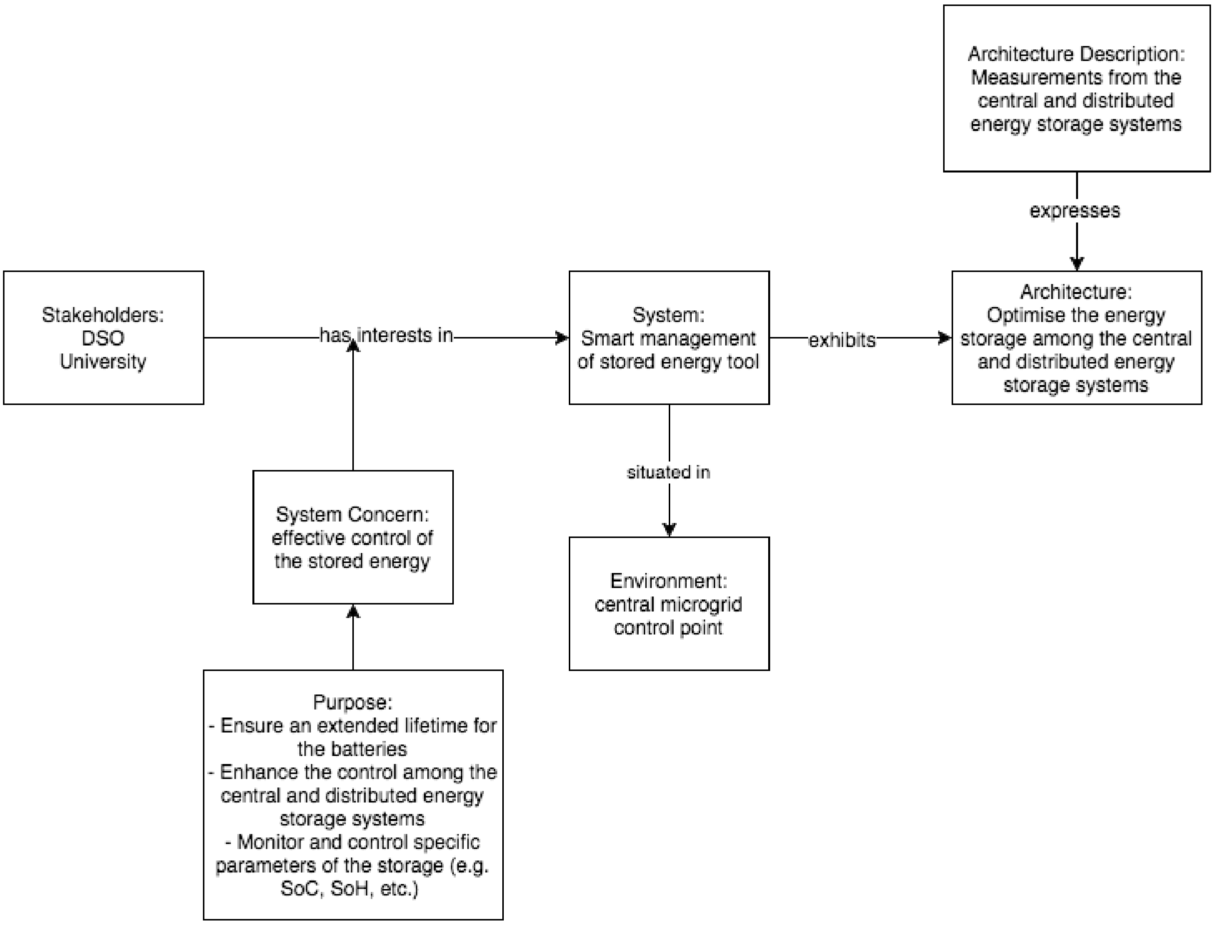

Figure 30. Nicosia. Energy Storage Technologies architecture

7.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The goals of the Pilot within inteGRIDy can be summarised through the utilisation of the following tools: Monitor and supervise the university microgrid, Implement advanced demand response schemes and Smart energy management of the stored energy.

Monitor and Supervision of microgrid will be managed by a dedicated tool, to be installed within the university campus in order to monitor several measurement parameters and data in a single control point. For this reason, UCY will employ a commercially available tool (e.g. a tool for aggregating the control of several BEMS, extensive usage of smart meters, etc.), which will be optimised in the exact needs of the microgrid as have been already determined. The target of this tool is to ensure the continuous and reliable monitoring of the microgrid. The tool will collect real-time or nearly-real-time data for the evaluation of the microgrid operation. The data will also include forecasting for demand and RES generation. One of the responsibility of this supervisory tool will be to alert the microgrid operator for any fault within the microgrid or within the distribution grid or other anticipated malfunctions of the system. Finally, this tool will handle the information of the operator for scheduled and past maintenances.

The Demand Response tool will be tested both within the buildings of the university campus and at prosumer premises. Regarding the installation within the university campus, a tool will receive input from the microgrid smart meters and sensors, such as the energy demand, PV generation and energy stored in the ESS. As for the prosumers, a tool (which can be a head-end smart meter with interrogation for exchanging information) will receive information from the installed metering infrastructure, and more specifically the data of the RES generation and consumption energy.

The DSO will be able to evaluate the real-time cost of energy based on the input measurements and forecasted energy consumption and generation, which will be calculated through the available historical data. The real-time prices will be provided to the end-users, which will monitor their consumption and take further DR actions. End-users will use a mobile application run in smart phones or a web-based application to manage their demand curve remotely, taking into account the settled technical and economic factors.

With respect to the energy storage, this will be split in both central and distributed storage unit; a dedicated tool will be adopted to achieve an effective energy management. The tool will combine the real-time measurements with the short-term and long-term forecasts of the energy demand and PV generation.

B. Use Cases

Actually, two different use cases will be examined. The first one concerns the university microgrid, while the second one the prosumers.

- University microgrid Use Case

The university microgrid includes the following equipment:

    - 350 kWp of installed PV;
    - 10 MWp new PV installations will be installed within the next year;
    - 1 MWh total energy storage capacity will be installed within the next year;
    - the battery storage will be both centrally placed and distributed;
    - advanced smart meters will be installed within the microgrid.

Since each building within the university campus has a different BEMS, a new central energy management system that will integrate the several BEMS with the different protocols will increase the controllability of the microgrid. Therefore, all the settings (e.g. temperature within the classrooms) will be adjusted from a single integrated point of control. Another issue for increasing the controllability within the university campus concerns the placement of smart meters and specified sensors. The installation points for the smart meters (e.g. at each distribution substation supplying the connected buildings) and the type of measuring sensors (e.g. measuring the temperature, humidity, solar irradiance, PV panel temperature, wind speed and direction, etc.) should be defined. All these data should be collected, edited and stored in the control point of the university. The monitoring and supervisory tool will help to implement this strategy. The tool will increase the ability to observe and control the microgrid, concerning (nearly) real-time data of the energy production, consumption and storage.

The collected data can be utilised to provide ancillary services to the network operators. The ancillary services can be defined taking into account the current network operator requirements, such as frequency support, voltage regulation, peak shaving, active and reactive power profiling, power smoothing, etc.

In order to increase the overall efficiency of the microgrid, a smart storage energy management system will be implemented. This system will take into account the energy consumption within the several consumption points of the university (e.g. buildings, student dormitories, athletic facilities, social facilities – such as cafes, restaurants, shops, banks, etc.), the energy forecast of the several installed PV, the nominal capacity and state of charge and health of the battery energy storage systems.

Another requirement concerns the energy management of the energy stored within the EV charging stations. The upcoming trend of using EV has raised the need for EV charging stations, both within the university campus and at user premises. Since new control functionalities, such as V2G strategies, have been established, the energy management of the stored energy should also take into consideration the storage capacity of EVs. However, the business case of implementing such solutions should carefully be addressed.

The ultimate target of implementing all these tools is the decrease of the total cost of electricity. With the current energy policies, the increase of self-consumption is the most prominent solution for decreasing the energy costs. However, since the recent Winter Package (Article 21 and 22) [NIC15] allows the trading of up to 500 MWh of excess energy at the average wholesale price, the final business case will be carefully examined.

The stakeholders are the University of Cyprus (Technical Services of UCY) and the Electricity Authority, which is the only DSO of Cyprus. Both stakeholders are partners in inteGRIDy project. The role of EAC is to provide the grid requirements, which will be traded with the university microgrid. The university microgrid will utilise the inteGRIDy tools in order to provide ancillary services to EAC and increase the effectiveness of the microgrid operation.

Table 45. Nicosia. Use Case UCY_UC01

USE CASE: Smartening the Distribution Grid	
ID	UCY_UC01
Name	University campus microgrid test case
Storyline	The university campus utilises all the available tools (monitor and supervision of microgrid, demand response tool, smart management of stored energy) in order to schedule the energy flow within the microgrid with maximised efficiency. Furthermore, the microgrid will communicate with the DSO, being able to trade its flexibility.
Goal(s)	Increase the effectiveness of the energy within the campus and provide ancillary services to the DSO.
Actors	UCY, DSO.
Preconditions	Weather forecast is adopted to predict production and consumption patterns. The microgrid optimises the energy flows (energy production, storage and consumption) for maximising its self-consumption. DSO acquires the grid information (voltage levels, current, etc.) and exchange possible flexibility signals (with offers).
Postconditions	Optimised microgrid operation and provision of flexibility to DSO.
Trigger events	These procedures are automatically updated with a continuous trading scheme with the DSO.

- Prosumer Use Case

The main objective regarding the prosumer case is to decrease the total cost for electricity by adopting a more grid-friendly behaviour. The high penetration level of RES and more specifically PV has provoked serious issues in the distribution grid. These issues can be alleviated by introducing new control functionalities at the prosumer premises.

Firstly, the self-consumption policy is promoted. The prosumers should adjust their consumption habits in a smart way, in order to continue feeding their loads in a reliable way, while their demand curve will be controllable. A first target is to shave the load peaks, concerning both the energy production and consumption. Another target is the load shifting to time periods with low load demands and high power generation. Furthermore, the ultimate load levelling should take place by adopting more energy efficient consumption habits (such as change the high-consumable electric devices with others of lower consumption class).

Secondly, the increased need for real-time monitoring the measured data, such as energy consumption, generation, net energy at the point of connection with the grid, measuring parameters (e.g. voltage, frequency, ambient temperature, PV cell temperature, etc.). These data can be provided for informative reasons regarding the prosumers, which will adjust their demand from the grid accordingly. Furthermore, the network operators can take advantage of this data for alleviating the grid issues.

Finally, all these solutions should be accompanied with the respective user interface. The user interface should be user-friendly, satisfying the user requirements for advanced controllability (e.g. through mobile applications, through user-friendly websites, displays at user premises, etc.).

The stakeholders are the prosumers and Electricity Authority of Cyprus (EAC), which is the only DSO in Cyprus. In order to implement the demonstration of the demand response tool, several dispersed prosumers within Cyprus (mainly in Nicosia and Larnaca district) have been selected to participate. EAC will provide the grid requirements, which will be traded with the prosumers, in order to adopt a more grid-responsive demand profile.

Table 46. Nicosia. Use Case UCY_UC02

USE CASE: Demand Response	
ID	UCY_UC02
Name	Prosumers Use Case.
Storyline	The prosumers are equipped with smart meters for measuring the energy production from PV and consumption. The smart meters are connected with the DSO, which shall trade flexibility offers with the prosumers.
Goal(s)	Trade flexibility with the prosumers and solve problems of the DSO.
Actors	Prosumers, DSO.
Preconditions	Measuring quantities from the smart meters (voltage, currents, etc.). Communication of the smart meters with the DSO. Communication of DSO with the prosumers in order to trade flexibility offers.
Postconditions	The DSO will solve issues of the distribution grid and the prosumers will profit from the flexibility offers and the new pricing scheme for adopting a more grid-friendly demand curve.
Trigger events	The procedure is automatically scheduled.

7.4 Regulatory Framework

The current regulatory framework does not include any economic incentive for providing ancillary services to the DSO nor the use of storage behind the meter. Each requirement concerning the grid operation is established under the connection regulations and each prosumer should comply with these regulations in order to be connected and inject the energy into the grid.

Another issue regards the participation of the prosumer to the energy market. Currently, three static pricing policies exist: the feed-in-tariff, the self-consumption (for industrial and commercial consumers) and the net-metering. Initially, the feed-in-tariff policy has boosted the PV penetration levels in Cyprus, when the PV installations were still very expensive and the payback periods lasted a large time period. Consequently, the net-metering policy has corrected the economic distortions and followed the rapid PV growth. However, the prosumers do not have the right incentives in order to adopt a more energy efficient behaviour and create a more grid-friendly demand profile. A possible policy to solve this distortion is to implement a time of use (ToU) tariff policy and dynamic pricing scheme. This means that the price of electricity will not be the same during the day, but will be adjusted either dynamically or in a predefined way. In rush time periods, a high price should be applied in order to encourage the prosumers delay their energy consumption in off-peak times. This control strategy can also be implemented directly by the smart energy management system. The DSO could also have control access to this energy management system, in order to adjust the energy flows according to the respective network requirements.

Furthermore, the extensive observability, visibility and controllability is not yet determined in the current regulatory framework. The DSO have access only to the installed metering equipment, without being able to interfere with the prosumer's equipment. An open discussion also regards the emerging concerns of the data protection and the freedom violation of the final users.

A serious issue of the regulatory framework is the operational details of the energy communities. The energy communities have been introduced and also promoted within the new Winter Package, however the regulatory framework has not included their operation. The university campus is going to participate in inteGRIDy project as a microgrid, with its own generation and consumption. This is the first time that such an energy entity is formed within the distribution network of Cyprus.

Another issue that should be addressed within the new regulatory framework is the role identification of the new actors of the energy market. Such actors can be the aggregators, the microgrid/energy community operator, energy retailer, Energy Service Companies (ESCOs), etc. These upcoming concepts should be explicitly determined within the regulatory framework, in order to participate in the energy market. In this concept, the active participation of the prosumer has not been defined.

Therefore, a revision of the regulatory framework is necessary to take place, in order to incorporate all these changes in the energy market and ensure the safe and secure operation of the distribution grid.

7.5 Technology Bounds

As detailed in the previous chapter, three tools are going to be installed and tested in Cyprus Use Cases: Monitor and supervision tool for the university microgrid, Demand Response Tool, Smart energy management of the stored energy.

The monitoring and supervision of the microgrid tool should be compatible with the existing and the future smart metering and sensor installations. The main bound regards the communication means for transferring the control signals and the measuring quantities from the monitoring and supervision of the microgrid tool to the respective distributed points of measuring and control and vice versa. In any case, the security of the information data shall be preserved and respected.

Actually, the microgrid will follow all respective technical standards and regulations for ensuring initially the safety and the protection of human and then of the installations (both of energy production and consumption). Such standards are: EN 50160, VDE 0126 (for PV installations), etc.

The demand response tool should be compatible with the existing smart metering infrastructure. The DSO in Cyprus has already started the installation of smart meters at prosumer premises, therefore they should response to the requirements of inteGRIDy project. Another issue is the acceptability level of the proposed solutions by the prosumers. For this reason, new pricing schemes shall be implemented, giving the needed incentives for adopting the novel solutions of inteGRIDy.

The smart management of stored energy should be capable to cooperate with the other tools, i.e. the monitor and supervision of the microgrid and the demand response tool. Furthermore, it should be capable to coordinate the control and operation of both distributed and central ESS, which may be of different kind in the future (e.g. electrochemical batteries and ice storage).

7.6 Business Model

The average cost of electricity in Cyprus is 16.96 €/kWh, which is constant within the day. By enabling new control functionalities and implementing a different tariff policy (e.g. time of use – ToU, dynamic pricing, etc.), the prosumers will shift their consumption in low-price periods in order to minimise their cost of electricity. The average PV installation of each prosumer is 3 kWp, which corresponds to 5.1 MWh annual energy production. By utilising the DSM/DR tool, the self-consumption of the prosumers will be increased, thus increasing the overall efficiency of the overall electrical system. Since the electricity market in Cyprus is not mature and the role of the aggregator is absent, each prosumer will trade its flexibility directly with the DSO who will act as aggregator of the provided flexibility. Therefore, the LV distribution grid can alleviate its congestion issues by implementing demand response strategies.

Regarding the university demonstration case, currently only a small part of the total PV is installed. Moreover, new buildings (such as the Faculty of Engineering, new Athletic installations, central Library) are in construction phase and will significantly increase the total cost of electricity for the university, inserting a serious load to the distribution grid. By utilising the Monitor and Supervision of the Microgrid tool, the extensive controllability will allow more PV to be installed (10 MWp are planned to be installed within the campus for the next 2 years). Within the connection terms of the new PV installations, is foreseen to deploy an energy storage system. The aggregated (both central and distributed) ESS is estimated to be 1 MWh, while a cost-benefit analysis will be carried out in order to determine the final economically optimum energy storage capacity. Furthermore, the Demand Response Tool will communicate with the existing BEMS in order to manage the energy flow in a more efficient way. The distribution grid within the university campus is fed by MV feeders from two transmission substations of the local DSO and distributed through many MV/LV transformers. Therefore, the implementation of the proposed tools will impact both the LV grid within the university campus (e.g. voltage regulation) and the MV distribution grid. The proposed tools can also be implemented in other use cases, e.g. large hospitals, other university campus, airports, etc.

The benefit for introducing all these new technologies in Cyprus depends largely in the final pricing and RES connection policy.

7.7 Replicability/Impact of the Pilot

The project solutions can be replicated and scaled in order to be implemented in other use cases. The use case of the microgrid can be replicated with different RES technology (not only PV), such as the wind energy, geothermal energy, etc. Furthermore, the case of connecting CHP units can also be utilised as a production alternative. The size of the university campus is indicative. The developed solutions can be implemented in different university campus or different block of buildings, which create an energy community or microgrid. The ancillary services can be adjusted to the needs of the LV and MV distribution grid and the requirements of the respective network operators.

Regarding the prosumer use case, the solutions can be adopted by prosumers of other distribution networks that pose different requirements from the prosumers (which are connected at LV). Furthermore, the capacity of the installed RES can be different, according to the specific weather conditions and the availability of renewable primary sources. RES technologies other than PV can be implemented, as well. The connection of the prosumer with the distribution grid can be either single- or three-phase, without affecting the functionalities of the inteGRIDy project. Moreover, the developed demand response solutions can also contain the energy storage at user premises behind the meter provided that the right incentives will prevail through revised market rules.

8. Survey on the Lisboa Pilot

8.1 Pilot Area Description

A. Area and Geographical Overview

The pilot will be deployed in the Campo Grande 25 building, where most part of the Lisbon Municipality work is performed, located in the area pointed by the red marker in the Figure 31.

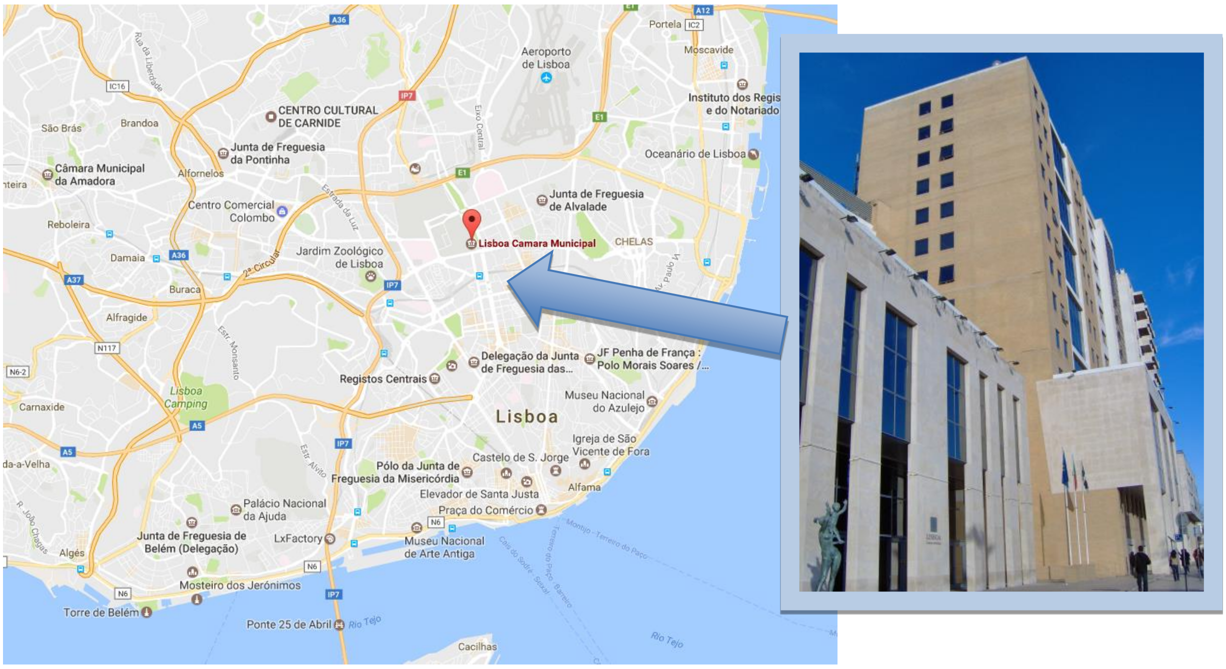

Figure 31. Lisbon Pilot geographical location

Lisbon is the capital city and largest city of Portugal with a population of 506,892 within its administrative limits on a land area of 100 km^2. The urban area of Lisbon spreads beyond the administrative city limits with a population of almost 3 million on an area of 1,390 km^2 making it the 11th most populous urban area in the European Union. Lisbon, like most European capitals, faces several challenges in terms of housing, transport, climate, infrastructure, security and many more. The current economic crisis is even making it harder for cities and their citizens, neighbourhoods and businesses to accomplish their goals and positively contribute to the city's development. Lisbon's commitment of becoming a smarter city comes as an answer to the biggest challenge faced by the city today: attract citizens. For the past decades, Lisbon has assisted to a significant decrease in its population. In over 30 years, 1981 to 2011, the city's population has decay from more than 800,000 inhabitants to 500,000 inhabitants nowadays, balanced by a daily reception of over 2 million people coming from the Metropolitan area. The pressure such a change implies at the local and regional level is remarkable, not only regarding the under use of the infrastructures dimensioned to face a certain demand, what puts their economic viability at stake, but also the decentralization of resources that needs to be put into place due to the increasing urban sprawl.

B. Needs and Opportunities

Lisbon profits of a very large year-round solar exposure, when compared to other cities in Europe. This makes for solar PV energy sources having a large potential in balancing the grid demand. Due to lack of investment, much of this potential is still to be explored. Lisboa E-Nova have published a Lisbon solar potential map [LIS01], showing many yet unused areas able for sun energy harnessing. Fortunately, a large PV park is located close by the pilot building, in the University of Lisbon domains. It is operated and maintained by Conergy

Systems GmbH and is composed of 10,000 photovoltaic panels, representing an installed capacity of over 2 MW and allowing them to achieve an annual yield of 4.28 GWh.

On the other hand, Lisbon is also, due to the solar exposition and climate, a quite warm city, especially during the hot summer months, leading to relevant cooling needs in buildings. In fact, the Municipality building's largest portion of electricity consumption during the summer goes to chillers in air conditioning systems, with peaks of consumption coinciding with peak prices, increasing the cost for power.

Campo Grande 25 is a 5-block building, where most administrative part of the Municipality work is performed. Around 2,000 people work there every day and many others are visiting the building, as it hosts some important public services, open to public. The building, has a total area of 55,000 m^2 and is supplied with medium-voltage and has an average yearly consumption of 3.2 GWh, and is owned and managed by the Municipality.

The cooling needs are provided by 3 chillers and 2 ice tanks that are charged during the night by 2 of the chillers.

A fleet of around 60 electric vehicles (mainly Peugeot iOn) is charged in this building in 2 charging stations, in different basement levels, level -1 and level -2. Each charging station has 15 plugs. Today the charging process has its own EMS, able to identify sources of savings and monitor the evolution of consumption.

There are two transformation stations and one LV Board located at level -1. The LV Board has 11 smart meters connected with a BEMS system, Kisence, which allow disaggregation of consumptions. The 11 meters are able to read data from the two transformation stations (separately), 4 of 5 blocks composing the building (blocks A, B, C and E), the three chillers (separately), the lifts and the EV chargers.

In general terms, the technical solution presented is based on a centralised platform architecture that receives information directly from the local installed equipment.

Table 47. Lisbon Pilot - Opportunities and needs

Opportunities	Needs
RES (Photovoltaic)	Exploitation of RES to decrease carbon emissions and to prepare the building for a production energy profile that will enhance the capacity of managing consumption during peak hours.
DR system application	A large consumer, such as the Campo Grande Municipality building, needs to have the capacity to better anticipate and actuate in response of the electric energy needs.
Energy storage and EV charging with dynamic tariffs	The managing capacity to store energy and charge EV will be tested when dynamic tariffs will be present in the electric system. This effect needs to be studied to prepare consumers for this event.

8.2 Context of the Architecture Proposed

Three different architecture descriptions are proposed according to the number of pillars which have to be addressed in this pilot.

A. Demand Response

The Pilot proposed will begin with a study of DR shift potential in the building. It will be developed using the predicted charge profile to be applied in the building electric consumption profile. This will be linked with the smart meters in the building to assess the positive effect in the charging system devices (thermal – ice tanks; and electric – EV), crossing information with VPS data managing system. Investments will be in a small PV plant to be installed in the rooftop of the building alongside with data readers for the energy that will be produced in the PV plant.

Table 48. Lisbon. Demand Response architecture description

IEEE 42010 components definition	Description
System	Managing demand response shift capacity.
Environment	The boundary conditions for the installation of the solar PV plant is the solar exposure, besides the building workers consuming behaviour and the distribution grid for demand response.
Stakeholder	The building owner, Lisbon municipality.
Purpose	The main purpose of this use case is to develop a smart local grid cross-functional solution, reduce carbon footprint and the electricity bill.
System concern	Stakeholders concern is to improve energy consumption predictability of the building.
Architecture	Monitor disaggregated energy consumptions & production, manage DR, either power or thermal and develop predictive DR algorithms and forecasting tools.
Architecture description	Smart meters, sensors and communication solutions will be implemented, besides the solar PV plant for self-consumption.

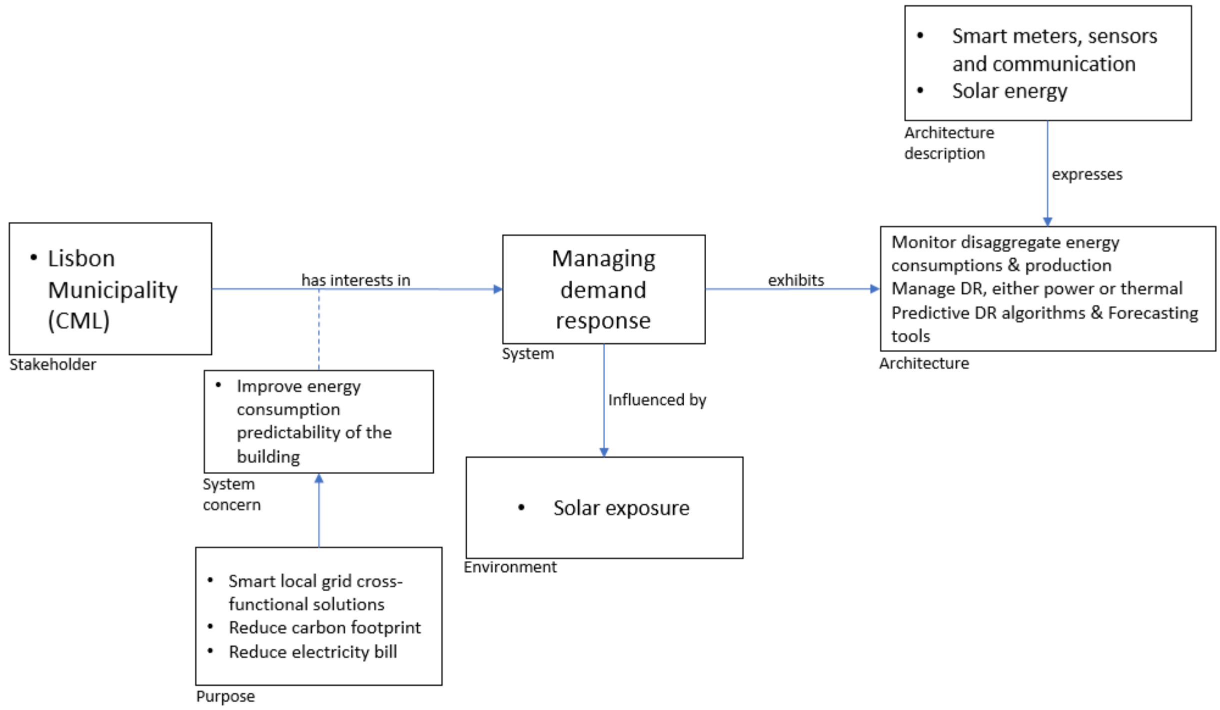

Figure 32. Lisbon. Demand Response system architecture

B. Energy Storage Technologies

The second issue investigated will assess the technical potential of an ice bank as energy storage system to provide the required DR shift according to virtual tariff flexibility. This potential will be optimised through investment in equipment to regulate the ice banks thermal energy heat transfer capacity in order to fit its transfer power with DR needs.

Table 49. Lisbon. Energy Storage Technologies architecture description

IEEE 42010 components definition	Description
System	Characterise and optimise the Ice tanks potential to store and transfer thermal energy.
Environment	The boundary conditions for the mentioned technical characterization are the building surroundings ambient temperature.
Stakeholder	The building owner, Lisbon municipality.
Purpose	The main purpose of this use case is to improve the building's energy storage efficiency and flexibility to transfer thermal energy in short notice, while reducing the electricity bill.
System concern	Stakeholders concern is to improve demand side flexibility.
Architecture	Manage thermal DR shift potential.
Architecture description	Thermal energy cold storage solutions, ice banks and transfer solutions, chillers.

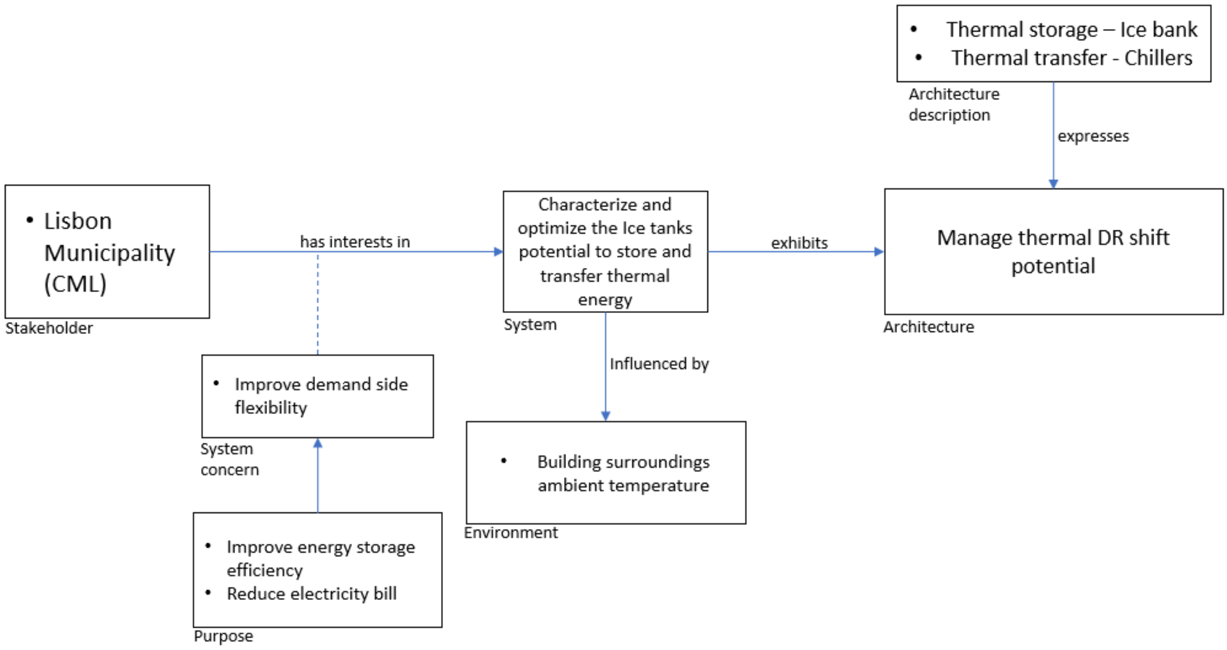

Figure 33. Lisbon. Energy Storage Technologies system architecture

C. Smart Integration of grid users from Transport

The third study will address the potential to adapt the EV charging cycles to dynamic tariffs, replacing the already used fixed-tariff system. This adapting procedure will later be implemented in a Building Energy Management System, with differentiation between the normal and fast EV chargers, with different charging characteristics, thus different potentials to exploit the tariff changes during time periods. To achieve this, smart meters will be installed.

Table 50. Lisbon. Smart Integration of grid users from Transport architecture description

IEEE 42010 components definition	Description
System	Manage EV charging according to dynamic tariffs, with differentiation between fast and normal chargers.
Environment	EV needs and battery charge state, human behaviour regarding transport.
Stakeholder	The building owner, Lisbon municipality.
Purpose	The main purpose of this use case is to develop a smart local grid cross-functional solution and to reduce the electricity bill.
System concern	Stakeholders concern is to improve demand side flexibility.
Architecture	Monitor disaggregate EV charger energy consumptions.
Architecture description	Installation of smart meters, other sensors and the suitable communication means to enable the monitoring and analysis of data. Different EV chargers will be addressed.

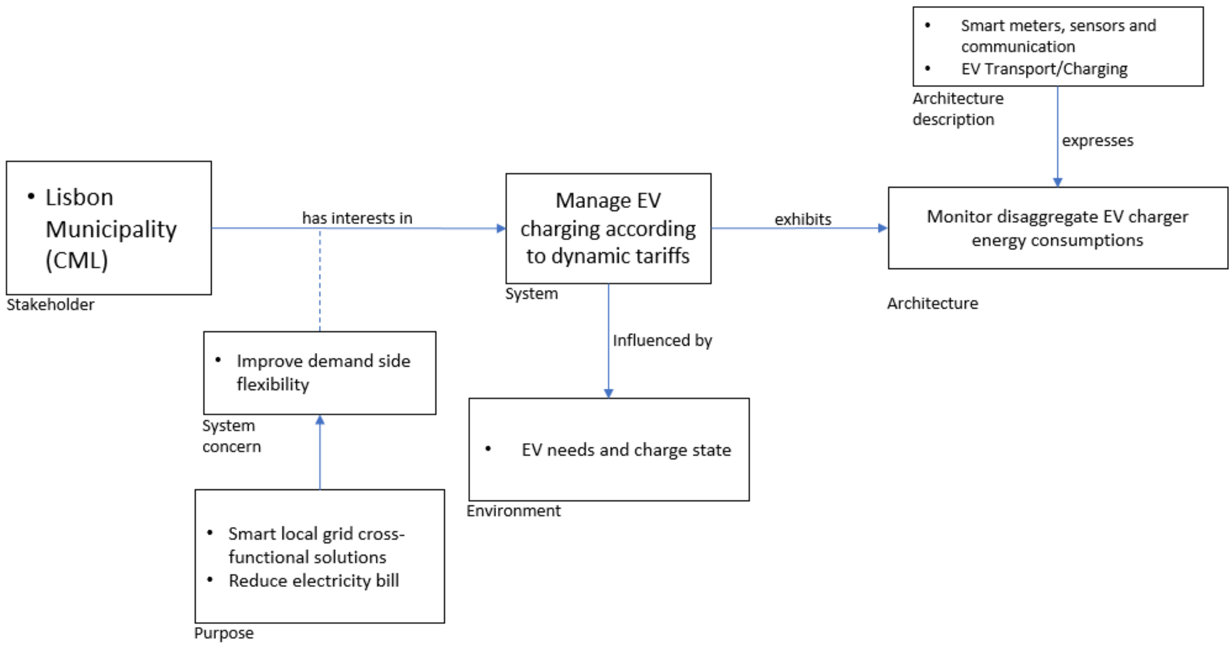

Figure 34. Lisbon. Smart Integration of grid users from Transport system architecture

8.3 Goal of the Pilot & use cases proposed

A. Goals

The Campo Grande 25 building is the municipality's biggest consumer of electric energy, with an annual consumption of about 3 GWh. Its major activities are public service and office work, with office equipment (i.e. computers, printers, etc.) and HVAC responsible for more than 70% of the building's consumption, according to the performed energy audit, followed by lighting (16%) and lifts (8%). The audit scored class B- for energy certification.

Dynamic electric tariffs allow the consumers who can mould or adapt their electric consumption to lower their electricity bills while bringing benefit to the national electric network. The purpose of dynamic tariffs is to influence and adapt the consumption behaviour by market effects, improving the overall energy efficiency of the national network. The main issue resides in the effective consumer ability to change their behaviour, reflected in the consumption profiles.

The selected building has an effective potential to test this capacity of changing the consumption profiles, since it features: 1) demand response shift capacity through energy storage systems such as the ice banks and EV batteries, 2) the future possibility of reducing its public network charge through the planned installation of PV panels for self-consumption and 3) the possibility of raising awareness throughout the building's workforce made up of 2,000 differently skilled workers and visitors.

An energy management system will be developed integrating these use cases. This way, an application will be proposed which allows the moulding of consumptions in function of dynamic tariff defined by the electricity retailer, and building energy production and consumption profiles forecast integration.

The Lisbon pilot aim is to implement a smart energy management application on the major energy consumers of the municipality building, Campo Grande 25, recurring to information such as the produced photovoltaic energy forecast and the building energetic needs, in order to implement dynamic tariffs and DR shift enabled by storage capacity of cold in ice tanks and electricity in EV batteries.

The workload involved in the pilot will be shared between the Portuguese partners involved in inteGRIDy project. The technological data gathering and the integration in the existing managing system will be developed by VPS alongside with ENOVA. As an electrical retailer, the inputs integrating virtual dynamic tariffs in the use cases will be provided by PHE. The business model behind the pilot will be designed in cooperation with UCP. ENOVA will be the coordinator of the pilot.

The building, due to its activity, has a great component of human activity associated to its consumptions. Being an infrastructure with high consumption rates, a movement has been witnessed from the Municipality to endow the building with more efficient equipment both investing on their own or through other community projects.

It is intended to supervise the implemented measures (e.g. light bulb change, HVAC equipment substitution), after their implementation, in a way that prevents any negative effects associated with a higher unnecessary usage rate of these new equipment. This will be accomplished with incentives to the efficient use of those equipment, through awareness raising measures and workshops.

B. Use Cases

- Demand Response

The demand response shift capacity allows the actual energy use to be allocated to user beneficial daily periods, both with respect to financial and comfort point of view.

A study of DR in the building will be developed using the predict charge profile that will be applied in the building electric profile in order to be implemented in a BEMS system in the future. This will be linked with the smart meters in the building to assess the positive effect in the charging system devices (thermal – ice tanks; and electric – EV), crossing information with VPS data managing system.

The investment in this use case will consist in a small PV plant to be installed in the rooftop of the building alongside with data readers for the energy that will be produced in the PV plant.

Table 51. Lisbon. Use Case LIS_UC01

USE CASE: Demand Response	
ID	LIS_UC01
Name	Demand Response
Storyline	The demand response shift capacity allows the actual energy use to be allocated to user beneficial daily periods, both in a financial and comfort point of view.
Goal(s)	Use the prediction of the PV plant energy profile to manage the building electric energy consumption.
Actors	Retailer, consumer.
Preconditions	PV plant installation. Smart meters upgrade.
Postconditions	Prediction of the building forecast profile.
Trigger events	PV production profile analysis.

- Energy Storage Technologies

A study of the energy storage existing solution, named *“Ice banks advantages and disadvantages and technical characteristics”,* is proposed in order to avoid charging these during peak tariff periods. This characterization will also provide information to optimise the charging process. In this use case, equipment will be acquired to manage the ice tanks fluid flow and data gathering and management (SCADA). This data will be analysed together with the electricity data from the meters at the chillers responsible for charging the ice tanks in order to implement an operational managing application for the ice tanks using virtual dynamic tariffs.

Table 52. Lisbon. Use Case LIS_UC02

USE CASE: Energy Storage in Ice Tanks	
ID	LIS_UC02
Name	Energy Storage in Ice Tanks
Storyline	The demand response shift capacity allows the actual energy use to be allocated to user beneficial daily periods, both in a financial and comfort point of view.
Goal(s)	Implement an operational managing application for the ice tanks to improve managing side flexibility charging and discharging the ice tanks.
Actors	Retailer, Consumer.

Preconditions	Installation of equipment to manage the ice tanks fluid flow.
Postconditions	An application to manage the ice tanks operation.
Trigger events	SCADA system implemented to gather data from ice tanks.

- Smart Integration of Grid Users from Transport

The EV charging systems have been under evolution in the last recent years resulting in new faster and powerful devices. The evolution of this charging systems together with the predictable appearance of dynamic tariffs in the electricity market raise concern on the energy managing system that shall be studied.

In this use case, the applicability of dynamic tariffs in a management system already in place, but with fixed tariffs, will be studied and implemented. This pilot is intended to assess the energy and financial outcome for the system obtainable with the implementation of these new tariffs, for a later integration in a BEMS designed for the whole building, supporting the normal and faster EV charging systems. For this use case, equipment to read data and integrate it in the existing VPS data management system will be acquired.

Table 53. Lisbon. Use Case LIS_UC03

USE CASE: EV charging management system integrating dynamic tariffs	
ID	LIS_UC03
Name	EV charging management system integrating dynamic tariffs
Storyline	The EV charging systems have been under evolution in the last recent years resulting in new faster and powerful devices. The evolution of this charging systems together with the predictable appearance of dynamic tariffs in the electricity market raise concern on the energy managing system that shall be studied.
Goal(s)	Avoid EV charging in peak hours with dynamic tariffs implemented.
Actors	Retailer, consumer.
Preconditions	EV charging management system in action. Virtual dynamic tariffs.
Postconditions	EV charging management system prepared to manage dynamic tariffs, avoiding peak price hours.
Trigger events	Implementation of virtual dynamic tariffs in the EV charging management system.

8.4 Regulatory Framework

The regulations which frame the current pilot are related to different topics and applications, such as market liberalization rules which affecting dynamic tariffs existence and usage within the pilot context, besides homologated equipment rulings, applied to the smart meters or solar PV panels which will be used. Actually, in the Pilot, the study of DR shift capacity in the building will evaluate also new PV plants which will be subject to DL 153/2014, a regulation being in this case for full self-consumption since its planned maximum capacity is lower than the building consumption power value for any daily period.

Across the entire Pilot, smart meters will be installed, subject to the Guide for Metering, Reading and Availability of Data of the electricity sector in Portugal, as well as being compliant with additional regulation Directive 10/2012 and Ordinance 231/2013. No regulation changes are needed at the moment to enable the achievement of the use cases' goals, as every aspect of the architecture proposed is regulated and within compliance.

It's relevant to mention that the national energy authority is the Energy Service Regulating Entity (ERSE), responsible for the regulation of the electricity and natural gas sectors, as they have an important role in drawing and implementing the regulations applying to the liberalised market of electricity. Their statutes were approved by the Portuguese parliament on the Decree-law (DL) 97/2002, reviewed on DL 212/2012, and on DL 84/2013. Its mission is to protect the final customer interests, promote the competition among market players, contribute to the continuous improvement of economic and environmental conditions and to provide judgement and solutions for litigation. The Law 9/2013, approved the sanction regime for the energy sector, establishing sanction duties to ERSE, in the context of the National Natural Gas System (SNGN) and National Electric System (SEN). Deepening the understanding and history of market transition to a liberal system, in Portugal, a phased transition was fully achieved from 1995 to 2006, following the methodologies implemented by other countries in the EU, starting with the largest consumers and highest voltage levels, followed by the small domestic consumer. Since the 4th September 2006, all consumers in Portuguese continental territory can choose their electricity provider. This date anticipated the accomplishment of Directive 2003/54/CE, which had established 1st of July 2007 as the final date for full transition to liberal market for every consumer.

The pilot's main stakeholder is Lisbon's Municipality, who owns the building and is interested in increasing its energy efficiency in order to reduce electricity bills while still providing a comfortable and lively workplace to its workers (through thermal comfort). The regulatory framework for building energy efficiency is also defined: the buildings sector is responsible for approximately 30% of final energy consumption in Portugal. DGEG (General Office for Energy and Geology) estimates that 50% of this consumption can be reduced by 50% through energy efficiency measures. Energy efficiency requirements for residential buildings were first introduced in Portugal in 1990 and for non-residential buildings in 1998. In 2006, building codes were revised for all buildings as a result of the transposition of the Energy Performance of Building Directive (EPBD) 2002/91/EC. Decree-Law 118/2013 and Law 58/2013 transposed the Directive 2010/31/EU on the energy performance of buildings and a new legal framework entered in force on 1 December 2013. This new legal framework replaced the previous 2006 provisions. The Energy Certification Programme aims to improve the average energy efficiency of buildings by implementing guidelines which regulate the Energy Certification System for Buildings (SCE), as a result of the transposition into domestic law of Directive 2010/31/EU by means of Decree-Law 118/2013 and Law 58/2013. ADENE (National Agency for Energy) manages the National Building Energy Certification program coordinating the training of qualified experts related to the EU Directive on the Energy Performance of Buildings.

Regarding the integration of EV charging cycles with dynamic tariffs, which is another important action to be implemented by this pilot, some related regulations are here mentioned: ordinances 220, 221 and 222/2016, establish the minimum installed power, the technical rules, the safety rules the private use licensing of public domain to be met by the charging facilities of electric vehicles in buildings.

8.5 Technology Bounds

In technological terms, the solution will be based on Kisense, an advanced, web based, Building Energy Management System (BEMS), developed by VPS. This EMS platform is designed as an n-tier (or modular) architecture in which the more complex modules are in turn designed following a service oriented architecture. In this way, the functionalities of the platform may grow or shrink in accordance with the requirements. On the other hand, the main functionalities are accessible using a web API, offering a standard (REST) interface for the development of rich and intuitive (web and mobile) user interfaces but also for the development of other (integration, forecast) services.

The platform will be deployed on a cloud data server/centre. In general terms, the field sensors and actuators are connected to a data concentrator/controller that is responsible for the communication with the server. Depending on the concentrator used (or needed) the field devices may be connected using wired (Modbus, Mbus) or wireless (ZigBee) protocols. Likewise, the communication with the server may use any available broadband connection (ADSL, GPRS, 3G). Specific data importers can be used/developed to integrated data available from other cloud sources (like weather forecasts). The server basic processing services include: data validation and aggregation, tariff and alarms.

The BEMS will use previously installed monitoring and control equipment (metering/submetering of the main electric circuits and metering and control of 15 EV charging points). New monitoring and control equipment will be installed to manage the ice banks. The PV park energy production information will also be integrated. In order to reach the main optimisation goals, forecasts for the energy consumption and generation will be developed.

During the course of the project new user interface views (dashboards and analysis) will be developed to present the additional information and also to enable new interactions.

In summary, the solution (architecture) is based on a commercial product that offers a varied set of integration and cross-operation possibilities. In terms of data monitoring and control devices, several standard protocols are already implemented (for example, Modbus, Modbus-TCP, OPC DA client, DLMS - Device Language Messaging Specification) and appropriate bridges can be used to connect devices with other protocols. On the other hand, as stated above, the retrieved and processed data can be easily accessible via a REST standard interface enabling the integration with other systems.

8.6 Business Model

The Lisbon pilot focuses on a municipality building, Campo Grande 25, thus a study of the business model on its perspective is here proposed. As a final user of electricity, the building is interested in reducing its bills.

To achieve this, different approaches will be studied. Firstly, the dynamic tariffs from the DSO combined with the demand side management to attribute bigger loads to low priced tariff times will enable savings. The demand side management will be achieved using the ice banks to store cold, or scheduling the EV charging periods to match low price periods of the dynamic tariff.

A small PV plant will also be installed at the rooftop with an area of about 50 m^2. The electric energy generated through this plant, combined with storage solutions, will also enable to reduce the grid load, leading to savings. Besides that, during the summer season, when cooling needs account for most of the building's consumption, this high load coincides with the time of the day when PV panels are generating the most electricity, meaning even greater savings.

Additionally, energy efficiency good practices (human behaviour level) will be disseminated among the building's workforce to further increase savings.

At last, the referred savings will enable a payback of the equipment and software systems to be invested, such as data loggers, smart meters, chiller actuators, and the building energy management system.

8.7 Replicability/Impact of the Pilot

The use cases proposed in Lisbon Pilot, to achieve a BEMS that will allow the Building Manager to modulate the consumptions in response to dynamic tariff, electric energy production and equipment's availability, can be replicable to more buildings across the inteGRIDy Pilots to enlarge the data and seek the validation of this managing system in a wider and complex environment.

This scattering would enhance the inteGRIDy platform since it could give a closer idea to the DSO, retailers and consumers of the advantages and disadvantages of implementing a smart grid energy service such as the proposed BEMS. The benefits would be shared between all parties.

9.Survey on the Xanthi Pilot

9.1 Pilot Area Description

Xanthi Pilot deals with the case of isolated small scale smart grid networks with local energy storage options where RES are the main source of power. Remote and isolated communities are a long distance from highly populated settlements and lack transportation links and infrastructures that are typical in more populated areas. Remote communities include isolated communities, refugee camps, and scientific outposts. There is diversity among remote communities, as each community has unique characteristics according to its population, geography, size, demographic composition, economic and social infrastructure as well as distance from populated areas. As well as being geographically isolated and distant from services, remote habitats are affected by ecological threats and economic downturn, putting enormous financial and environmental stress on these communities.

In order to study such type of networks and explore the integration of inteGRIDy's innovative solutions towards a flexible and smarter distribution network, the infrastructure of SUNLIGHT's RES park will be used. The specific pilot serves the local demand for power and operates at realistic conditions.

Figure 35. Xanthi. Islanded RES-powered microgrid with battery stacks and hydrogen storage at SUNLIGHT premises

B. Needs and Opportunities

The needs by network derive from the fact that at isolated areas or areas of specific interest, the transport or use of conventional fuels is difficult and in some cases not feasible at regular intervals. Therefore, the autonomy and the ability to self-sustain the supported systems is of major concern. The opportunities and needs of Pilot are summarised in the following table.

Table 54. Xanthi. Opportunities and needs of Xanthi Pilot

Opportunities	Needs
RES (Hydrogen, PV, Wind) availability in a rural area	The main needs of the pilot are: • Ensure security of supply, rerouting of energy based on dynamically evolving conditions. • 24/7 availability and minimum time between redistribution of energy. • Automatic decision support based on available resources. • Redundancy of the energy routes combined with backup reserves. • Forecasting of demand at daily or long-term basis.
Final user participation to the ancillary market	Xanthi Pilot is an islanded grid with local storage. It's a self-sustained microgrid that can provide energy in isolated areas. Market solutions extend the overall goals of the pilot.

Properly exploit energy storage options	Balance the stored energy among hybrid storage options (electricity, hydrogen). Optimise the use of energy storage to avoid RES curtailment. Demonstrate of the ESS technologies utilising flexible storage management algorithms for charging/discharging. Formulate a Virtual Central Storage from aggregated distributed storage systems. Deploy Smart Energy management tools of with RES-enabled storage systems.

9.2 Context of the Architecture Proposed

At Sunlight premises (Xanthi, Greece) the islanded smart microgrid network operates in a way that fulfils local load demand. The grid consists of three nodes, where smaller microgrids at each of them are connected together through a common DC bus. Each microgrid consists of equipment exploiting various RES, a local load, a battery and a diesel generator.

The nodes are powered by PV and Wind Generators (WG). One of the nodes has hydrogen generation infrastructure from PV and a fuel cell (FC) that consumes the hydrogen upon demand based on the status of the other subsystems.

The electrical topology is complemented by communication and automation infrastructure which leads to the formation of the smart grid and facilitates the decision-making process for the exchange of energy among the systems. Besides the local data acquisition systems, an interoperable SCADA system exists that monitors and manages the power exchange at the network.

CERTH and Sunlight are the stakeholders that have interests in the functionality and the outcome of the system. Through the monitoring of the network energy exchange and the technical constrains of each node separately, data and knowledge will be collected and used for developing tools for smartening the grid.

The integration and interconnection of the field level equipment is another concern which will lead to the interconnection with the inteGRIDy Platform.

The architecture description of the aspects that will be addressed adopting the IEEE 42010 standard are described below.

- Demand-Response

Table 55. Xanthi. Demand Response architecture description

IEEE 42010 components definition	Description
System	In the demand response project topic, the microgrid itself acts as a prosumer.
Environment	The surrounding area of the main system which have an influence on that are the supervisory station and the smart microgrid itself acting as a prosumer.
Stakeholder	Sunlight and CERTH are the stakeholders of the system.
Purpose	The main purpose of this activity is to secure loads and services, control of the loads by reducing peak demand and increasing self-

	consumption.
System concern	Stakeholders concerns in the event of this purpose is concluded in the self-sufficiency of the microgrid.
Architecture	Smart control of the energy production, consumption and distribution in the microgrid network.
Architecture description	The measurements from the energy flow between the nodes and the equipment will result data archives, which will be used in the decision-making tools and for optimisation of energy control and storage.

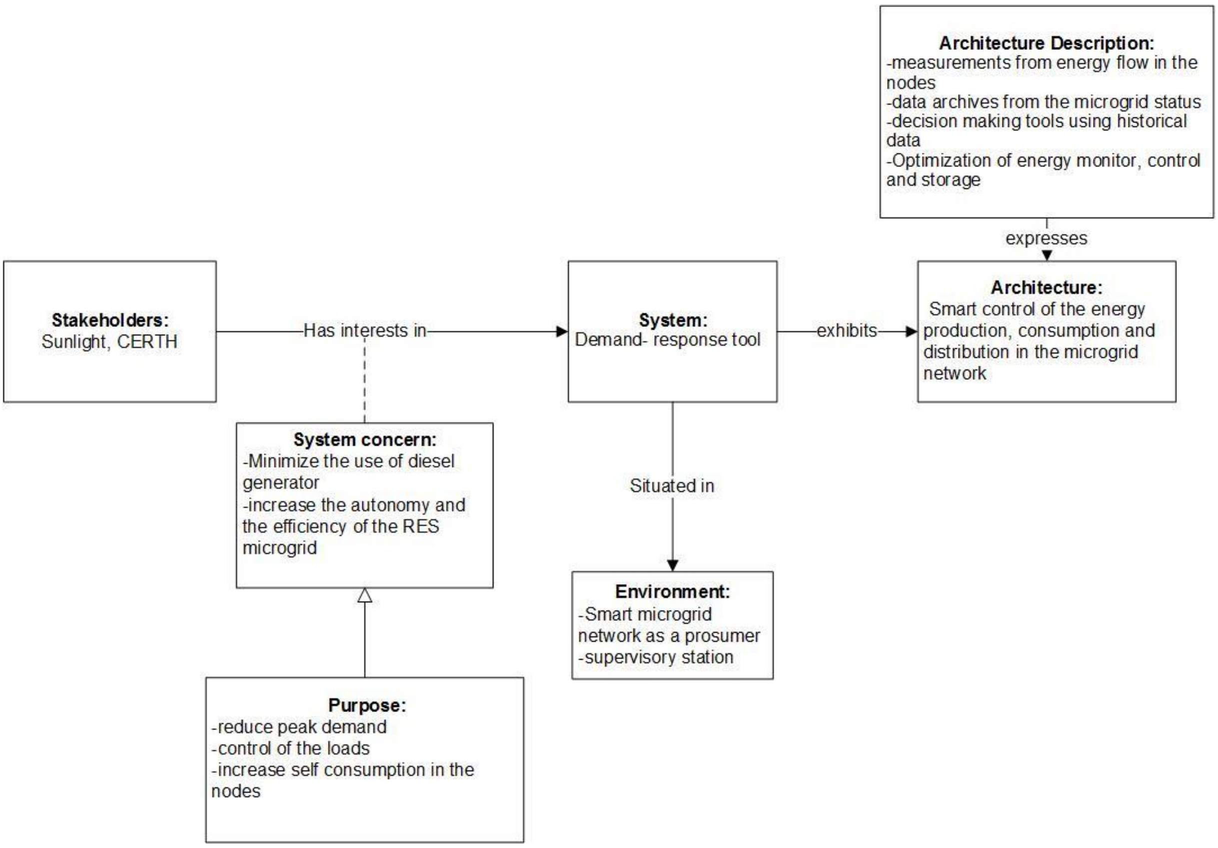

Figure 36. Xanthi. Demand Response system architecture

The DR aspects of the Pilot will be initially evaluated at the respective activities of the project and will be selected or not for implementation if the existing infrastructure is able to host such operation. Overall, the DR scheme will be studied at simulation level to the extent that SUNLIGHT determines that it provides a feasible scenario of operation for the isolated nodes of the network into consideration.

- Smartening the Distribution Grid

Table 56. Xanthi. Smartening the Distribution Grid architecture description

IEEE 42010 components definition	Description
System	Tools for monitoring, supervision and optimisation based decision making of the energy management.
Environment	The surrounding area of the system which have an influence on that

	are the supervisory station, the microgrid and certified remote users.
Stakeholder	CERTH is the stakeholder of the system.
Purpose	The main purpose of this activity is to monitor and manage the systems of the grid and deploy services for optimum energy management.
System concern	Stakeholders concerns in the event of this purpose is concluded in the optimised management of energy.
Architecture	Monitoring, supervision and smart control of the energy production, consumption and distribution in the nodes of the microgrid network.
Architecture description	The products of the system are monitoring and visualization solutions and services, decision-making, EMS, control and optimisation, operation analysis and simulation, modeling for network control optimisation and storage.

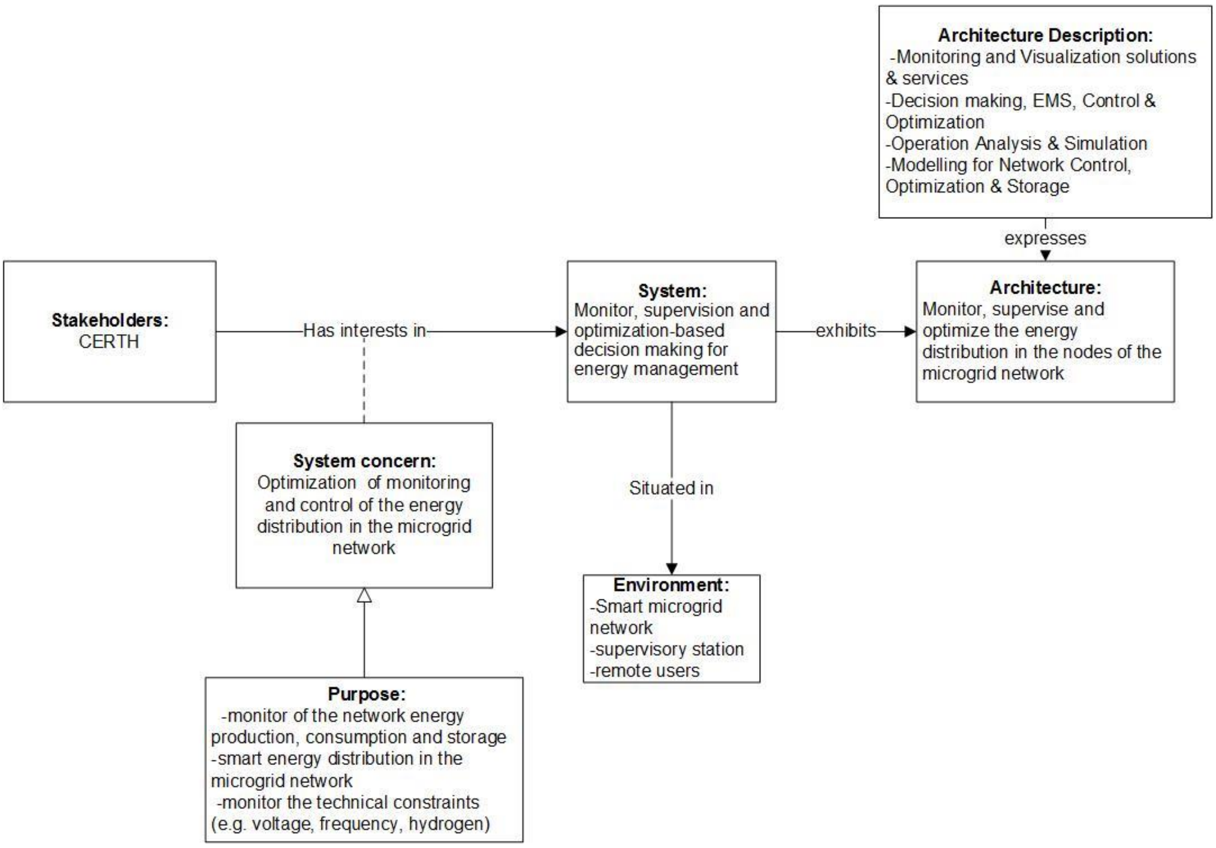

Figure 37. Xanthi. Smartening the distribution grid system architecture

- Energy Storage Technologies

Table 57. Xanthi. Energy Storage Technologies architecture description

IEEE 42010 components definition	Description
System	Smart energy management tools of RES enabled storage systems targeting for formulating a virtual central storage from aggregated

	distributed storage systems.
Environment	The surrounding area of the main system which has an influence on that is the supervisory station and the microgrid network.
Stakeholder	Sunlight and CERTH are the stakeholders of the system.
Purpose	The main purpose of this activity is to monitor technical parameters of the storage systems (batteries, hydrogen), and extend the lifetime of the batteries.
System concern	Stakeholders concerns are the balance of the energy among hybrid storage option and optimum distribution.
Architecture	Smart control of the energy storage and distribution in the microgrid network.
Architecture description	Integration and interconnection of storage systems, formulating a virtual central storage for optimum management of energy distribution.

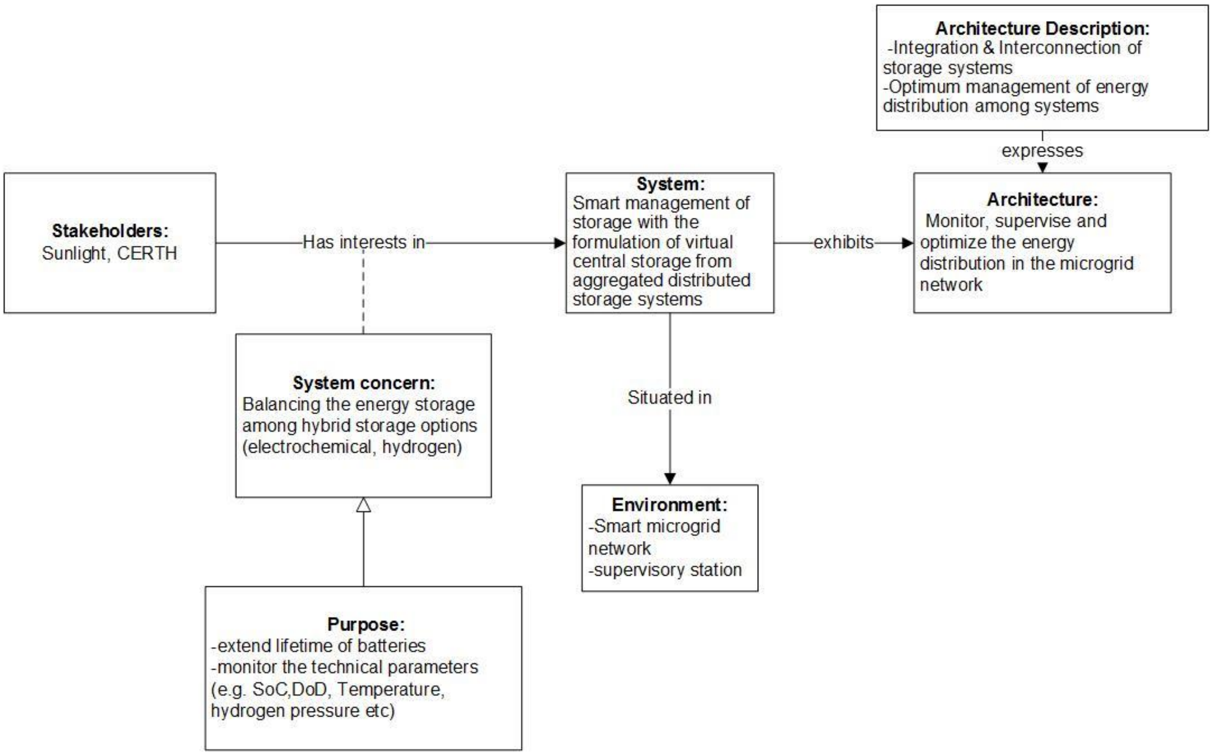

Figure 38. Xanthi. Energy Storage Technologies system architecture

- Smart Integration of grid users from Transport

Table 58. Xanthi. Smart Integration of grid users from Transport architecture description

IEEE 42010 components definition	Description
System	In the integration of grid users from transport aspect, EVs and their charge points (i.e. the interfaces with respect to the electric grid) are the system under analysis, where EVs can store and return energy to the

	grid.
Environment	The surrounding area of the main system which have an influence on that are EV charging station, the smart microgrid network that provides or absorbs energy from the EV upon demand, and the supervisory station that controls the distribution of power.
Stakeholder	The stakeholders that have interests on the system are CERTH and Sunlight.
Purpose	The main purpose of this activity is to monitor the network peak energy consumption and optimise the energy distribution in the microgrid. The use of the diesel generator for power balance on the grid needs to be minimised and the EV charging/discharging schedules have to be optimised.
System concern	Stakeholders main concern is to minimise the use of fossil fuels and increase the power autonomy of the grid using RES.
Architecture	An optimised monitoring and energy distribution is performed using the EVs as microgrid storage mean.
Architecture description	Products of the system are the measurements from EVs charging and discharging cycles, prediction tools for the peak energy consumption in the grid and tools for optimising EV integration in the microgrid.

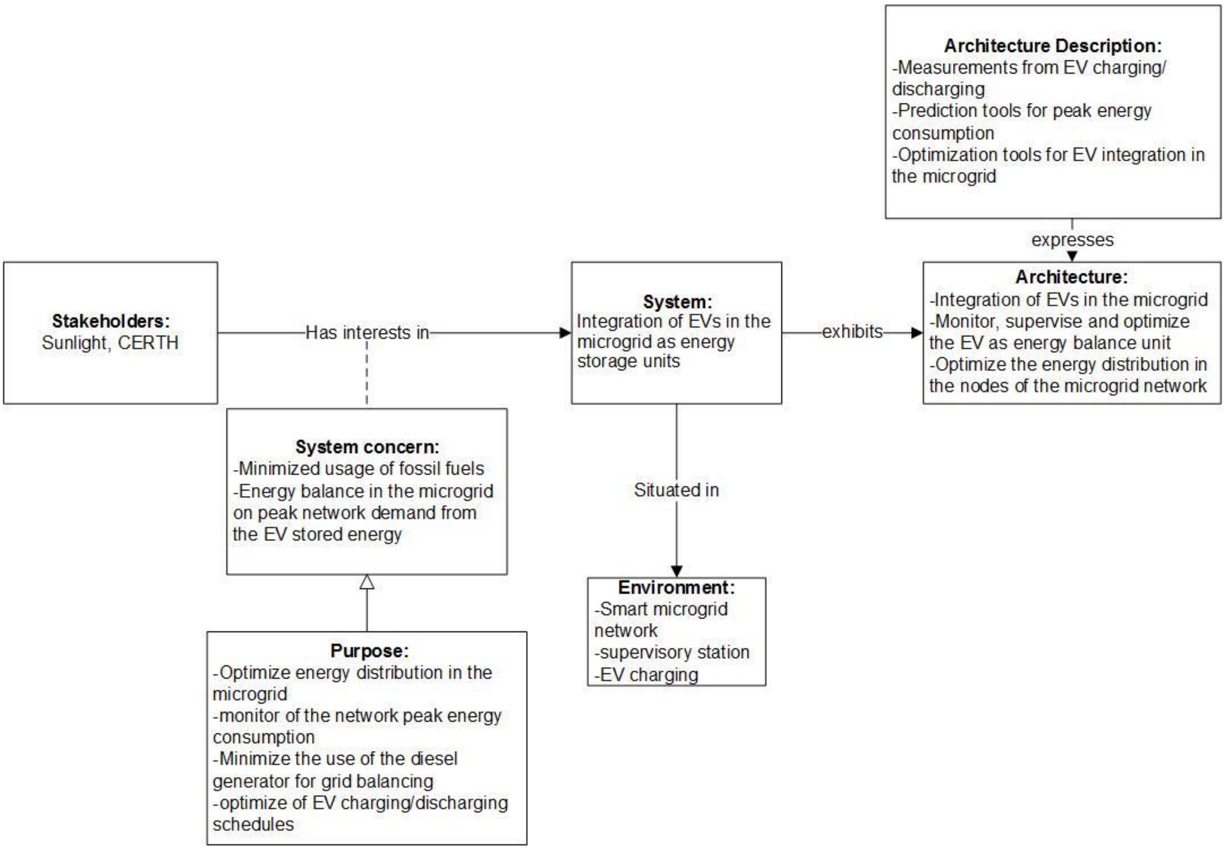

Figure 39. Xanthi. Smart Integration of grid users from Transport system architecture

9.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The overall goals that the Xanthi Pilot will address are derived from its nature, which is the isolated operation with the need for autonomy using local energy storage. More specifically, the goals are listed in the following.

The initial goal is to adapt the response of energy usage based on the requested demand. Therefore, the existing model of the network will be extended to incorporate energy DR matching and DR shifting when appropriate relying on the results from the multi-objective optimisation strategies. Also, the local energy demand will adjust the auxiliary loads based on the prosumer profiling according to available RES production and the forecasted based on the day-ahead analysis results.

To improve the energy exchange at the distribution level, smart and adaptable energy management strategies will be used. Advanced Model Predictive Control using the system/network model will be applied in order to achieve the optimum power distribution in the grid. Furthermore, the supervisory monitoring options and services will be enhanced so that the grid operator will be able to receive knowledgeable actions using the multi-criteria (KPIs) decision analysis and capitalising on the historical data of the network behaviour. The information/notification and status metrics will be included in the multipurpose dashboards for visual analytics of the distribution domain status, in the local and remote HMIs.

The optimisation of the energy storage capabilities usage within each station and at network level is another goal of the pilot. The field trial is carried out on the 3 nodes with active serving to storage and to the load demand utilising Flexible storage management algorithms for charging/discharging. Furthermore, the formulation of a Virtual Central Storage from aggregated distributed storage systems will offer balancing solutions among hybrid storage options (electricity, hydrogen) utilising Smart Energy management tools of with RES-enabled storage systems.

The last aspect involves smart Integration of grid users from Transport. The energy management methods will be evaluated considering the forklift charging at dynamically changing schedules using RES, batteries or stored hydrogen options on demand. The integration of EVs will offer grid balancing solutions through the ability to provide flexibility in DSM and, in the case of the EV charging unit, returning power to the grid at peak network demand.

In the project, the focus is towards isolated smart-grid networks and more specifically to their operations domain in terms of information exchange and distribution of energy, including three domains: Customer, Operations, and Energy Distribution. The operational objectives are to exchange power based on demand-response strategies, to maximise the usage of available stored power at network level and to utilise the total amount of available renewable energy. The desired features for the overall behaviour of the network are to ensure the security of supply, to reroute the energy based on dynamically evolving conditions and to provide an automatic decision support mechanism based on available network resources.

The specific autonomous isolated smart microgrid has 3 nodes with the following: AC load (3 kW), the PV rated at 12.7 kW, 15.4 kW and 15 kW. Lead-acid batteries (BAT) are also utilised to provide the necessary power to the systems during night time and when the available renewable power is not enough to serve the demanded loads. As a backup option, each system has a diesel generator (DG) of 1.1 kVA. Wind generators, 3 kWp each, a Polymer Electrolyte Membrane (PEM) electrolyser that produces and stores hydrogen at 30 bar pressure cylinders and a PEM FC system that produces power when required using the stored hydrogen are also present. The energy exchange within each standalone node where DC and AC busses exist, is established through power converters. A 300 V DC busbar is used to exchange the power between the nodes using a set of DC Buck/Boost converters at each node of 1 kW each.

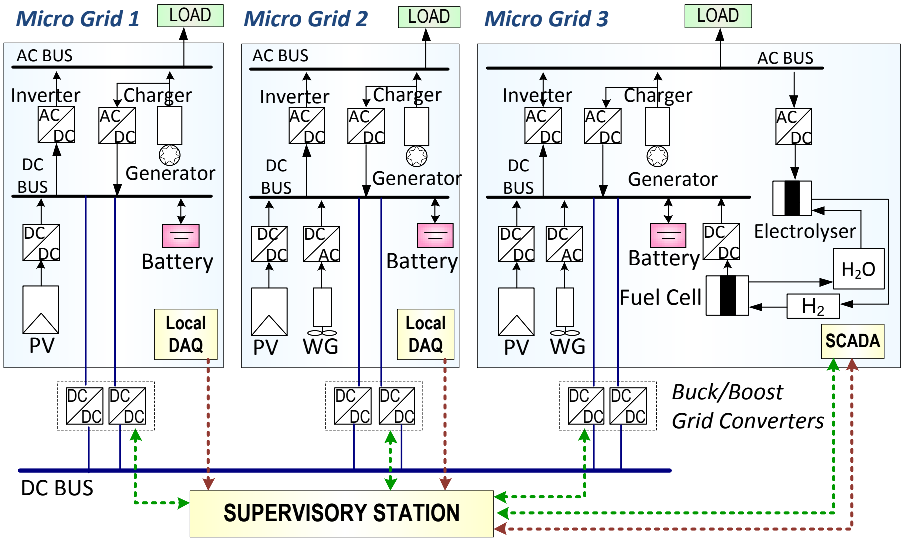

Figure 40. Xanthi. Topology and main subsystems of the autonomous Smart Grid network

Even though each system is designed to operate autonomously, they are also connected one to each other through a separate external DC bus and energy exchange is allowed to take place when pre-specified conditions are satisfied. Therefore, as in every Smart Grid, it is necessary to have a supervisory station advocating the decision-making required for efficient energy exchange among the considered systems.

The objective of the supervisory station is to manage the distribution of energy implementing appropriate power management strategies (PMS), to support proper actions that enable the maximum utilization of the available renewable energy sources, while preserving the lifetime of each subsystem within every system.

The grid operation is monitored using a Supervisory Control and Data Acquisition (SCADA) system while the Machine to Machine (M2M) communication for the decision making is implemented by the IoT enabled architecture. A middleware implements the exchange of information between the network nodes and the supervisory station. In order to make this network as self-sustained as possible the main target is to minimise the use of the diesel generator.

The partners involved in the Xanthi Pilot are Sunlight and CERTH. Sunlight is providing the islanded grid with all the necessary storage subsystems and will maintain the daily operation of the islanded grid. For the integration of grid users from transport, the fleet of EVs and the charging station is also provided from Sunlight.

The role of CERTH/CPERI is to deploy the tools and services for optimised energy management between the nodes of the grid and the BMS for the cycling of the batteries of the EVs. CERTH/CPERI is also responsible to design and develop advanced model-based control strategies and demand response mechanisms.

B. Use Cases

Table 59. Xanthi. Use Case SUN_UC01

USE CASE: Smartening the Distribution Grid	
ID	SUN_UC01
Name	Monitoring, supervision and optimisation based decision-making for Smart Distribution Grid

Storyline	The Automated Grid Supervision System analyses and takes decisions for optimum energy distribution at the grid level to minimise usage of back-up sources (diesel generator) and to maximise utilization of available RES.
Goal(s)	Apply online supervisory control of the grid based on loads behaviour in order to optimally exchange energy upon request, maximise the RES usage and network autonomy.
Actors	RES sources, Local Loads, Energy Storage, Automated Grid Supervision System.
Preconditions	Online and historical data from RES (PV, Wind) energy production and from each node's load and consumption profiles. Automated Grid Supervision System (central SCADA) acquires grid information from converters, chargers and energy storage subsystem (battery stacks and hydrogen). At the central SCADA the optimisation and decision support results are communicated based on the model utilization of each node based on selected variables (voltage, current, operation status, etc.).
Postconditions	Optimal and stable grid operation upon request, online performance analysis and avoid RES curtailment.
Trigger events	The operation is in continuous mode and the various activities are triggered based on the status of the RES, storage and load condition.

Table 60. Xanthi. Use Case SUN_UC02

USE CASE: Energy Storage Technologies	
ID	SUN_UC02
Name	Flexible local and virtual central storage management strategies
Storyline	Utilization of the local storage systems based on each node's needs and concurrently provide a virtual storage that can be used upon request and availability at the grid level in collaboration with the Automated Grid Supervision System.
Goal(s)	Protect the lifetime and operational capacity of the local storage systems and utilise the virtual central storage system at the grid level.
Actors	Energy Storage, Local and Virtual Central Supervision System, Automated Grid Supervision System.
Preconditions	Online and historical data from the battery utilization profiles and stored hydrogen levels from each node. Calculation at the Local and Virtual Storage Supervision modules of qualitative and status information (SOC, DOD, etc.). Establish M2M communication with the central SCADA for critical data exchange upon request.
Postconditions	Online status and performance analysis of the storage capacity and capabilities for long-term optimal battery utilization and stable operation.

Trigger events	The local operation occurs continuously and the grid level Virtual storage operation is upon request periodically.

Table 61. Xanthi. Use Case SUN_UC03

USE CASE 3: Integration of grid users from transport	
ID	SUN_UC03
Name	Supervisory EV charging and optimum profiling
Storyline	Renewable growing penetration ask for new regulation resources. Nevertheless, ancillary services market is nowadays closed to dispersed generation and storage. The need is to aggregate several small/medium resources in order to play on the electric market.
Goal(s)	The operational objectives are to charge batteries utilising stored energy from RES and to derive charging profiles upon request and overall evaluation of the EV charging effect at the storage systems.
Actors	EV charging station, Energy Storage, Charging Supervision System.
Preconditions	Historical data from EV charging profiles and utilization of stored energy. Interconnection of a charging facility with the grid to allow for the MHE EVs to use the stored energy, especially in cases of surplus. Charging schedule needs of the EVs.
Postconditions	Online status and performance analysis of the storage capacity and capabilities for long-term optimal battery utilization and stable operation.
Trigger events	The charging procedures that utilise the islanded grid infrastructure of the EVs is scheduled periodically at regular intervals or upon surplus estimation and forecast.

9.4 Regulatory Framework

The regulatory framework depends of the areas of application and the involved end users. As far as it concerns the implementation of the Pilot, it will take place in N.Olvio in Xanthi in Greece. The experimental grid will not have any connection to factory's grid, it will be totally isolated. The Greek legislation for autonomous power supply, occurs only if a connection to national grid is going to be established (ΦΕΚ Ά 118/24.6.1965, ΦΕΚ ΄Β 844/16.5.2004). Therefore, only the European Union regulations apply. Regarding the equipment that is being used, it must be subjected to legislation.

The equipment that is going to be used can be divided in two categories. The first one concerns the devices that are available in the market and have been approved according to European standards such as batteries, PV panels, fuel cell, etc. The second category concerns the equipment that are prototypes and have been designed to run this particular pilot. The equipment meet all the necessary conditions and regulations for experimental use. Concerning the end-users, in order to install and operate an isolated Smart Grid in Greece, the equipment must meet the defined standards (e.g. ISO, EC) and the installer should have the appropriate planning permissions in order to proceed with the implementation.

9.5 Technology Bounds

Some of the technologies that will be used in the Xanthi pilot have already been developed by CERTH/CPERI and will be used on Sunlight use case. A detailed description about the functionalities of the tools and technologies is given:

- Optimisation-based Decision Making (ODM) Tool has been developed by PSDI and deployed that applies optimisation derived decision-making actions online which implements decentralised automated algorithms.
- ANOSYS tools for network monitoring and apply supervisory control to the nodes with demand and supply matching model and optimum use of power/hydrogen.
- Industrial-grade Supervisory Control and Data Acquisition (SCADA) from General Electric with flexible EMS Flexibility Optimised Management are implemented to control and manage the network.
- Long-term archiving infrastructure (iHistorian) for individual measurements used for post-processing and analytics.
- Real-time monitoring (local/remote HMIs) of energy generation and consumption to be extended with IoT multi-sensors.
- A platform that monitors the operations of distributed energy networks has been currently developed by CERTH/CPERI that involves various electrical/electrochemical signals.

The modifications at the existing infrastructure will be:

- The central SCADA centre will be extended to include the Forecasting and VA suites and provide network Management Services to the individual nodes of the network and it is responsible for the overall management of the available energy.
- Controllable and smart EV charging facilities connected to the main DC part of the distribution network.
- Network extensions to share RES power to the charging of part of the EV fleet (Material Handling Equipment - MHE) and demonstrate the integration of EVs to smart RES-enabled networks.
- For each node, a prosumer profiling and DR mechanisms will be deployed integrated with the automation systems.

The interconnection of the hardware devices inside each node is achieved with the use of the OPC protocol. A middleware implements the exchange of information between the network nodes and the supervisory station where the main SCADA system based on the OPC or the IEC 61850 protocol.

In order to perform an interconnection with the inteGRIDy platform, a possible/suggested case of standard is the use of IoT technologies realised by the MQTT protocol, creating a more dynamic way of data archiving and control actions. Also another alternative for upper level services will be usage of ISA-95 (through B2MML) realised by Restful services, according to the specifications of the CMP platform.

9.6 Business Model

The Pilot will develop a prototype system of RES-powered microgrid. Even though the system development is in an early stage, it will be presented below an overview of the business model.

The RES-powered microgrid of the Pilot uses several components and devices such as energy production units, energy storage units, smart control system and electronic components. The energy production units are PV panels, wind generators and Diesel generator. The storage units are batteries and hydrogen-fuel cells. The electronic components are DC/DC converters, inverters, chargers and electrical panels. Finally, the smart control system is implemented on software.

The key activities of the RES-powered microgrid are based on the smart control system. The research activities that are taking place at Xanthi's pilot focus on four goals (i) to adapt the response of energy usage, (ii) to improve the energy exchange, (iii) to optimise the energy storage and (iv) to realise a smart integration of grid users from transport. Research results will act as key activities.

RES-powered microgrid will have the ability to electrify remote areas such as mountainous areas or isolated islands, where the connection to the grid is unprofitable.

From the economic point of view, due to the fact that RES-powered microgrid is a custom-made product, and consequently presents the extra cost of project study and system design, the cost of equipment varies according to microgrids scale; however, the processes of assembly installation, commissioning and testing are fixed costs. Nevertheless, the project is devoted to develop and test new solutions driving to a standardization of the apparatuses and, consequently, to a costs optimisation.

With respect to the income expected, it is worthwhile to stress that the remote area electrification will not have to compete with national grid LCOE.

Actually, the RES-power microgrid has three revenue streams. The first one is by selling the whole system, the second one is by leasing it for a certain period and finally, maintenance revenues.

9.7 Replicability/Impact of the Pilot

The solutions that will be developed for the Xanthi Pilot could be easily replicated to other sites with RES, PV or WG and also energy storage systems using battery stacks. The solutions that will be provided can be inherited in a larger scale grids capable of providing energy in remote or isolated areas where connection with the main grid is difficult or in some cases impossible. Moreover, scientific outposts and antennas facilities can be the candidates for such grids where power quality and security emerges.

10. Survey on the Ploiesti Pilot

10.1 Pilot Area Description

A. Area and Geographical Overview

The Ploiesti Pilot, Intelligent Energy Demand and Supply Matching, feats innovative simulation and command-control for energy grids in Ploiesti City, Prahova County, Romania. The Pilot consists of three buildings with residential apartments in Ploiesti.

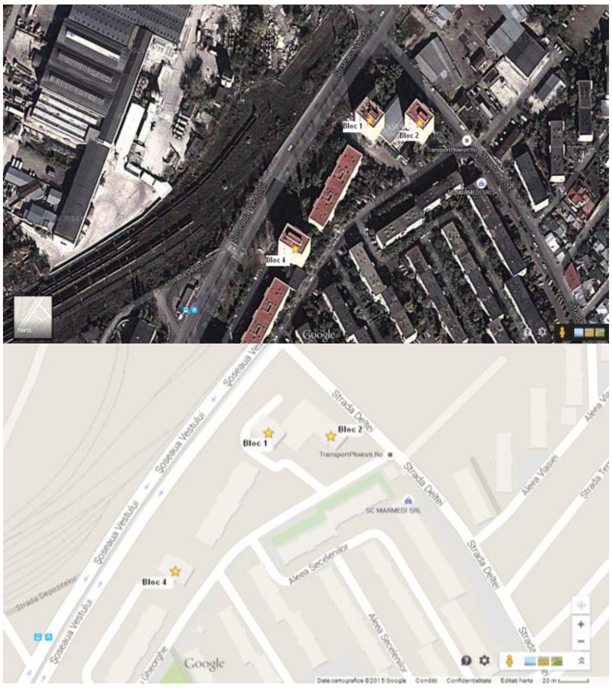

Figure 41. Ploiesti Pilot geographical location - Satellite view, Street view (Map)

Each building included in the Pilot is a ten-storey block with four apartments per floor and commercial areas on the ground floor. The apartments are with two and three rooms, about 50 to 70 square meters each. On the ground floor, there are shopping areas. The Pilot presumes both normal customer appliances (LED lighting, air conditioning systems, washing machines, etc.), as well as large scale appliances like elevators. In the same buildings, the Pilot will cover small commercial consumers (local shops) and a large consumer (a company named Cosmote Shop offering telecommunications services).

The Pilot implementation takes into consideration the following relevant aspects concerning the consumers.

Types of people populating the buildings:

- Families, active people with children.

Number of people populating the buildings:

- For each building about 90-100 persons.
- A company for telecommunications services Cosmote Shop activates in one of the buildings.

Time spent by the people in the building:

- Mainly in the afternoon and during the night.
- From 9 a.m. to 8 p.m. for the Cosmote Shop.

B. Needs and Opportunities

The purpose of Ploiesti pilot is to ensure a Demand Response smart grid, where building energy management and control systems (EMCSs) can operate based on critical peak pricing (CPP) or other DR programs that could be implemented.

The area has been selected for implementing the Pilot because buildings are already equipped with smart meters, however there is no real usage of data and there is no centralised solution for integrating and processing the collected data.

For the DR functionality, it's necessary to integrate the existing meters with some smart meters, capable to automate DR process/algorithms.

The goal is to monitor and control how to operate DR programmes in order to decrease the peak of power consumption for 8 customers equipped with smart meters with DR functionality. With this in mind, we aim to incentivise customer participation in DR programmes testing and validating the concept of a DSO as user of demand-side flexibility and its interaction with the customers.

Table 62. Ploiesti. Opportunities and needs of Ploiesti Pilot

Opportunities	Needs
Smart metering infrastructure availability in the residential area.	Implementing the EIIS (Energy Integrated Information System), a solution to automate the process of DR based on smart meters infrastructure.
Analysing the effect of the automated DR on the energy consumption in targeted/specific areas and the positive outcomes for the DSO and consumers.	Automating and optimising the process workflow from the data collection and metering to data processing based on DR methods and algorithms in order to improve the management of the energy consumption.
Properly exploit the DR approach options; analyse and apply the cost efficiency/cost-benefit method and principles during the implementation of the business model.	Reducing the overall electric consumption of the building with the implementation of the elicited technologies leading to lower costs on the electric bill.

10.2 Context of the Architecture Proposed

The Pilot of Ploiesti will implement the EIIS (Energy Integrated Information System); this is a technical solution with a centralised integrated architecture, based on innovative technologies which allow data consolidation into a single control point. The goal is to automate the process of DR based on smart meters infrastructure.

Actually, three perspectives could be considered for describing the solution architecture: physical architecture, logical/conceptual architecture and functional architecture. The physical architecture addresses the way of orchestrating and administering the following components:

- Electrical infrastructure (smart meters, data concentrator, communication infrastructure, sensors, home smart controllers – with DR, home displays).
- ICT infrastructure (hardware and communications infrastructure).

The conceptual architecture addresses the way of orchestrating and administering the specific components featured in the logical diagram IEEE guidelines.

The processes flows (inputs and outputs) between the architectural components are compliant with ISO/IEC/IEEE 42010:2011, as revealed in the following diagram.

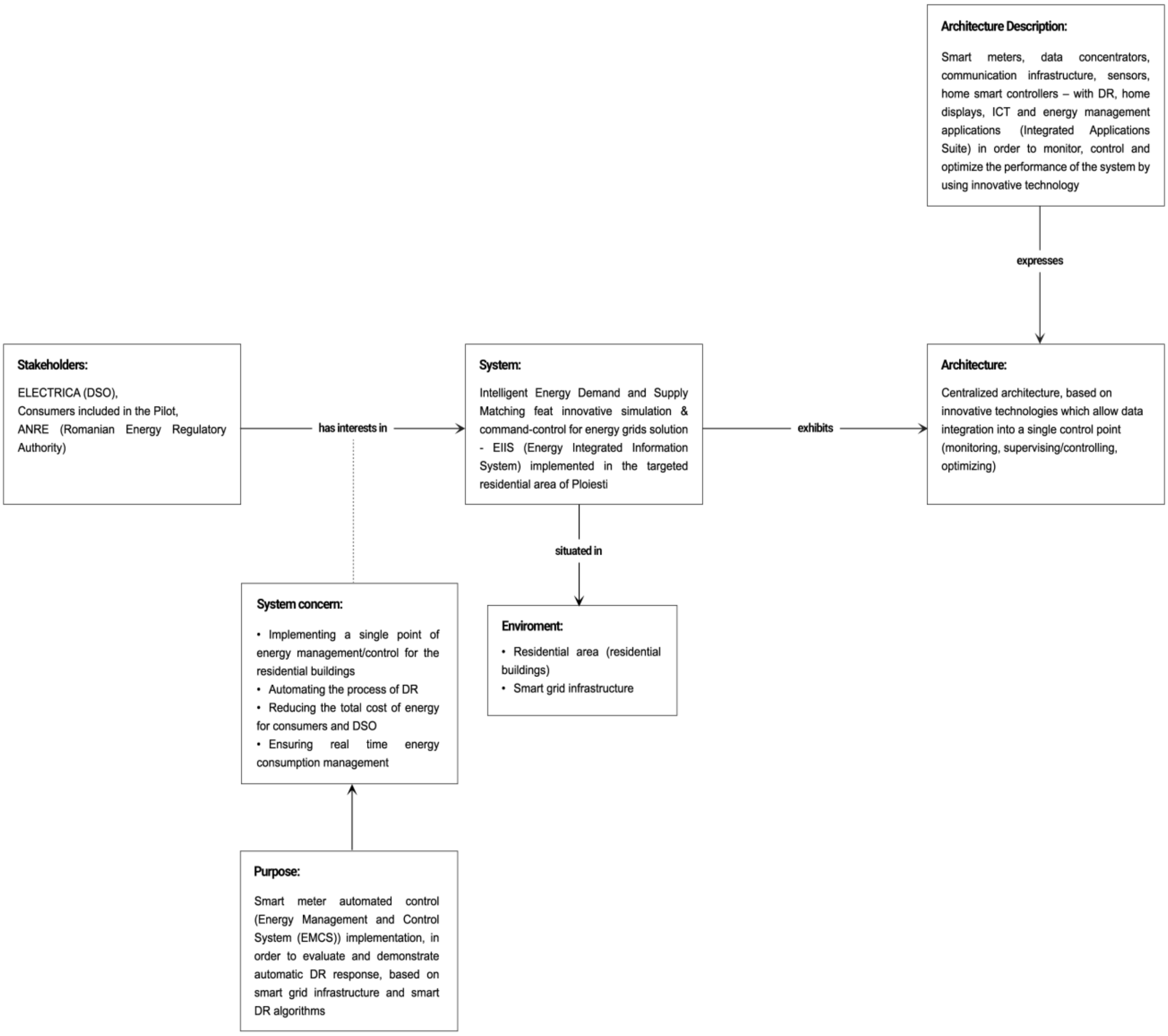

Figure 42. Ploiesti. Pilot system architecture

The major architectural components presented in the above diagram are described in the following table. The goal is to automate the DR process thanks to an advanced smart meters infrastructure (actually Ploiesti Pilot is focused on the Demand Response pillar).

Table 63. Ploiesti. Pilot architecture description

IEEE 42010 components definition	Description
System	Intelligent Energy Demand and Supply Matching feat innovative simulation & command-control for energy grids solution - EIIS (Energy Integrated Information System) implemented in the targeted residential area of Ploiesti.
Environment	Residential area (residential buildings). Smart grid infrastructure.
Stakeholder	DSO (Electrica), Consumers included in the Pilot, ANRE - Romanian Energy Regulatory Authority.

Purpose	Smart meter automated control (Energy Management and Control System, EMCS) implementation, in order to evaluate and demonstrate automatic DR response, based on smart grid infrastructure and smart DR algorithms.
System concern	To have a single point of energy management/control for the residential buildings, to automate the process of DR, to reduce the total cost of energy for consumers and DSO, real time energy consumption management.
Architecture	Centralised architecture, based on innovative technologies which allow data integration into a single control point.
Architecture description	Smart meters, data concentrators, communication infrastructure, sensors, home smart controllers – with DR, home displays, ICT and energy management applications (Integrated Applications Suite) in order to monitor, control and optimise the performance of the system by using innovative technology.

10.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The Pilot of Ploiesti presumes the following:

- To implement the EIIS (Energy Integrated Information System), an energy management solution to automate the process of DR based on smart meters infrastructure.
- To optimise the process workflow (from data collection and metering to data processing based on DR methods and algorithms) in order to improve the management of the energy needs.
- To evaluate and test the validity of the taken DR business model.
- To analyse and validate the integration of the proposed technical solution for the Ploiesti Pilot in the inteGRIDy framework (data model, data communication – formats and protocols).

Considering the above-mentioned aspects, the Ploiesti Pilot intends to accomplish the following objectives:

- Engagement of the customers in energy management driven by information and/or price signals/notifications which leads to electricity usage reduction or load shifting.
- Evaluation of the opportunity to lower energy bills.
- Reduction of peak purchase, contributing to downward energy prices on spot markets.
- Offsetting the need for increasing the distribution capacity.
- Improving the load predictability of the consumption.
- As DSO involved in the project, ELECTRICA will provide relevant information about the real needs and requirements of the DSO and consumers; moreover, the DSO will have a significant role in the analysis and design stage.
- ELECTRICA will participate actively to the design of the technical solution of EIIS and will implement (install and configure) the electrical infrastructure (smart meters, data concentrator, communication infrastructure, sensors, home smart controllers – with DR, home displays).
- ELECTRICA will contribute to define the major functionalities of the system. A designated team will ensure support for defining/selecting the appropriate DR algorithms to be implemented, and also will experiment and test the EIIS applications.
- As technological partner (ICT) involved in the project, SIVECO will define the ICT infrastructure (hardware, communications, devices) and will determine the user needs

and requirements, based on possible scenarios and use cases. SIVECO will design the architecture of technical solution (ICT layer) and will implement/develop specific DR smart algorithms and business models.

Actually, each building included in the Ploiesti Pilot area is provided with smart meters for each user, common utilities, elevator in commercial areas, a data concentrator for the building and communication equipment via GPRS.

The meters for residential users are mounted in metering and distribution cubicles located in the common areas on 1st, 3rd, 5th, 7th and 9th floor of the building under test. On the ground level, in the metering and distribution cubicle, are mounted the meters for the common utilities, elevator and for the commercial areas.

The technical infrastructure will comprise the following components:

- Home area network including sensors, home display, home smart controller with adapted software for automated DR, smart metering system.
- Data concentrators.
- GSM/GPRS modem for the Data concentrators.
- ICT infrastructure and specific software applications/solutions:
    - HES (Head End System) for the smart metering.
    - MDM (Meter Data Management) solution.
    - PCs and/or mobile devices of the consumers.

Regarding the technical infrastructure, based on the preliminary study, we intend to use the following equipment/devices:

- Single Phase Smart Meter with isolated MBus interface, powered MEP (Monitored Energy Protocol) interface, load control relay and S0 output and magnetic tamper detection.
- Poly Phase Smart Meter with isolated MBus interface, powered MEP (Monitored Energy Protocol) interface, load control relay, S0 output and magnetic tamper detection.
- 0.5% CT Meter (5 A rated current; 10 A maximum current) with isolated MBus interface, powered MEP interface, load control relay and S0 output.

The proposed architecture of the EIIS (Energy Integrated Information System) solution (Customer – Home Area Network, DC PLC/PT, DSO – Control and Command) for the Ploiesti Pilot is presented in the following diagram and the functionalities that will be developed could be listed as:

- Energy Management and Control System (EMCS) that will be based on critical peak pricing (CPP) or other demand response (DR) programs.
- Energy Command and Decision system (ECCDIS).
- Automated Demand response based on consumer profiles including Demand Response Automation Server (DRAS).
- Public web portal with basic area consumption and project results facilitating the end consumer participation.

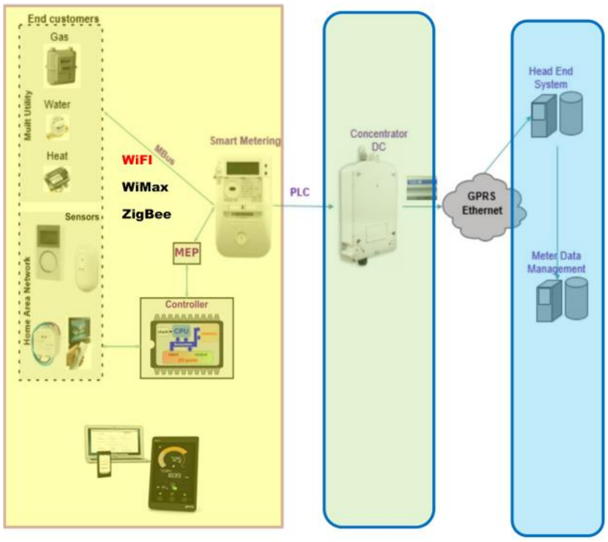

Figure 43. Ploiesti Pilot Overview Architecture

B. Use Case

Based on the above presented architectural design and relevant aspects concerning the Pilot infrastructure, the specific Use Cases of the Ploiesti Pilot are presented in the following. Actually, the proposed Use Cases satisfy the objective of the Pilot, namely comparing the results of the implementation of a DR automated solution with the results of the existing AMR (Automated Meter Reading) solution.

Table 64. Ploiesti. Use Case DR_PL 01

USE CASE1: Automated Meter Reading	
ID	DR_PL 01
Name	Implementing HES 1 (Head End System 1) – DSO perspective
Storyline	*Monitor and Control* - Accessing relevant information concerning the consumption of the residential area in the Command and Control Centre of the DSO (ELECTRICA).
Goal(s)	Collecting relevant data regarding the consumption of the residential area, based on the existing infrastructure. Assessing the power demand and monitoring the evolution of consumption (Real-time energy consumption management). Determining the tendencies and prognosis of the consumption (profile of the consumption curve). Optimising the consumer bill based on the prognosis of consumption, using different rates (CPP, TOU, PTR, CTP). Optimising the performance of electrical infrastructure.
Actors	DSO.
Preconditions	Equipment and infrastructure ready – installed and configured.
Postconditions	N/A
Trigger events	The meters for residential users are mounted and measure the relevant parameters of consumption.

Table 65. Ploiesti. Use Case DR_PL 02

USE CASE2: Automated DR solution (DSO)	
ID	DR_PL 02
Name	Implementing HES 2 (Head End System 2) – DSO perspective
Storyline	*Monitor and Control* - Accessing relevant information concerning the consumption of the residential area in the Command and Control Center of the DSO (ELECTRICA), based on the DR infrastructure.
Goal(s)	Collecting relevant data regarding the consumption of the residential area, using smart meters with DR functionality. Assessing the power demand and monitoring the evolution of consumption (Real-time energy consumption management). Determining the tendencies and prognosis of the consumption (profile of the consumption curve); Statistics. Automated controlling of the power demand, based on the implementation of smart DR algorithms. Optimising the consumer bill based on the prognosis of consumption, using different rates (CPP, TOU, PTR, CTP). Reducing the loss of electrical power. Optimising the load of power cables.
Actors	DSO, Consumers.
Preconditions	Equipment and infrastructure ready – installed and configured.
Postconditions	N/A
Trigger events	The smart meters for residential users are mounted in series with the existent meters and measure the relevant parameters of consumption.

Table 66. Ploiesti. Use Case DR_PL 03

USE CASE3: Automated DR solution (Consumers)	
ID	DR_PL 03
Name	Implementing HES 2 (Head End System 2) – Consumer perspective.
Storyline	Accessing relevant information concerning the own consumption by the consumer, based on the DR infrastructure.
Goal(s)	Displaying / accessing relevant data regarding own consumption. Accessing the own savings in monetary unit (RON). Consumption and peak load decrease, based on the implementation of smart DR algorithms. System alerts/notifications concerning the optimisation of own consumption / costs.
Actors	Consumers included/monitored in the project.

Preconditions	Equipment and infrastructure ready – installed and configured.
Postconditions	N/A
Trigger events	The smart meters for residential users are mounted in series with the existing meters and measure the relevant parameters of consumption.

10.4 Regulatory Framework

In Romania, ANRE, the Romanian Energy Regulatory Authority, assumes the responsibility to monitor and implement energy efficiency measures and promotes the use of renewable energy sources to the final consumer [AUT16].

Regarding the regulatory framework in Romania, the enforced law in the energy field is the Energy Efficiency Law no.121/2014 [AUT16], [AUT17].

This Law transposes the European Union regulations into national legislation set out under Directive 2012/27/UE regarding the energy efficiency, amending the Directives 2009/125/EC and the 2010/30/EU ones and repealing the Directives 2004/8/EC and the 2006/32/EC ones. [AUT17].

The major purpose of the Energy Efficiency Law no.121/2014 is to establish a coherent legislative framework for the development and the application of the national energy efficiency in Romania, in order to accomplish the national target of increasing the energy efficiency [AUT17].

The Energy Efficiency Law no.121/2014 addresses explicitly the DR approach in Art.15 of Chapter Production, transport and distribution of energy and Annex 8 concerning the energetic efficiency criteria for regulating the energetic grids and for the electrical networks rates.

A specific issue for the regulatory framework in Romania with impact on our Pilot is represented by the lack of regulations to offer incentives for eventually prosumers/consumers and DSOs.

Furthermore, another legislative issue which might affect our Pilot is represented by the inconsistent regulations regarding data privacy protection and security.

10.5 Technology Bounds

As already described, the Ploiesti Pilot intends to implement the EIIS (Energy Integrated Information System). It is very important to mention that this solution will be developed from scratch and we can provide in this stage of the requirements analysis only preliminary data regarding the technological approach.

Based on the proposed architectural design, where the major components and data flows are described, we have ranged the relevant functionalities by corresponding equipment as following:

- Electrical technology (specific for smart metering solutions): sensors, smart meters, data concentrator, communication infrastructure, home smart controllers – with DR, home displays, compliant with Wi-Fi, WiMax, ZigBee, MEP and PLC (Programmable Logic Controller) standards and protocols.
- ICT technology: hardware and communication compliant with Wi-Fi/GPRS/3G/LTE, data base solutions, software applications for data modelling and processing/smart algorithms (HES and MDM).

In order to guarantee apparatuses interoperability, open standards will be used for data transmissions/exchange.

10.6 Business Model

As mentioned hereinbefore, the Ploiesti Pilot is a solution developed from scratch. The economical objective of the Pilot is to analyse the effect of the automated DR solution, based on smart meters infrastructure, on the energy consumption in targeted/specific areas and the positive outcomes of implementing this type of solutions for the DSO and consumers.

Moreover, as presented in the previous section 10.3, the specific Use Cases comply with the objective of the Pilot, namely comparing the results of the implementation of a DR automated solution with the results of the existing AMR (Automated Meter Reading) solution. In this context, the proposed Use Cases aim to denote the positive outcomes/economic benefits of implementing the innovative solution to both, DSO and residential consumers.

As specified in the Use Cases, two major goals would be achieved: assessing the power demand and monitoring the evolution of consumption (Real-time energy consumption management), and optimising the consumer bill based on the prognosis of consumption, using different rates (CPP, TOU, PTR, CTP).

Existing business models based on costs and revenues which have been applied in DR projects will be explored. Like methodological approach of developing the business model, we intend to study and apply the cost-efficiency method and principles.

10.7 Replicability/Impact of the Pilot

The purpose of the Ploiesti Pilot is to ensure a Demand Response Smart Grid for a residential area, where the buildings' energy management and control system will function based on intelligent DR algorithms. By implementing the Pilot, we intend to monitor and control DR programmes operation in order to decrease the peak power of consumption for the targeted consumers, equipped with smart meters with DR functionality.

Four major goals would be achieved by implementing the proposed DR solution: real-time energy consumption management, ensuring a single point of energy management for the residential buildings, improving the load predictability of the consumption and reducing the total cost for energy for the consumers and DSO. In our case, the small dispersion of the residential consumers creates an advantage for data analysis and future replicability.

After the evaluation of the Pilot outcomes, similar solutions to the one tested in the project would be applied for residential buildings/areas on a larger scale. Replicating and enlarging the scale of applicability for the proposed use cases depends on the positive outcomes resulted from automating and monitoring the demand response process, based on consumer profiles. We intend to replicate and deploy similar DR solutions in other residential areas, including not only residential buildings, but also other types of commercial surfaces (shops, malls).

Furthermore, from the perspective of the DSO, the replicability of the Pilot is of great interest because the proposed solution provides peak load decrease and electrical power loss reduction; two significant benefits for DSOs, considering the fact that starting from 1st January 2018, in Romania, all the energy will come from the free market, and the smart energy management will become a priority.

10.8 Miscellaneous

The Ploiesti Pilot is a solution developed from scratch, being the first implementation of this type of DR solution in Romania, offering a good opportunity not only for implementing an innovative DR technical solution in the energy domain, but also the opportunity of implementing and validating domain specific smart algorithms and intelligent domain specific business models.

11. Survey on the Thessaloniki Pilot

11.1 Pilot Area Description

A. Area and Geographical Overview

The Thessaloniki pilot will mainly focus on the demonstration and assessment of different Demand Response techniques and the sustainability of related business models offered from a Utility/ESCO company to residential consumers (not prosumers) and commercial customers.

In both cases, the utilization of battery energy storage systems will also be evaluated.

The demonstration will take place in *residential and commercial buildings* in the metropolitan area of Thessaloniki, in northern Greece. All the participating buildings are part of WVT (WATT+VOLT) consortium partner's customer portfolio, an innovative electricity provider in the Greek market, further promoting smart metering solutions since 2012.

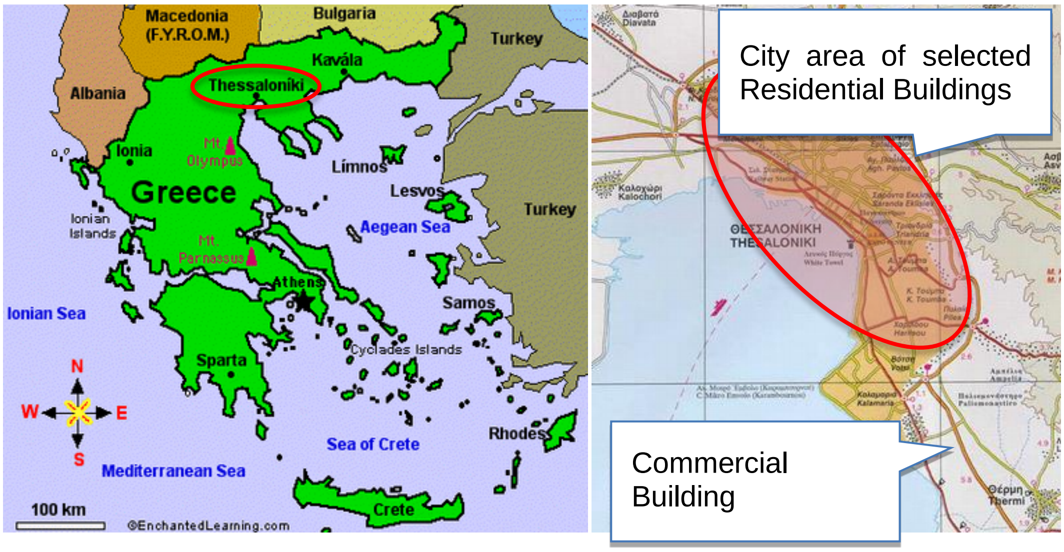

Figure 44 Thessaloniki Pilot geographical location and commercial building location

Thessaloniki is the second biggest city in Greece with a dense city centre and a population of more than a million people. Thessaloniki is a popular young destination, as every year a net inflow of about 12,000 people with ages of 18-25 years old for higher education and career occurs. However, we examine two broad categories [ELI15] of variables that have been identified as potentially important for explaining variability in energy consumption and conservation:

- socio-demographic factors (e.g., income, employment status, dwelling type/size, home ownership, household size, stage of family life cycle);
- psychological factors (e.g., beliefs and attitudes, motives and intentions, perceived behavioural control, cost-benefit appraisals, personal and social norms).

In Greece, a large percentage of the population are not aware about the proper use of electrical appliances and Greeks do unexpected use of electricity at peak times. Also, the use of alternative energy sources, for instance RES, has only lately begun to rise, possibly due to costly electricity bills, but currently it is mainly applied in rural areas, in the surroundings of big cities.

B. Needs and Opportunities

Table 67. Opportunities and needs of Thessaloniki Pilot

Opportunities	Needs
Participation of consumers in price-based or incentive-based DR programs	The performance of the aforesaid programs needs to be evaluated at the residential and commercial level. In particular, the economic benefits from both peak shaving of the demand and the maximum self-consumption need to be determined.
Enrolment of residential end-users in the pilot site to use DR	Need to determine motivational patterns for direct acceptance and introduction of the new notion of energy consumption.
Flexibility within power system operation	Take advantage of the plethora of laborious findings in control theory and the abundance of affordable computational and communication resources for the seamless integration of the targeted IT solutions such as smart meters and battery storage systems.
Introduction of the nearly zero energy buildings (NZEB) concept	Provision of motivation and stimulation of the major renovations to the existing buildings so as to adopt energy management systems.
Use of low-carbon electricity in both the commercial and residential sectors	The DR utilization requires active involvement of end-users to shift/reschedule the operation of some of their controllable loads or make use of some form of storage.

11.2 Context of the Architecture Proposed

In the frame of the Thessaloniki Pilot, three different use cases will be evaluated, each of them with different system and architecture. With respect to the inteGRIDy functionalities, the Thessaloniki Pilot will investigate the Demand Response and Smartening of the Distribution Grid pillars, as detailed in the following.

First, the architecture of the use case with 100 residential buildings (use case TH_UC01) is displayed in the figure below.

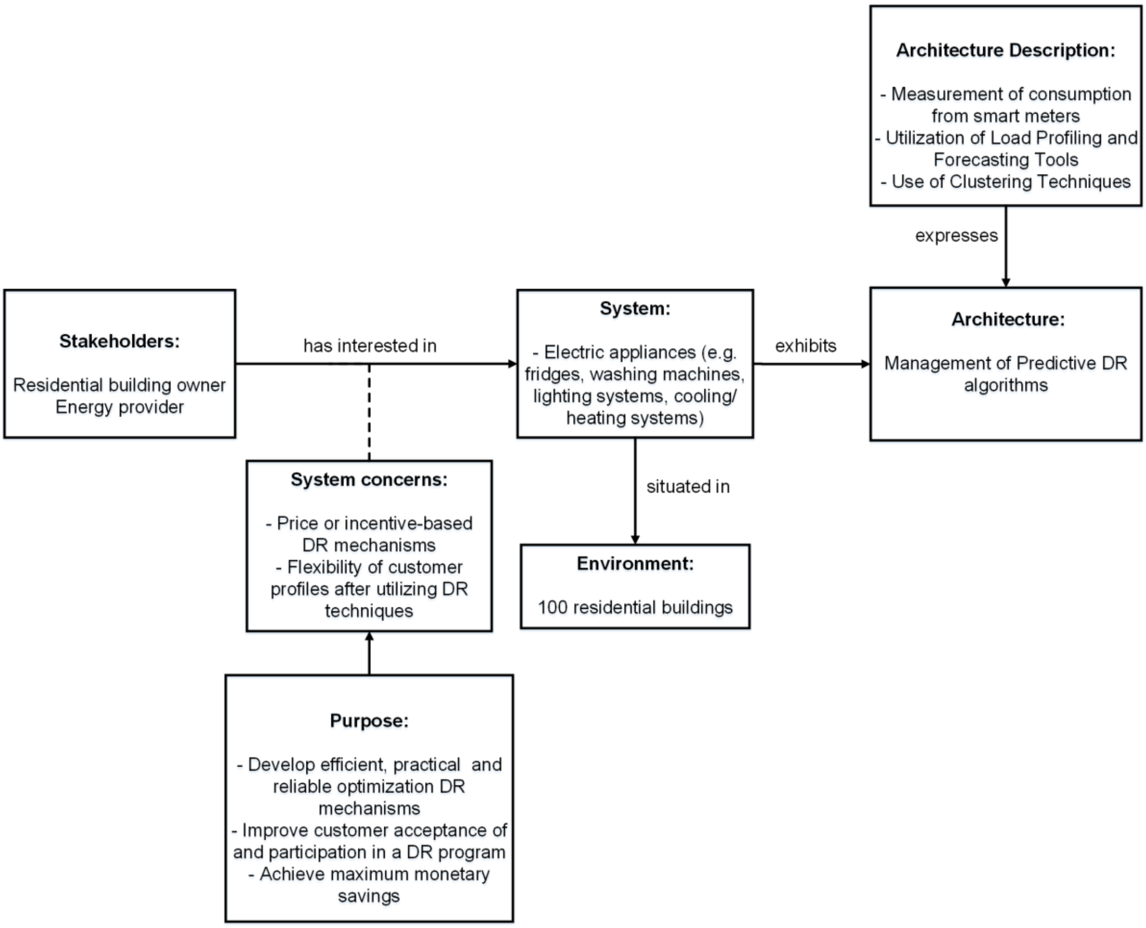

Figure 45. Thessaloniki. Architecture for the use case of 100 residential buildings

Table 68. Thessaloniki. Architecture for the use case of 100 residential buildings description (use case TH_UC01)

IEEE 42010 components definition	Description
System	100 dwellings with electric appliances (e.g. fridges, washing machines, lighting systems, cooling/heating systems) will be equipped with smart meters, allowing for real-time monitoring of consumption per residence.
Environment	100 residential buildings in the metropolitan area of Thessaloniki.
Stakeholder	Residential Building owners and energy providers are interested in this pilot's aspect.
Purpose	The main purpose is to develop efficient, practical and reliable optimisation DR mechanisms for residential customers. The proposed techniques are utilised for minimising their electricity payment or maximising their welfare in order to achieve a generally uniform electricity load profile with reduced peak power. The long-term purpose is to encourage more customers to change their demand pattern through incentive-based DR program.
System concern	One of the system concern is to specify the most appropriate incentive-

	based DR program in terms of the financial or other type of incentives that need to be offered to encourage the end-users to change their demand pattern. Moreover, the flexibility of customer's profiles after utilising DR techniques.
Architecture	All required historical data, such as energy measurements of end-users will be processed and exploited in order to develop different clusters of customer profiles. These clusters will constitute the input data for the application of predictive DR algorithms and flexibility optimisation management schemes.
Architecture description	The buildings are equipped with smart meters, allowing for real-time monitoring of consumption per residence or, in some cases, enhanced with more individual appliances consumption (utilising wireless connected smart-plugs) and some multi-sensorial sensors (e.g. motion sensors), allowing real-time monitoring or creation of individual profiles. Finally, apart from the development of different DR schemes, clustering techniques can also be implemented to group the provided set of 100 profiles with respect to timing of and amount of electricity demand. Hence, the utilization of the exported clusters will enable the design of generic algorithms that can be applied in any type of distribution network.

Next, the architecture for the use case of around 10 residential buildings equipped with a BESS is illustrated in the figure below.

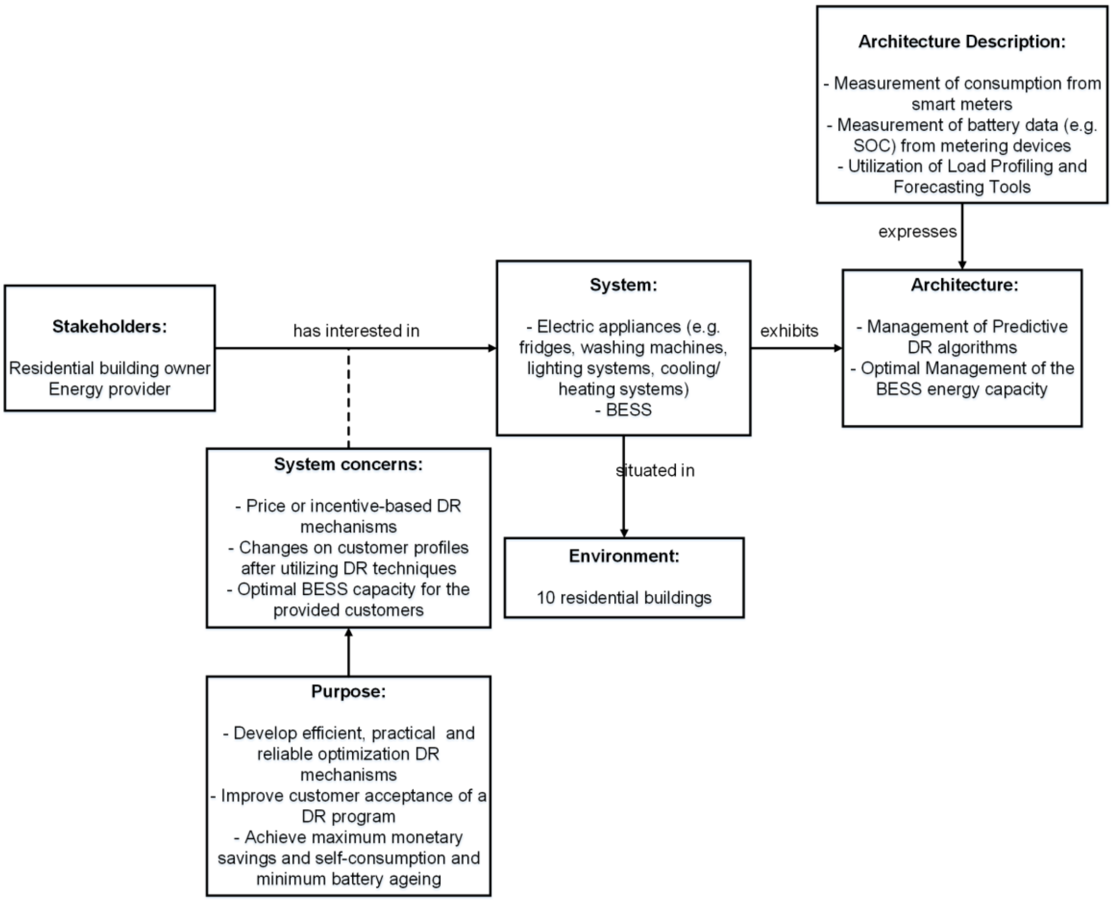

Figure 46. Thessaloniki. Architecture for the use case of about 10 residential buildings

Table 69. Thessaloniki. Architecture for the use case of about 10 residential buildings description (use case TH_UC02)

IEEE 42010 components definition	Description
System	10 dwellings with electric appliances (e.g. fridges, washing machines, lighting systems, cooling/heating systems) will be equipped with smart integrated home batteries solutions (Li-ion, Lead-Acid etc.) allowing the experimentation and optimal control and automation of the battery in-house utilization.
Environment	10 residential buildings in the metropolitan area of Thessaloniki
Stakeholder	Residential Buildings owner and energy provider are interested in this pilot's aspect.
Purpose	The main purpose is to develop efficient, practical and reliable optimisation DR mechanisms for residential and commercial customers. The proposed techniques are utilised for minimising their electricity payment or maximising their welfare in order to achieve a generally uniform electricity load profile with reduced peak power. The long-term purpose is to encourage more customers to change their demand pattern through incentive-based DR program. Another purpose in this use case is to achieve maximum monetary savings and self-consumption and minimum battery ageing.
System concern	One of the main purpose of this survey is to specify the most appropriate incentive-based DR program in terms of the financial or other type of incentives that need to be offered to encourage the end-users to change their demand pattern. Moreover, basic requirement is to determine the rewards/penalties incurred when the end-user accepts/falls short on a specific demand response request. The BESS will also be evaluated in order to optimise the end-users' behaviour through shaving their peak demand and minimising their electric bill cost with dynamic energy pricing models. The proposed strategy of customer-controlled BESS is based on costs incurred due to peak support.
Architecture	The proposed DR schemes will be deployed in the house to manage the demand of air-conditioning units and lighting systems, respectively. Furthermore, battery management systems (BMS's) need to be installed to achieve peak shaving, load shifting, self-consumption as well as to increase the financial savings of the building.
Architecture description	The buildings are equipped with smart meters, allowing for real-time monitoring of consumption per residence or, in some cases, enhanced with more individual appliances consumption (utilising wireless connected smart-plugs) and some multi-sensorial sensors (e.g. motion sensors), allowing real-time monitoring or creation of individual profiles. Also, the BMS, which allows the optimal control and automation of the battery in-house utilization considering current battery State of Charge (SOC), real-time energy consumption measurements and optimal discharge curves of the different batteries used.

Finally, the architecture for the use case of PAOK Sports Arena is depicted in the following.

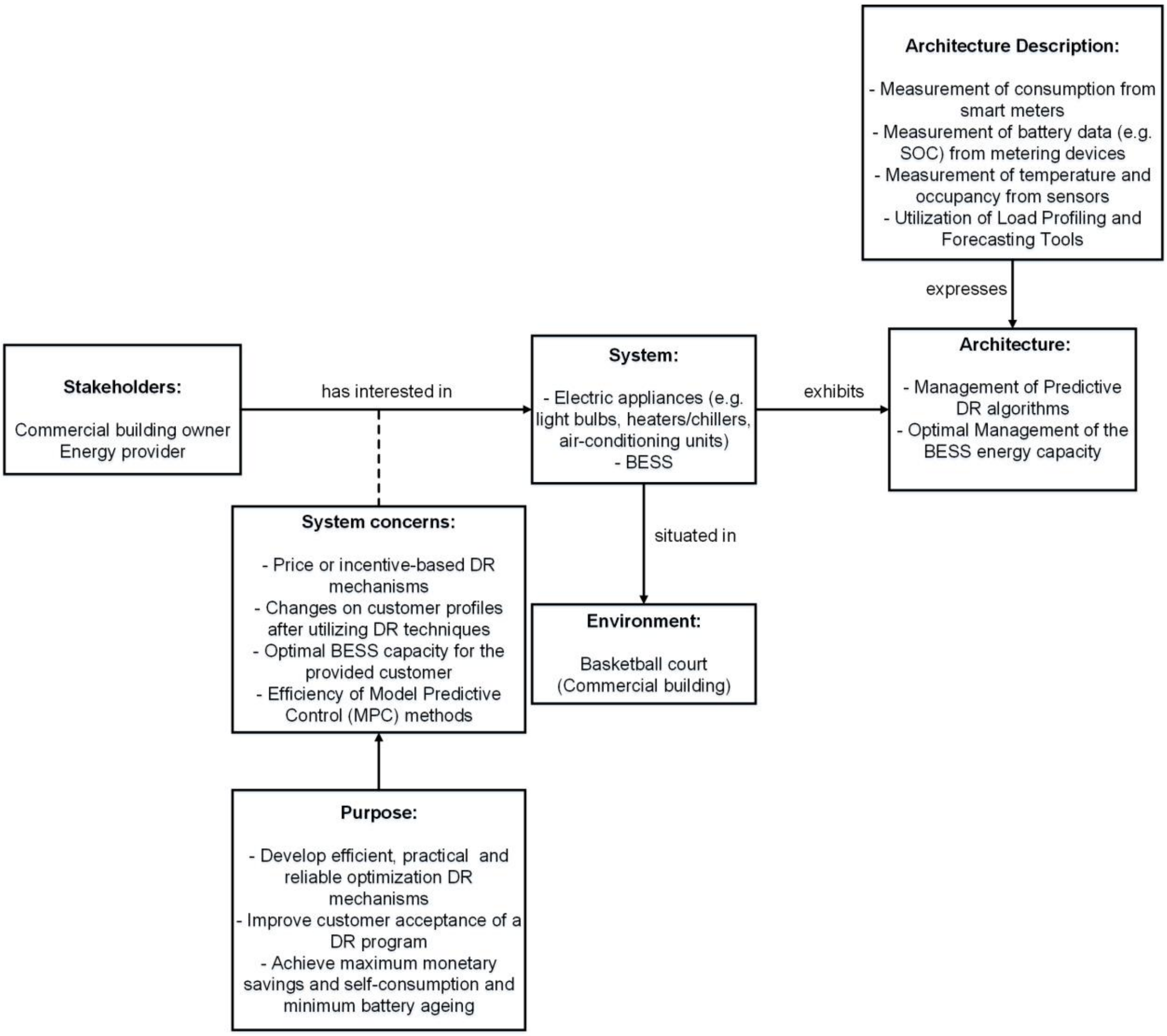

Figure 47. Thessaloniki. Architecture for the use case of PAOK Sports Arena

Table 70. Thessaloniki. Architecture for the use case of PAOK Sports Arena description (use case TH_UC03)

IEEE 42010 components definition	Description
System	PAOK Sports Arena is equipped with electric appliances (e.g. light bulbs, heaters/coolers, air-conditioning units) and buildings will be equipped with smart integrated batteries solutions (Li-ion, Lead-Acid etc.) allowing the experimentation and optimal control and automation of the battery in-house utilization.
Environment	Commercial Building, the Basketball Court in Thessaloniki
Stakeholder	Commercial Building owner and energy provider are interested in this pilot's aspect.
Purpose	The main purpose is to develop efficient, practical and reliable optimisation DR mechanisms for residential and commercial customers.

	The proposed techniques are utilised for minimising their electricity payment or maximising their welfare in order to achieve a generally uniform electricity load profile with reduced peak power. Another purpose in this use case is to achieve maximum monetary savings and self-consumption and minimum battery ageing.
System concern	One of the main purpose of this survey is to specify the most appropriate incentive-based DR program in terms of the financial or other type of incentives that need to be offered to encourage the end-users to change their demand pattern. Moreover, a basic requirement is to determine the rewards/penalties incurred when the end-user accepts/falls short on a specific demand response request. The BESS will also be evaluated in order to optimise the end-users' behaviour through shaving their peak demand and minimising their electric bill cost with dynamic energy pricing models. The proposed strategy of customer-controlled BESS is based on costs incurred due to peak support.
Architecture	The proposed DR schemes will be deployed in the offices and the training court to manage the demand of air-conditioning units and lighting systems, respectively. Furthermore, battery management systems (BMS's) need to be installed in both areas to achieve peak shaving, load shifting, self-consumption as well as to increase the financial savings of the building.
Architecture description	The commercial buildings are equipped with smart meters, allowing for real-time monitoring of consumption per residence or, in some cases, enhanced with more individual appliances consumption (utilising wireless connected smart-plugs) and some multi-sensorial sensors (e.g. motion sensors), allowing real-time monitoring or creation of individual profiles. Also, the BMS allows the optimal control and automation of the battery in-house utilization considering current battery State of Charge (SOC), real-time energy consumption measurements and optimal discharge curves of the different batteries used.

11.3 Goal of the Pilot & Use Cases Proposed

A. Goals

The main goal of this project is to develop efficient, practical and reliable optimisation DR mechanisms for residential and commercial customers. The proposed techniques are utilised for minimising their electricity payment or maximising their welfare in order to achieve a generally uniform electricity load profile with reduced peak power.

On one hand, this study aims at determining the benefits brought by the utilization of DR techniques for the participant and the society as a whole. The evaluated benefits are split up in four categories:

- Participant financial benefits, which may consist of either short-term direct bill savings resulting from incentive payments or a decreased electricity bill, or other offers such as provision of innovative services or products (e.g. smart home automation equipment) provided at reduced prices or free-of-charge.
- Market wide financial benefits, which are divided into short-term operational benefits and long-term investment benefits. DR can lead to operational benefits in the short run due to a reduced start-up cost of expensive peaking generation units. In the long run, utilities avoid capacity, transmission and distribution investment costs, since the system can be tuned to a lower peak demand due to sustained Demand Response. Both short and

long-term benefits result in a lower electricity price for both participating and non-participating end-users due to more efficient power system operation.

- Reliability benefits, as additional system flexibility reduces the probability of a demand-supply imbalance.
- Market performance benefits that correspond to the reduction of generator's incentives to bid above marginal generation cost owing to end-user's ability to decrease electricity consumption during high price moments.

This project focuses on the assessment of participant financial and reliability benefits, since the maximisation of both monetary savings and self-consumption for the end-users is the most crucial objective. The long-term objective of this pilot is to encourage more customers to utilise DR methods considering the aforementioned benefits. As for the DR impact on the market, it is also of major concern, therefore, it can be evaluated in a future work, taking into account a higher number of end-users (e.g. various LV distribution networks).

On the other hand, both price-based and incentive-based DR programs rely on the demand-price elasticity concept to design an optimum scheme for achieving the maximum benefit of DR. The objective is to not only reduce costs and improve reliability but also to improve customer acceptance of a DR program by limiting price volatility that reflects the uncertainty of prices over a period of time.

Regarding the price-based concept, time-varying tariffs also referred to as dynamic tariffs, approximate the actual cost of energy. Those tariffs are offered to make end-users shift consumption from high to low price periods. Although many variants of price-based DR methodologies exist, most can be classified in four subcategories according to their tariff design: time-of-use (ToU), critical peak, day ahead and real-time pricing [ALB08]. The ToU pricing, mainly applied in Greek LV distribution networks, corresponds to day-night pricing with a lower price during the night. The different theoretical concepts need to be constructed and assessed in the frame of this project.

As for the incentive-based concept, participating users receive payments for reducing their demand at critical times. Incentive-based programs include six subcategories: direct load control, curtailable load, demand bidding, emergency demand response, capacity and ancillary services markets programs. One of the main objectives of this survey is to specify the most appropriate incentive-based DR program in terms of the financial or other types of incentives that need to be offered to encourage the end-users to change their demand pattern, experimenting with different kinds of participation applications (such as mobile apps) for dynamically triggering end-user's active involvement. Moreover, basic requirement is to determine the rewards/penalties incurred when the end-user accepts/falls short on a specific demand response request. Obviously, it is also possible to use both types of DR programs in various combinations. In this study, the optimal use of both incentive-based and price-based concepts in a combined DR program is evaluated. The hybrid solution aims at bringing the maximum amount of the aforesaid benefits for all the participants.

In Thessaloniki pilot, in the frame of DR concept, the energy VA/billing system, which was designed by WVT and the battery storage solution will be provided by SUNLIGHT consortium partner. As for the BMS, CERTH has already developed a battery charging optimisation engine which allows the optimal control and automation of the battery in-house utilization considering current Battery State of Charge (SOC), real-time energy consumption measurements and optimal discharge curves of the different batteries used.

B. Use Cases

Thessaloniki Pilot will be detailed in three Use Cases, as detailed in the following tables.

Table 71. Thessaloniki. Use Case TH_UC01

USE CASE: Demand Response in residential buildings with smart meters	
ID	TH_UC01
Name	Demand Response in residential buildings with smart meters
Storyline	100 different dwellings consisting of various buildings and customer profiles will be selected (e.g. individual housing buildings, apartments, families, students, one-person occupied flats etc.). The selection of the load profiles is based on different occupation patterns (time spent in the house by the residents, modularity of the patterns etc.) aiming to represent a broad range of residential building consumption profiles and, thus, deployment in various demand response patterns. Installed smart meters will monitor the energy consumption of the dwelling and will regulate the load by prompting users to adopt different energy consumption behaviour.
Goal(s)	The main goal is to specify the most appropriate incentive-based DR program in terms of the financial or other type of beneficial factors that will encourage the end-users to change their demand pattern.
Actors	Energy provider, end-users
Preconditions	Energy consumption historical data of each dwelling. Installation of sensors/devices for user monitoring (e.g. motion sensors, wireless network and connected smart plugs). Real-time monitoring and prompting system based on individual profiles. Definition of holistic user-centred rewards/penalties towards the user in situation of acceptance/ignorance of specific demand response system's requests.
Postconditions	The performance of the smart meters will be evaluated at the residential level. The economic benefits from both peak shaving and energy consumption shifting will be optimised.
Trigger events	Smart meters will be always active and prompting signals will be passed to the user when real time energy consumption is sub-optimal.

Table 72. Thessaloniki. Use Case TH_UC02

USE CASE: Demand Response in residential buildings with BESS	
ID	TH_UC02
Name	Demand Response in residential buildings with BESS
Storyline	10 dwellings will further be carefully selected to be equipped with smart integrated home batteries (Li-ion, Lead-Acid etc.) allowing the experimentation and optimal control and automation of the battery in-house utilization.
Goal(s)	The main goal is to specify the most appropriate incentive-based DR program in terms of the financial (or other type of) incentives that need to be offered to encourage the end-users to change their demand pattern. The BESS aims to optimise the end-users' behaviour through shaving

	their peak demand and minimising their electric bill. The proposed strategy of customer-controlled BESS is based on costs incurred due to peak support.
Actors	Energy provider, end-users
Preconditions	Energy consumption historical data of each dwelling. Installation of sensors/devices for user monitoring (e.g. motion sensors, wireless network and connected smart plugs). Real-time monitoring and prompting system based on individual profiles.
Postconditions	The performance of the home batteries will be evaluated at the residential level. The economic benefits from both peak shaving and due to energy consumption shifting will be optimised.
Trigger events	The procedure is periodically scheduled, eventually it is activated in case of critical changes when real-time energy consumption is sub-optimal.

Table 73. Thessaloniki. Use Case TH_UC03

USE CASE: Demand Response in Commercial Building with BESS	
ID	TH_UC03
Name	Demand Response in Commercial Building with BESS
Storyline	PAOK Sports Arena, a basketball court which features a very disperse and seasonal power demand, typically ranging between a minimum of approximately 30 MW and a maximum of approximately 70 MW. Sports Arena comprised of a basketball court with 8,500 seats, accompanied by a smaller training court, fully equipped gym, club offices, shops, and a small museum dedicated to PAOK basketball club. The building has an average annual consumption of 500 MWh and is supplied by the MV distribution network. Installed smart meters and BESS will monitor the energy consumption of the Sports Arena and will regulate the load by prompting users to adopt different energy consumption behaviour.
Goal(s)	The DR schemes will be deployed in the offices and the training court to manage the demand of air-conditioning units and lighting systems, respectively. Installed battery management systems will achieve peak shaving, load shifting, self-consumption as well as to increase the financial savings of the building.
Actors	Energy-provider, end-user.
Preconditions	Energy consumption historical data of each dwelling. Installation of sensors/devices for user monitoring (e.g. motion sensors, wireless network and connected smart plugs). Real-time monitoring and prompting system based on individual profiles and patterns.
Postconditions	The economic benefits from both peak shaving and due to energy consumption shifting will be optimised.
Trigger events	Smart meters will be always active and prompting signals will be passed to

	the user when real-time energy consumption is sub-optimal. BESS is periodically scheduled, eventually it is activated in case of critical changes when real-time energy consumption is sub-optimal.

11.4 Regulatory Framework

The liberalization of national electricity markets in Europe, which was established by European Directive 96/92/EC [[EUR96], led to fundamental changes in the organization and operation of the electricity markets within the EU member states. In Greece, the liberalised electricity market is operated by the Hellenic Transmission System Operator (HTSO) and is supervised by the Regulatory Authority for Energy (RAE). RAE is an independent administrative authority with legal personality, which was established under L. 2773/1999 with a view to harmonising the Greek legislative and regulatory frameworks with the provisions of the latest EU Directives 2009/72/EC [EUE09] and 2009/73/EC [EUG09] concerning common rules for the internal market in electricity and natural gas, respectively. The electricity market rules that are in effect today are defined in the Grid Control and Power Exchange Code for Electricity, hereinafter referred to as the “Code”, which was developed by RAE.

Greece’s liberalised electricity market design consists of two separate markets, as follows:

- Wholesale electricity market
- Capacity assurance (or adequacy) market (or mechanism) (CAM).

The Greek wholesale electricity market is structured around a gross mandatory pool in which energy and ancillary services are simultaneously traded in a day-ahead market and are dispatched on the available units. In essence, the Greek market design introduced a distinction between day-ahead market and the balancing mechanism. This structure reflects with more clarity the factors influencing prices, the uncertainties involved and the implied risks at these distinct time scales. In particular, during the transitory market regime, the day-ahead market provided an indicative unit commitment schedule and a reference spot price (SMP forecast), which served purely as a signal. Cash-flows were based on ex-post SMP prices. However, market participants do not submit bids and offers for deviations from their day-ahead schedules, so as to formulate the imbalance prices, as the case with the balancing mechanisms of other countries is. Instead, the imbalance prices were derived by re-solving the same cost-minimisation algorithm, as in the day-ahead schedule, by inserting metered values of the various inputs (mainly demand, plant availabilities and renewables’ output) instead of day-ahead forecasts. These ex-post prices were applied to the actual quantities consumed or produced (the latter reflecting to a large extent the real-time dispatch orders of the TSO).

Uniform pricing still applies in the day-ahead market, reflecting the offer of the most expensive unit dispatched so that predicted demand is satisfied. As a result, the setting of energy price caps well below the presumed scarcity value of energy and “out-of-merit” dispatching, lead to a “missing money” issue. Namely, the prices paid to suppliers are substantially below the levels required to stimulate new entry. Zonal pricing, intended to reveal congestion problems and signal the location of new capacity, has not been activated yet, although two zonal prices, applicable to generators, are explicitly derived, currently only as an indication. Participants may enter into bilateral financial contracts (CfDs), but physical delivery transactions are constrained within the pool and related contracts do not exist.

The capacity assurance market aims at complementing the energy market arrangements, stimulating suitable new investment and ensuring long-term adequate generation capacity availability. In particular, this market is applied for the partial recovery of capital costs, with suppliers being obliged to buy capacity certificates from generators. The CAM has so far taken the form of regulated payments as there is limited competition for the market-based enduring format to be applied.

As for the Greek retail market, the sector is about to undergo significant changes due to the compulsory reduction of PPC's share in the supply sector and the recent introduction of NOME, which provide access to lignite and hydro generated electricity to the alternative suppliers. These expectations have already resulted in an increase of interest by companies which are active in other sectors for entering the electricity supply market.

In Greece, smart meter installation, which is underway, is a prerequisite for dynamic pricing; nevertheless, it is possible to manage peak demand by providing multi-brand tariff (day/night rates). In recent years, electricity prices have risen steeply, in response to the removal of price caps and market liberalisation. According to [ECO16], the average retail electricity price increased at an average annual rate of 3.2% between 2008 and 2015, while the energy component (the part of the price paid to the electricity retailer) declined by 15% during this period. This pass-through of the energy component is influenced by the degree of competition in the market and the regulation of market prices. Consequently, it is crucial that consumers are offered services (such as participation in DR) and the ability to better control their costs in the upcoming future. Whereas the lack of smart meters renders a considerable barrier of this implementation for the residential customers with efforts being mostly concentrated on large commercial industrial customers. Characteristic examples of this framework are: (i) a discount of 10% on PPC rates for companies with annual consumption of over 1,000 GWh, and (i) an additional discount of 25% on its night and weekend rates for industries with annual consumption below 1,000 GWh [BER16].

Two DR interruptible programs have been established in Greece and have been launched in 2016. Albeit they do not as yet allow for aggregation, they are dynamic, auctioned on a monthly basis and intended for frequent use. Consumers with 5 MW of flexible load might participate. On the other hand, LV customers can participate, when they are equipped with smart meters and receive approval from the TSO. Apart from the roll-out of smart meters, clear and simple modalities for participation and a positive business case for end-users are needed to enable DR. In particular, measurement and verification requirements need to be developed, in combination with fair payments and penalties. Empowering intermediaries, such as aggregators and service providers will also be a powerful means for reaching out a maximum number of customers. Greece is also carrying out a full regulatory review in preparation for a Capacity Remuneration Mechanism (CRM), and plans to define aggregation within this framework. Finally, regulatory measures should be complemented with pilot project or information campaigns for the targeted groups.

BESS is currently hampered by legislative barriers and disincentives both at EU and Greek level. There is lack of regulatory frameworks, therefore, they are normally treated as generation systems. According to [EUE09], the BESS utilization by grid operators is very limited at present, as unbundling requirements do not allow TSOs and DSOs to directly own, or control, energy storage infrastructure. Particularly, there is no definition of energy storage in the current EU legislative landscape, leading to a series of unintended barriers and thereby creating an uncertain investment environment. Besides that, the EU market does not currently recognise the value of ancillary services to balance the grid, while some states impose double grid fees on storage systems or direct taxation on self-consumed energy. Consequently, the developed regulatory framework should recognise the importance of BESSs by the legislators, with the removal of legislative and market barriers.

11.5 Technology Bounds

In general, a smart metering communication system consists of the following components: smart meter which is a two-way communicating device that measures energy consumption; Home Area Network (HAN) which is an information and communication network formed by appliances and devices within the home; Neighbourhood Area Network (NAN) that collects data from multiple HANs and delivers the data to a data concentrator; Wide Area Network (WAN) which is the data transport network that carries metering data to central control centres; and Gateway which is the device that collects or measures energy usage information from the HANs and transmits this data to interested parties.

Actually, WVT has already developed an advanced metering infrastructure (AMI), so smart meters can measure and record actual energy consumption from all the buildings at certain time interval of 5 minutes. Further occupancy and environmental monitoring equipment will be utilised in the commercial building use case. The data gathered will be aggregated at a gateway at the building level and forwarded to the back-end WVT analytics system over a secure network through wired or wireless communication.

A significant barrier of this technology is related to consumer resistance issues that are primarily driven by three reasons:

1. The household metering equipment gateway needs an active internet connection, so in case the internet connection is interrupted and or there is no power on the local internet router, the internal gateway's memory could store data just for 1 day.
2. Consumers might fear that security and privacy of data gathered by smart metering cannot be guaranteed and hence unauthorised parties might have access to private data.
3. Consumers might also fear that the costs for deploying a smart metering infrastructure could end up with them, leading to higher energy costs, whereas their benefits might prove to be overestimated.

In cases (2,3), the main problems and therefore the main instruments to mitigate consumer resistance are a lack of consumer awareness, trust and knowledge. As a result, the successful deployment of smart metering infrastructure in the frame of this pilot can create the necessary acceptance from the customers and, secondly, can enable the consumers to benefit from the possibilities smart metering provides.

Moreover, in the Pilot a home battery system will be tested. Actually, the main requirement of a DER installation at distribution level is the compliance with the European standard EN 50160 [ENE50]. Since BESS's are also considered as DER technologies, customers equipped with such units must avoid any violations of the EN 50160 constraints with respect to the voltage and frequency characteristics in European distribution networks.

Regarding the technology bounds of a BESS, battery ageing is of considerable concern and its variation depends on the operational system behaviour. Since battery ageing is related to battery cycling behaviour, up and low bounds for BESS charging and discharging power, as well as boundaries for the state of charge (SOC) of the BESS need to be clarified. Moreover, the power constraint in charging and discharging depends to large extent on how the battery is charged, therefore it should be predefined whilst dimensioning the system. The aforesaid technical bounds are taken into account in the use cases of buildings equipped with a BESS.

11.6 Business Model

As denoted in the previous section, the specific use cases target to demonstrate innovative DR services to both residential and commercial end-users. Today's energy market remains demand-driven, in particular at the LV/MV level, which means that energy providers need to buy energy at high rates in the energy Market Point to meet the demand requests during peak hours. Currently only static models exist (offering different day-night pricing), thus, the investigation of different active DR business models is of main interest. Existing tariff designs (such as ToU, critical peak and real time/dynamic pricing) that have already been applied in other countries will be followed. The main concept of this implementation is to achieve partial distribution of the energy providers/utilities' profit to the participating end-users.

The investment cost will considerably decrease when no BESS will be installed in the end-users' premises, since it will mainly comprise the implementation of respective tools and services. Without a doubt, the expected impact on the load shifting/reduction will further be minimal. Nevertheless, if such a business model proves to be profitable it can bring a great potential, since it can easily be rollout and scaled-up to many residential customers.

In the cases of the BESS usage, the investment cost is relatively high while there are certain prerequisites for a profitable realisation of such a business model. Therefore, a very careful selection of the potential, residential customers, with respect to their load profile and building characteristics, is required. As all of the buildings were selected from the urban area of the city of Thessaloniki, where no local DG units (such as roof-top PVs) exist, prosumer-cases are not considered in this survey. Though both the potential of load flexibility and the use of self-consumption are limited, this study represents the current status in Greece and generally in Europe, where the percentage of prosumers is still restricted.

Part of the business model analysis will further take into account the depreciation time of the investment considering both the investment (capital) and operational costs. The depreciation cost depends on the battery lifetime, which is either limited by the shelf-life (independent of battery usage) or by the life-cycle, whichever is shorter. An estimation of the depreciation cost time of the investment of Tesla-type battery would be 7-8 years [BEN17].

There is also high environmental impact of the proposed use cases, once they scale-up, providing reduction of CO_2 emissions, increasing self-consumption, as well as enabling grid stabilisation. Finally, the implementation of DR mechanisms in large-scale systems will allow the higher and more efficient RES penetration, which might lead to additional revenues in the cost benefit analysis of the respective business models.

11.7 Replicability/Impact of the Pilot

Taking into account the utilization of resources, demand volatility often leads to the planning and installation of additional generation capacity so as to cope with peak demand. The peak load units operate only for a fraction of a day, leading to a suboptimal utilization of resources. Apart from that, they also affect prices in electrical energy markets, typically increasing the average production cost. In the meantime, the respective conditions of tight supply enable suppliers, even with relatively little market power, to manipulate the market and raise system-wide prices to excessive levels.

Based on the aforementioned discussion, it seems that the rationalization of electrical energy consumption beyond the goals already achieved will inevitably require further involvement of the end-users through the proposed DR programs. The next step of the pilot solutions would be the shift from addressing consumers as individuals to considering them as groups with common consumption patterns and goals. This will enable the large-scale application of the developed DR mechanisms and stronger consumer involvement, achieving in turn higher acceptance rates.

Since demand response is mainly deployed in industry, a large potential of the residential sector has remained hitherto untapped. In addition, replicating and upscaling the use cases of residential properties (with/without BESS's) focus not only on urban areas, but on all kinds of areas. As for the commercial buildings, the undertaken activities do not target a specific type of building or business, such as sport facilities that usually have limited DR flexibility due to the specific peak demand times of the building. On the contrary, such DR services can be easily replicated and deployed in many different types of commercial buildings (e.g. shopping malls, hospitals, restaurants) allowing even more flexibility to be provided. Besides that, the size of the selected city area is indicative, thus, the developed methods can be implemented by all end-users of large-scale feeders.

Regarding the BESS usage, the domestic sector is expected to have crucial impact on the reduction of carbon, as well as on the price volatility when applied at large-scale. In addition, the large-scale usage of BESS's will affect the maturity and the cost of this technology, making them economically viable in the market. Recently, the increasing use of both home battery systems (e.g. PV storage systems in Germany) and electric vehicles (EVs) have led to the reduction of BESS investment cost. This trend is expected to make BESS even more affordable facilitating their larger-scale implementations. One of the main barriers that needs to be removed concerns the establishment of a regulatory framework for ESS. Today, the lack of framework leads to ownership issues for the ESS, thus, they need to be clarified.

The large-scale implementation of DR mechanisms is expected to have dynamic impact on the liberalised market, since the consumers will also obtain competitive attitude with respect to their maximum monetary savings. In particular, the end-users will be able to select both their energy provider and consumption times according to dynamic pricing models. Due to a more competitive electricity market, the energy providers will need to offer not only lower prices to attract new customers, but also to aim to provide such innovative DR services to gain more added-value in the competition.

11.8 Miscellaneous

Some further issues that should be taken into account concerning the specific use cases:

- Households' socio-demographic characteristics and energy conserving behaviour

An energy saving campaign should face consumers as subgroups with different needs and different aspects of lifestyle. Thus, in Greece this framework would be more effective if the diffusion of information with regards to energy saving measures begins from the primary education since attitudes, beliefs and norms of younger people are more receptive to changes.

- Ethics and privacy issues

The proposed solutions do not expose, use or analyse personal sensitive data for any purpose and therefore no ethical issues are raised by the technologies to be employed in Pilot sites foreseen in Greece. Furthermore, to further ensure that the fundamental human rights and privacy needs of participants are met, in the Evaluation Plans a dedicated section will be delivered for providing ethical and privacy guidelines. In order to protect the privacy rights of participants, a number of best practice principles will be followed. In particular, no data will be collected without the explicit informed consent of the individuals under observation (all participating end-users will be required to read and sign an informed consent form that will explain in both plain English and in local language).

12. Pilots cross evaluation

All inteGRIDy pilots have been extensively studied and described throughout this document. The most relevant highlights regarding each case are listed in this section in an attempt to ease reader reference and quick search of technologies and objectives covered.

Table 74. Summary of inteGRIDy pilots.

		DR	SG	ES	EV
Isle de Wight (UK)	Improve the grid design, storage, EV penetration and RES installation on a self-sufficient island.	✓	✓	✓	✓
Terni (IT)	Integrate offline micro grid owned by local farmers cooperative with MV grid	✓	✓	✓	✓
S. Severino Marche (IT)	Enhance the distribution grid with topology optimization processes based on forecasting power flows	✓	✓	✓	
Barcelona (ES)	DR optimization and storage solutions to help grid penetration of RES. Sports centre building demo	✓	✓	✓	
(FR) St Jean Maurienne	Integration of DER into the distribution grid without threating its stability. DR in buildings and Power-to-Heat for VES	✓	✓	✓	
Nicosia (CY)	Implementation of a micro grid between UCY campus and households, including DR and DSM strategies	✓	✓	✓	
Lisboa (PT)	Control system for buildings and accounting system to promote integrated prosumer management	✓		✓	✓
Xanthi (GR)	DR mechanisms, supervision functions, virtual central storage and charging facilities for local isolated micro grid	✓	✓	✓	✓
Plolesti (RO)	Energy information system (EIS) for control and command distribution of information in a 3-building smart grid	✓			
Thesaloniki (GR)	DR management scheme for different consumer profiles and flexible storage types and management methods	✓		✓	

In the **Isle of Wight** Pilot one of the main goal is the energy autonomy, i.e. the effective exploitation of the locally available renewables in order to feed the energy needs avoiding main grid reinforcement (e.g. a new interconnector with the main land). In order to guarantee a reliable working condition of the electric system, new resources capable to provide ancillary services will be required (this could lead to financial opportunities to the final users), similarly energy storage solutions and electrical vehicles management could contribute to load balancing.

For the reasons, four Use Cases will be investigated involving:

- **Demand Response:** through an advanced BMS to manage the final users' peak load.
- **Smartening of the Distribution Grid**: based on an advanced monitor of the island electric grid and on the management of Energy Storage Systems and Demand Response strategies.
- **Energy Storage**: based on the retrofitting of an electrically-powered thermal store, to optimally shape the consumption pattern of the users.
- **Smart Transport**: based on a smart management of EV charging processes in order to provide demand side response to the grid.

In the **ASM Terni** Pilot the focus is on the optimal management of a rural microgrid, exploited as a regulating resource for the main grid. The goal is to provide higher electric service reliability and better power quality to the end customers, in particular, a Flexibility Optimized Management Cockpit (FOMC: a platform developed in previous projects that will be enhanced in order to support DSO to optimally manage the resources, both the one connected to the MV grid and the one connected to the microgrid). In particular, given the communication needs, in the ASM Terni Pilot communication and data exchange between generation/consumption resources, the DSO and the Microgrid will be deeply investigated.

Actually, four Use Cases will be investigated:

- **Demand Response:** thanks to the FOMC platform the DSO will provide a flexible management of the resources in order to maximise savings and economic benefits.
- **Smartening of the Distribution Grid**: in case of abnormal condition on the grid the DSO will exploit FOMC capabilities in order to improve the power quality.
- **Energy Storage**: an electrochemical energy storage (connected to the rural microgrid) will be exploited in order to support the distribution grid.
- **Smart Transport**: based on a smart management of charging processes in order to provide demand side response to the grid.

Actually, the scenario is quite different with respect to the Isle of Wight one; nevertheless, the goals and the use cases proposed resulted to be quite similar. Thanks to the already available FOMC platform, preliminary results of the ASM Terni Pilot could turn out quite useful for the Isle of Wight in order to design an effective infrastructure for the data gathering and the resources coordination.

The **San Severino Marche** Pilot will involve the whole MV distribution grid, in particular sensors will be deployed for an effective (real-time) monitoring and optimisation of the system. Goals are in the optimal management of the renewables and in the maximisation of the system efficiency and reliability. Moreover, new approaches to the ancillary services market will be investigated.

Three Use Cases will be investigated:

- **Demand Response:** based on electrochemical energy storage solution and on a proper information approach to the final users (to drive a more aware energy behaviour).
- **Smartening of the Distribution Grid**: thanks to the monitoring infrastructure that will be deployed, the DSO will identify the optimal topology of the grid in order to host dispersed generation, to minimise losses and to maximise grid resilience.
- **Energy Storage**: several Energy Storage apparatuses will be coordinated in order to provide front-of-the meter services. Performances will be compared with respect to a second, more conservative, approach based on a ESSs local management devoted to providing behind-the-meter services.

As already discussed in the ASM Terni Pilot, also in this case communication requirements will be particularly strict. The DSO will have to collect data over the grid, and to interact with the users (active and passive one). Consequently, new (open) protocols will be tested (standard IEC 61850 will be exploited for LAN and WAN applications on the distribution grid).

The **Barcelona** Pilot will focus on the optimal energy management of a sport Centre, managing both thermal and electrochemical storage solutions. Actually, in Spain, demand-side resources are not allowed to participate in the markets, and the balancing and ancillary services can only be accessed by generation, consequently the Pilot will test innovative demand response approaches.

For this Pilot, three Use Cases will be investigated:

- **Thermal and electric synergies**: heat pumps in the building will be managed in order to optimise both the energy flows (cfr. the economics) and the final users comfort. The use of a swimming pool with a huge thermal inertia will be analysed.
- **Photovoltaic and Electric Storage Optimisation**: PV generators will be coupled with an electrochemical energy storage in order to test peak shaving, load shifting and maximising self-consumption.
- **Uninterruptible Power Supply:** in case of outages, an islanded management of the loads will be adopted in order to feed critical users (e.g. emergency lighting, Data Centres, others to be determined by sport facility managers).

The **St-Jean** Pilot aims at the optimal management of the distribution grid in the area through the active participation of consumers in explicit (automated) DR schemas. In particular, the goal is to test demand flexibility services for the different business objectives defined by the local DSO (congestion management in day-to-day network operation in order to save on network reinforcements, better management of grid charges, better local RES exploitation). Similarities could be found with the Isle of Wight, ASM Terni and San Severino Marche Pilots in terms of optimal management of the local distribution grid through DR strategies evaluation. Similarly, a similar Demand Response approach will be investigated in the Barcelona Pilot, to evaluate Demand Response strategies by taking at the same time into account the occupants comfort boundaries.

Actually, three Use Cases will be investigated:

- **Demand Response:** the DSO will act as aggregator and will be in charge of the management of consumers/prosumers portfolio with special focus on demand flexibility potential.
- **Smartening of the Distribution Grid**: the DSO triggering DR strategies to meet specific business objectives.
- **Energy Storage**: HVAC and water storage thermal inertia will be exploited in order to optimally shape the demand energy behaviour.

The **Nicosia** Pilot is arranged in two different test areas. The first one regards the microgrid within the campus of University of Cyprus in Nicosia city, while the second one regards dispersed prosumers within the Cyprus island. The goals of the Pilot are directly related to the need of an electric grid in a geographical island. The integration of renewables could drive to critical problems such as power system stability problems, grid congestions, increase of the spinning and non-spinning reserves, frequency deviations, voltage profile violations, high-order harmonic pollution, voltage unbalance, etc.

Such a scenario is even more critical than the one related to Isle of Wight and ASM Terni Pilots because these ones impact on local grids weakly connected to the main system, vice versa for the Nicosia Pilot the electric grid of the island does not have any connection to a main system. In such a perspective, the ancillary services provision to the electric grid (that will be also investigated) results to be particularly interesting, both from the economic (with respect to final users) and from the system (with respect to grid operators) perspective.

Actually, two Use Cases will be investigated:

- **Smartening of the Distribution Grid**: related to the university campus microgrid and devoted to an advance monitoring of the energy resource (production, consumption and storage apparatuses) in order to schedule energy flow within the microgrid with maximised efficiency.
- **Demand Response:** related to prosumers dispersed in Cyprus island and devoted to decrease the total cost for electricity by adopting a more grid-friendly behaviour.

The **Lisboa** Pilot is focused on the optimal energy management of Campo Grande 25 building. The goals are in an effective demand response approach, based both on the load management, on electrochemical energy apparatuses and on electric vehicle charge processes control in order to maximise the exploitation of local renewable resources and to limit peaks in the consumption profile.

Similarities are with respect to the Barcelona Pilot and with Ploiesti and Thessaloniki ones. Actually, comparing the results collected in these Pilots will provide useful information in terms of evaluation of the effectiveness (reliability) of the control actions scheduled

Actually, three Use Cases will be investigated:

- **Demand Response**: Smart meters, weather forecast, electrochemical and thermal energy storage will be managed in an advanced BEMS in order to evaluate the energy shift capacity of the building.

- **Energy Storage:** ice tanks will be investigated to provide flexibility to the building energy needs.
- **EV charging managing system integrating dynamic tariffs**: dynamic tariffs will be tested in order to avoid EV charging in peak hours.

The **Xanthi** Pilot deals with the case of isolated small scale smart grid networks with local energy storage options where RES is the main source of power. In this Pilot, there isn't any DSO to coordinate/control the microgrid: it has to work stand alone.

Generally speaking, this Pilot emphasises the topics already discussed for the Nicosia Pilot (renewables management in a small grid). Similarly, in a future scenario, when the microgrid could be connected to a distribution grid, the regulation capabilities of the microgrid could be an interesting resource to provide ancillary services.

Actually, three Use Cases will be investigated:

- **Smartening of the Distribution Grid**: an advanced monitoring of the microgrid will be adopted for an optimisation of the energy resources (maximise renewables, avoid diesel generators activation, etc.).
- **Energy Storage**: Energy Storage will be scheduled with respect to the needs on each node of the microgrid.
- **Integration of grid users from transport:** EV charge processes will be coordinated with the microgrid regulation needs.

The **Ploiesti** Pilot consists of three buildings with residential apartments in Ploiesti. The purpose of the pilot is to test a Demand Response where building energy management and control systems can operate based on critical peak pricing or other DR logics.

Actually (as already discussed), it presents similarities with Barcelona, Lisboa and Thessaloniki pilots, i.e. across evaluation of the results will be quite interesting for an assessment of the demand response effectiveness.

Three Use Cases will be investigated:

- **Automated meter reading**: relevant information concerning the consumption of the residential area will be collected.
- **Automated DR solution – DSO perspective**: to implement an energy management solution to automate the process of demand response based on smart meters infrastructure. DSO oriented regulation will be tested.
- **Automated DR solution – consumers' perspective:** to implement an energy management solution to automate the process of demand response based on smart meters infrastructure. Consumers' oriented regulation will be tested.

The **Thessaloniki** Pilot aims to develop efficient, practical and reliable optimisation demand response mechanisms for residential and commercial customers. The goals are in an optimisation of final users' electricity payment while preserving their comfort. The pilot involves residential consumers and commercial customers; the utilization of battery energy storage systems will also be evaluated.

Three Use Cases will be investigated:

- **Demand Response in residential buildings with smart meters:** 100 different dwellings consisting of various buildings and customer profiles will be selected in order to identify the most appropriate incentive-based demand response approach.
- **Demand Response in residential buildings with BESS:** 10 dwellings will further be carefully selected to be equipped with smart integrated home batteries (Li-ion, Lead-Acid etc.) allowing the experimentation and optimal control and automation of the battery in-house utilization.
- **Demand Response in Commercial Building with BESS:** Demand Response approaches will be tested in the offices and the training court of the PAOK Sports

Arena (a basketball court which features a very disperse and seasonal power demand), to increase the financial saving in the building.

For all the Pilots, apart the Use Cases discussion, a preliminary description of the Regulatory Framework and of the Business Model has been reported in the report. These are motivated to drive an effective evaluation of the situation in place and of the barriers to be managed. In the following Work Package 2 and Work Package 3, these topics will be deeply investigated.

Finally, for each Pilot a first evaluation of the replicability of the project has been discussed. The scenario results to be quite promising, motivating, for the following Work Packages, a close monitoring of the project in order to compare the evolution of the project with respect to the solutions/approaches proposed in this report. A cross evaluation of the disparity will result an essential outcome to bridge the gap between the theoretical approaches proposed and their effective exploitation.

13. Conclusions

This report has elaborated the survey of inteGRIDy Pilot Sites and the definition of the Use Cases that will be investigated. The aim of the report is to capture, analyse and communicate stakeholder needs for the proposed technology in an effective manner.

Actually, inteGRIDy project targeting goals could be summarised as follows:

- Facilitate the decarbonisation of the electricity grid and the integration of large shares of distributed renewable generation, through the deployment of innovative and highly efficient DR, storage, EV management and SG technologies.
- Integrate innovative smart grid technologies and concepts with a scalable and replicable Cross-functional Modular Platform, enabling the optimal and dynamic operation of the distribution system's assets within high grid reliability and stability standards.
- Demonstrate the use of modelling and profiling extraction techniques for network topology representation, innovative DR mechanisms and Storage System characterization, in order to support automated scenario-based decision making in everyday distribution system operations.
- Demonstrate the use of predictive algorithms, forecasting tools and scenario-based dynamic simulation, facilitating an innovative Operation Analysis Framework of the DG and enable significant avoidance of RES curtailment while enhancing self-consumption and net metering utilising storage technologies.
- Demonstrate an integrated Decision Making and Optimisation Framework featuring a grid balancing and stability engine, optimisation-based energy synergies to ensure energy security.
- Deliver a set of integrated Visual Analytics tools, along with innovative HMIs and Services for energy stakeholders and end-users/prosumers, allowing optimal monitoring and control of the distribution network built upon real-time context and forecasted simulated scenarios.
- Implement and Deliver added value end-user applications for all stakeholders and new business models involved in the Smart Grid value chain, enabling, also, their participation in energy markets. Contribution to the transformation of the energy market situation in Europe in order to comply with the ongoing energy related activities for standardization and regulatory frameworks.

In such a framework, each Pilot Site has been detailed in terms of opportunities and needs, to point out goals and barriers. In particular barriers could be related to technology or to the regulatory framework. In the first case, inteGRIDy Partners do not identify particular bounds; problems could arise from the lack of standards but this is considered to be a problem whose constituent parts can be identified and effectively managed. Open platform/protocols will be adopted or, if needed, properly conversion interface will be deployed.

Vice versa, the Regulatory Framework results to be a cornerstone problem that could affect, in particular, an effective development of Demand Response approaches and the deployment and exploitation of energy storage technologies.

In such perspective, inteGRIDy project is particularly on-time and the Pilot Tests will provide real-life data and results that will be quite useful to policymakers and stakeholders to manage and regulate the evolution processes.

In particular, within the inteGRIDy project a common approach is proposed. All the Pilots are based on a Cross-Functional Platform (CMP) of replicable solutions to connect existing energy networks; it will be implemented, demonstrated and validated in real-life conditions in 4 pre-pilot small-scale cases and 6 large-scale pilots based on predefined Use Case Scenarios. Actually, use cases proposed are based on the same platform (CMP) and are detailed with respect to the needs, the goals and the bounds of each single implementation.

All in all, this report can be seen as the logical refinement of all proposed pilots with respect to the project proposal taking into account all early adaptions and considerations with respect to the first project activities, mostly related to requirements, standards, regulation and business model identification. This input will be directed to all inteGRIDy active and ready to start tasks, especially Task 1.5 on “Architecture, Functional & Technical Specifications” and WP4 on “Distribution Grid Optimization Framework”, which will both pave the way towards the definition and adoption of inteGRIDy’s Cross Modular Platform and its integration and demonstration along project pilots.

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