RE-EMPOWERED

Renewable Energy EMPOWERing
European & InDian Communities

Deliverable 2.1: Report on requirements for each demo, use cases and KPIs definition

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R Document, report	**PU** Public
DEM Demonstrator, pilot, prototype	**CO** Confidential, only for members of the consortium (including the Commission Services)
DEC Websites, patent fillings, videos, etc.	**EU-RES** Classified Information: RESTREINT UE (Commission Decision 2005/444/EC)
OTHER ETHICS Ethics requirement	**EU-CON** Classified Information: CONFIDENTIEL UE (Commission Decision 2005/444/EC)
ORDP Open Research Data Pilot	**EU-SEC** Classified Information: SECRET UE (Commission Decision 2005/444/EC)
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EXECUTIVE SUMMARY

The "RE-EMPOWERED" project aims to develop and demonstrate novel tools for complete energy solutions for islanded/isolated communities. The main goal is to foster the energy transition of local energy systems based on multi-energy Microgrids, interconnecting multiple energy vectors. From planning, to optimized management, electric vehicles, and demand side management but also community engagement and digital solutions, the RE-EMPOWERED project tools will upgrade the local energy systems of the European and Indian demo sites.

The overall objectives of the project are split in three main pillars. First, it aims at achieving highly efficient and reliable energy systems with increased renewable energy sources (RES) penetration, and high flexibility. The second objective refers to the ambition of the project to provide the local communities with tools for economic and social development, through a sustainable energy system, based on local resources that protects the environment and delivers unhindered energy access. The last core ambition of RE-EMPOWERED is to create a platform for knowledge exchange between EU and India, to achieve replicability and scalability of its accomplishments.

To achieve the project's objectives, an extensive analysis of the status in each of the four demo sites was conducted, which resulted in the identification of goals that each demo aims to achieve, but also the main obstacles and challenges (technical, financial, social, or regulatory) that might occur in the process. Based on the analysis, a set of Use Cases were defined for each of the proposed technical solutions (i.e. tools), that describe in detail the functionalities and services that will be provided, to tackle the issues of each demo site, and foster sustainable energy transition. The Use Cases are then mapped with the demo sites, to indicate where they are going to be implemented and tested. A comprehensive analysis of the Use Cases is presented in the Annexes, covering the functionalities, requirements and step by step analysis for all the tools.

The defined Use Cases present functionalities or services provided by the tools, that can be demonstrated and tested in the field, that can also be assessed and measured through appropriate indicators. The tracking of this process will be performed through Key Performance Indicators (KPIs), that have been preliminarily defined in the document. The KPIs are associated with Use Cases and will be re-iterated in the assessment phase, to finalize the relevant indicators and evaluation process.

The results of this work will serve as foundations for the definition of RE-EMPOWERED tools system architecture, but also will be used as guidelines in WP3, WP4 and WP5 in the development of the tools. Finally, they will be utilized along with the KPIs in the demonstration and assessment activities of WP7 and WP8.

KEYWORDS:

Use Cases, Key Performance Indicators, Demonstration, Smart Grids, Energy islands, Local Energy Systems, Bornholm, Kythnos, Ghoramara, Keonjhar, ecoEMS, ecoMicrogrid, ecoPlanning, ecoDR, ecoMonitor, ecoPlatform, ecoCommunity, ecoResillience, ecoConverter, ecoVehicle

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Acronyms

Acronym	Description
LES	Local Energy System
UC	Use Case
KPI	Key Performance Indicator
RES	Renewable Energy Source
EU	European Union
HLUC	High Level Use Case
DR	Demand Response
EV	Electric Vehicle
DER	Distributed Energy Resources
ICT	Information and Communication Technology
HIL	Hardware In the Loop
PV	Photovoltaic
IoT	Internet of Things
O&M	Operation and Maintenance
DSO	Distribution System Operator
EMS	Energy Management System
NII	Non-Interconnected Island
AMI	Advanced Metering Infrastructure
MGCC	Microgrid Central Controller
PaaS	Platform as a Service
API	Application Programming Interface
CHP	Combined Heat and Power
DHN	District Heating Network
P2X	Power to X
TRL	Technology Readiness Level
ILC	Intelligent Load Controller
OREDA	Odisha Renewable Energy Development Agency
SGAM	Smart Grids Architecture Model
DSM	Demand Side Management
WBREDA	West Bengal Renewable Energy Development Agency
OCPP	Open Charge Point Protocol
SCADA	Supervisory Control And Data Acquisition

1 Introduction

1.1 Purpose and scope of the document

This deliverable refines the high-level objectives of the RE-EMPOWERED project and defines the conditions that need to be fulfilled, for each tool to be developed. To fulfill the objectives, the set of solutions that are going to be developed will be tailor-made to the needs of each demo, thus the comprehensive descriptions for each tool are presented in this deliverable. Also, descriptions of the demo sites based on a conducted survey and additional information provided by the demo leaders, are presented.

The survey facilitated the acquisition of details about the existing local energy systems (LES) (consumption, production, available energy vectors, connections with the external grid, etc) of the demo sites, as well as the planned installations, stakeholders and citizen engagement planned in the framework of RE-EMPOWERED. Furthermore, information was acquired about the potential issues and obstacles to the LES, which was used to customize some of the tools' functionalities, to support the mitigation of these issues.

Apart from the provision of information related to the tools and demos, the document defines a methodology for the Use Case (UC) definition, delivers detailed description and explanation of the UCs of the tools, and presents the mapping of the UCs to the Demo sites. These are the outcomes of activities related to Task 2.1 "Demo Analysis and Use Case definition/surveys" and will provide input to other tasks of WP2 "Foundations and innovation analysis", specifically Task 2.4 "Technical architecture design" and Task 2.5 "Functional specifications of the tools and solutions".

Last, the preliminary description of Key Performance Indicators (KPIs), which is the outcome of activities related to Task 2 .2 "KPI analysis – Implementation and evaluation plan" is within the scope of this work. The outcome of this Task will be utilized to elaborate on the guidelines for implementation and evaluation of the demo activities, feeding the activities of Task 7.1 "Deployment and demonstration activities planning", Task 8.4 "Technical and economic assessment of demos and tools" and Task 8.5 "Social and environmental assessment".

1.2 Structure of the document

Section 2 set the objectives and high-level UCs, describes the nature of those (Technical, Socio-economic, Coordination) and provides a brief explanation and description of each of them. Then, a description of the functionalities of each tool is presented, as well as the associated targets for RE-EMPOWERED (section 3). In section 4 information about the four demonstration sites are presented, along with the results of a dedicated survey, aiming to further analyze their status. Section 5 describes the utilized methodology for the definition of Use Cases, that will assist in the development, testing and demonstration of the tools. Section 6 describes the preliminary indicators, identified to help the assessment of the developed solutions, and provides an explanation of the terminology. The document concluded with several Annexes presenting the detailed information of the work that was conducted. Particularly, the full description of the use cases for each tool is presented in tables in the annexes.

2 RE-EMPOWERED Objectives

The overarching goal of RE-EMPOWERED is to develop a set of solutions for efficient, decarbonized and RES-intensive multi-energy local energy systems. Special focus will be given on exploiting synergies among energy vectors, increasing demand flexibility through customer engagement using digitization that will foster an active energy community via sustainable business plans and investments.

The solutions of the toolset will be tailored to the specific needs of four pilot cases in the EU and India but will aim at a wide target group for replication and exploitation in both the developed and developing world. Bornholm (Denmark) will focus on unlocking the demand flexibility for higher RES utilization in grid-connected islands; Kythnos (Greece) will target at increased whole system efficiency and digitization with reduced imported fuel and RES curtailments for non-interconnected islands. Kythnos demo also includes the Gaidouromantra microgrid, a 100% RES system, which will be upgraded. Ghoramara (India) will explore a newly built 100%-RES standalone system for the island aiming at improved energy access for sustainable community development. Keonjhar (India) will examine the upgrade of the existing rural microgrid towards higher energy availability and affordability and improved local air and water quality.

RE-EMPOWERED objectives are organized in 3 pillars, each one comprising a set of sub-objectives or High-Level Use Cases (HLUCs). The first pillar includes 4 Technical HLUCs, the second pillar 3 Socio-economic and the third pillar 2 Coordination HLUCs. For their identification they are presented in Table 2 color-coded.

Table 1 RE-EMPOWERED Objectives

Objectives		
Tag	**Name**	**Description**
O1	**Increased energy efficiency, RES utilization and reliability**	The objective is to achieve a highly efficient and reliable energy system with increased RES penetration and high flexibility, that exhibits competitive performance over available commercial solutions.
O2	**Fostering sustainable and economic community development**	The ambition of RE-EMPOWERED is to provide to the community the tools for economic and social development, through a sustainable energy system based on local resources that protects the local environment and delivers unhindered energy access, health benefits and a good return on investment. Tools that drive these objectives are eco-{DR, Monitor, Community, Vehicle}.
O3	**Exchange, replicability and scalability in EU and India**	The RE-EMPOWERED consortium involves world known experts in energy islands, which combined with the differentiated focus and development level of the four pilot cases will render this project an ideal EU-India platform for knowledge exchange and use case replicability.

Table 2 RE-EMPOWERED High Level Use Cases

High Level Use Cases (HLUC)		
Tag	**Name**	**Description**
HLUC-1	Optimal operation, high flexibility and efficiency	By identifying synergies and co-optimizing different energy vectors and uses (electricity, district heating, irrigation, transport etc.), the toolset aims to achieve higher overall system efficiency. Special focus is given on demand side management, aiming to unlock the demand flexibility by incentivizing customers engagement, which has great potential at all sites. By improved forecasting and multi-energy scheduling, the project aims at optimal operation and reduced variable operating costs for the energy system.
HLUC-2	Higher RES penetration and utilization	The energy system fostered by the project's toolset has at its core renewable energy, mainly solar PV and wind, due to their local availability and very competitive costs. The solutions aim to leverage multi-energy coupling and demand-side flexibility towards higher RES utilization and less curtailments. This is particularly important in RES-based systems, such as Bornholm, Kythnos, Ghoramara and Keonjhar.
HLUC-3	Reliable and resilient operation	Reliability is among the top concerns in rural microgrids, seriously challenging the customers confidence for energy service provision. RE-EMPOWERED will build upon the partners' expertise on microgrid operation and stability, to deliver highly reliable energy systems with minimum interruptions and improved power quality. In addition, resiliency is a new major goal of this toolset, aiming at a system design to withstand cyclones of up to level 3. This will address a long-lasting problem in large parts of India.
HLUC-4	Digitalization and ICT deployment	RE-EMPOWERED carries concrete steps towards a digitized energy system, providing a complete set of digital solutions targeting the full range of stakeholders, from the operator to the customer. Embracing an IoT philosophy and aiming to unlock the true potential of customer engagement, data security and protection will be integrated in the heart of the RE-EMPOWERED toolset.
HLUC-5	New competitive business models and financial tools	New business models will be designed capitalizing on the added value the developed tools bring to new (e.g. Ghoramara) and existing (e.g. Kythnos) energy systems. The added value concerns reduced capital and O&M costs towards sustainable subsidy-free investments. The experienced partners in the project will develop exploitation plans that account for the entire value

		chain and the regulatory framework in each region and with the appropriate financing tools for the EU and India side towards high replicability.
HLUC-6	Community engagement and training	Major objective of RE-EMPOWERED is to achieve very high levels of customer engagement. ecoCommunity will raise awareness on the energy prospects and savings and will form a multi-directional channel for sharing experience and training among the members of the community. The tools will be as simple to use and maintain as possible, to be largely managed by the community.
HLUC-7	Improved energy access and environment quality	RE-EMPOWERED will contribute to energy-disadvantaged communities, especially in India, by providing improved access to clean, affordable, and reliable energy with substantial social and health benefits. Special focus will be given to the water quality, that will be monitored and controlled via the ecoMonitor tool.
HLUC-8	Knowledge exchange and training between EU and India	RE-EMPOWERED will form two main channels for knowledge sharing: short-term research exchanges among the consortium members to build upon the complementary expertise, and local workshops in the pilot sites to train and engage local people, receive feedback, and learn from the activities.
HLUC-9	Use case replicability across EU and India	The lessons and use cases extracted from the four demonstration sites will be made available for sharing and training in other islands through channels, like European Utility Week and European DSO association (EDSO).

3 RE-EMPOWERED Tools

The overarching goal of RE-EMPOWERED is to develop a set of solutions for efficient, decarbonized and RES-intensive multi-energy local energy systems. Special focus will be given on exploiting synergies among energy vectors, increasing demand flexibility through customer engagement using digitization that will foster an active energy community via sustainable business plans and investments. The solutions of the toolset will be tailored to the specific needs of four pilot cases in the EU and India but will aim at a wide target group for replication and exploitation in both the developed and developing world. The following sections briefly describe each of the solutions to be developed, their scope and objectives. Further analysis of the tools and the defined Use Cases are presented in Section 5, while their full descriptions are presented as Annexes at the end of the document.

3.1 ecoEMS

ecoEMS is an Energy Management System aiming at optimizing the overall performance of isolated and weakly interconnected systems in liberalized market environments by increasing the share of RES. ecoEMS considers storage facilities and provides advanced on-line security functions, both in preventive and corrective mode. More specifically, the EMS is a modular system comprising, **load and RES Forecast, Unit Commitment and Economic Dispatch and on-line Security Assessment functions.** It serves the operators' goals to maximize the RES share in the energy mix for economic and environmental sustainability. The experience in the Greek islands shows that reaching an annual RES penetration up to 30% is easily achieved without significant additional investments in specialized equipment/EMS. Further increase of the RES penetration however might create operational problems, which could even lead to black outs, while RES penetration higher than 40% requires installation of storage. The goal of ecoEMS is the full exploitation of the RES potential (i.e. RES penetration levels above 40%) at reasonable costs in isolated electricity systems.

The basic functionalities of the tool were developed in various EU research projects starting for the CARE-More Care where the first version was developed and demonstrated in Crete, Greece and partially in Ireland. Next in Anemos.plus the forecasting algorithms were further enhanced and stochastic unit commitment algorithms were integrated. In the Sustainable project the tool was demonstrated in Rhodes Island and in TADNI (funded by GiZ/iBMW) a prototype was tested in the same island adopting a Unit Commitment Module fully compatible with the Greek Code of Non-Interconnection Islands. Finally, in the Kythnos Smart Island Project integration with desalination units will be demonstrated as well as new functionalities reserve limits. The tool has connectivity with commercial SCADAs using DNP3, OPC, Modbus, IEC61850, ICCP and CIM. It was developed using technologies such as Angular/AngularJS (previously Silverlight), C#, SQL Server and GAMS

The goal in this project is to integrate in the system operation the new types of flexibility coming from Demand Response (DR), Electric Vehicles (EVs) and the coupling with other energy carriers. The goal is to reduce RES curtailment and maximize the overall system efficiency. More specifically, the flexibility will be used not to stress the ICE (Internal Combustion Units) close to their technical minimum, which is the main cause of RES curtailment. OCPP V2 for the communication with EV charging stations as well the KNX for the integration with Battery Management System (BMS) will be adopted and tested in real environment.

3.2 ecoMicrogrid

The ecoMicrogrid tool will focus on the development of an advanced energy management system for microgrids. Advanced management algorithms will be deployed that will optimize the performance of the microgrid, namely cost and DER optimization, taking into consideration synergies with other vectors like water management and cooling systems. The ecoMicrogrid solution will monitor the state of the microgrid components, such as RES production, flexible loads' consumption, and battery storage charge level and forecast its short-term development. An optimization procedure will dictate the required actions like load shedding, diesel generator start-up/shut-down and RES power curtailment according to the desired optimization goals. In addition, smart meter-based outage detection and location algorithms will be developed.

Optimization algorithms and basic hardware infrastructure are currently being developed at the Kythnos Smart Island (KSI) project by ICCS-NTUA and will be complemented by the work performed at the RESCUE and UKICERI projects. At the KSI the microgrid management solution is being developed in accordance with standards for microgrids like the IEEE 1547.4-2011 and IEEE 2030.7 "Standard for the specification of Microgrid Controllers" and also industrial communication protocols like the IEC 61850 and DNP3. During the KSI project laboratory validation will be performed via Hardware In the Loop (HIL) simulations at ICCS-NTUA premises.

At the RE-EMPOWERED project, the energy management tool will be upgraded to a complete industrial solution in close cooperation with industrial partner PROTASIS, including all the necessary infrastructure (controller, communications, servers, etc.). New functionalities for synergies with other energy vectors, like water management and cooling systems will be developed and integrated in the ecoMicrogrid solution, tailored to the pilot sites. The new functionalities of ecoMicrogrid will be designed according to industrial standards for microgrids like the IEEE 1547.4-2011 and IEEE 2030.7 "Standard for the specification of Microgrid Controllers" continuing the work already done in the KSI project. The overall ecoMicrogrid solution will be based on validated industrial hardware and communication protocols, like the IEC 61850 and DNP3. The hardware solution will be developed making use of cutting-edge information and communications technology (ICT) for contemporary industrial applications. Automation and control components will include embedded multi-core processors characterized by multithreading capability, whereas data concentration, management and visualisation will be achieved by means of modern communication protocols. Cybersecurity features will be provided as well, ensuring resilient operation of critical power assets. ecoMicrogrid will be demonstrated at all four pilot sites. Prior to the field deployment, validation and testing will be performed at the ICCS-NTUA laboratory via Hardware in the Loop (HIL) simulations following the IEEE 2030.8 "Standard for testing of Microgrid Controllers".

3.3 ecoPlanning

Energy Planning is a software tool developed by the Electric Energy Systems Laboratory of NTUA serving as a tool for performing simulations that support the decision-making process regarding the deployment of new electricity generation units (conventional and renewable) in the electrical systems of Non- Interconnected Islands (NIIs) in a mid-term horizon. To this purpose, the tool allows defining scenarios pertaining to the electricity demand forecast and the composition of the electric system (types of production units, technical and economic characteristics, operation rules, etc.). Additionally, it allows performing the following types of studies: 7-Year Energy Planning for assessing the deployment plan of new conventional production units. RES Hosting Capacity for assessing the hosting capacity of Renewable Energy Sources in the electric system. Interconnection Assessment by performing steady state simulations of the electric system to evaluate the interconnection advantages and reports (in aggregated and analytical format) the operation of the production units and several results pertaining to the energy production in terms of quantity, fuel consumption and cost, CO2 emissions, etc

The tool was developed during various EU and National Funded projects. The starting point was the CARE/MORE Care projects where the Unit Commitment Algorithm was developed, followed by several functionalities developed by funding and cooperation with the Greek DSO, which is responsible for the management of the Greek Non-Interconnected islands. . During TADNI (funded by GiZ/iBMW) functionalities for the assessment of interconnections have been integrated. The software is in compliance with the Greek Regulation and the Code of Non-Interconnection Islands. Currently, all studies for new thermal capacity and the assessment of RES hosting capacity in islands are conducted with this tool. The tool was developed using technologies such as Angular/AngularJS (previously Silvelight), C#, SQL Server. Furthermore, it has connectivity with GAMS. Reports can be exported in different formats: MS Excel, MS Word , PDF and csv

During this project, the goal is to expand the functionalities considering the flexibility provided by DR and other energy carriers, such as cooling. The tool will identify the additional RES hosting capacity as well as the possibilities on investment deferral for new conventional units.

3.4 ecoDR

The ecoDR tool focuses on the development of advanced metering infrastructure (AMI) with inbuilt load controller and protection functionalities. In addition to measurement and billing of household energy consumption, it will facilitate remote monitoring and control of non-critical loads based on user preference. This tool will be capable to communicate with ecoPlatform tool to access services such as demand-side management, to implement scheduling of critical/non-critical loads via load shedding and to access dynamic electricity pricing tariffs for computation of the energy cost of residential loads.

Under EDMISSIBLE project, a prepaid energy meter with programmable load limiter was developed by CSIR-CMERI. An algorithm was developed to maintain data consistency by avoiding corruption due to interruption in power supply during a write operation of non-volatile memory. The Operated Prepaid Energy Meter was designed in accordance with IEC 61036 and IEC 62053-21. Technology was licensed to two companies namely WBREDA in 2004 and EP meter Pvt Ltd in 2013. There was also a patent granted, namely WIPO(PCT) Publication : WO2008/059528 A2.

Through RE-EMPOWERED project, the energy management tool will be integrated with other tools, such as ecoCommunity via ecoPlatform in close cooperation with other project partners. ecoDR will add new functionalities to measure electrical energy consumption and time stamp it for computation of cost of electrical energy consumption from real time pricing data received via ecoPlatform tool, and communicate the computed cost to the ecoPlatform. This tool will also have programmable load shedding controller to disconnect the load in case the energy demand exceeds the predefined threshold limit, and this threshold limit is being received via ecoPlatform tool. Further, ecoDR will implement improved functionality for load scheduling for critical/non-critical loads based on the information received from ecoPlatform tool. ecoDR will be designed with respect to Indian/IEC standards for smart energy meters like the IS 13779/IEC 61036 for power consumption and IS-15959/IEC-62056-21 “Data exchange for electricity Meter reading, Tariff and Load Control”.

3.5 ecoPlatform

The ecoPlatform will be a lightweight cloud-based platform with a focus on interoperability. One of the primary objectives of the platform is to provide the RE-EMPOWERED tools with a secure and reliable interface to the deployed distributed energy infrastructure. In addition, the ecoPlatform will be capable of managing, processing, and handling the heterogeneous data and command stream from the RE-EMPOWERED tools, metering infrastructure, SCADA systems, MGCC (Microgrid Central Controller), edge devices, and selected controllable assets. In other words, the Eco platform can serve as an intermediary for software-based tools to convey commands to controllable assets, either directly integrated into the Eco platform or indirectly via other tools developed in the project. In this way, ecoPlatform can assist the operation of the other tools for data exchange and cooperation. To sum up, ecoPlatform will provide a Platform as a Service (PaaS) that can integrate all the solutions in one software structure. This will enable the customers or operators to freely customize the applications and acquire the data streams needed for operation. Also, the ecoPlatform will be able to translate the data and messages from the interfaces into a common data model. Finally, the transfer access will be authenticated and authorized by the eco platform to ensure security.

Furthermore, ecoPlatform will also serve as a data storage hub for dependent tools. ecoPlatform will facilitate short-term storage for data and command stream requiring low latency. The data stream, microgrid states, and commands necessary for real-time processing need to be routed to storage optimized for fast access. However, longer-term data that are not time-critical will be routed to cost-effective storage, which is comparatively slow to access. Such data will be redirected to cost-effective storage. API's will be provided for accessing the data archived by ecoPlatform.

3.6 ecoMonitor

The ecoMonitor tool focuses on the surveillance and monitoring of drinking water quality parameters and deployment of water purification plant. Within the RE-EMPOWERED project, the water samples will be collected and based on water quality analysis, a community level solar powered water purification plant will be deployed to provide safe drinking water to the residents. Further, water quality parameters such as conductivity (salinity), dissolved oxygen, and ORP/Redox etc, water temperature and pH level etc will be monitored periodically. CSIR-CMERI has previous experience in development different water purification technologies including high flow rate iron and fluoride removal plant, multifunctional adsorbent based integrated water filtration unit for removal of ground water fluoride microorganism with supported handy fluoride level detection kit and proper management of generated sludge etc. These are being deployed in different parts in India.

3.7 ecoCommunity

ecoCommunity is a digital platform developed aiming to enhance citizen engagement, active participation and technology acceptance in the four demo sites. The main functionalities of ecoCommunity are **dynamic pricing mechanism for residential loads, management of non-critical loads, electronic billing, payment and a feedback portal**. A few industry level tools are currently available with functionalities like demand side response and direct load control. ecoCommunity will contain advanced functionalities and is tailored to the special requirements of energy-disadvantaged communities, such as the ones in India and other developing countries.

The dynamic pricing mechanism is simple (color coded, time zones) to foster technology acceptance, while the tool facilitates coordination of communal energy uses (e.g., irrigation electric pumping). Customers can schedule their loads easily based on the color-coded slots information. Billing and payment information will be provided to the customer in this platform. More functions, such as the interaction forum and digital walkthroughs will also be present in this tool. ecoCommunity aspires to be the main contact point for all technical and social interactions of the residents with the energy system laying the ground for customer engagement and coordinating communal uses. Guidance and training material will be provided in this tool to ensure effective operation and maintenance of the tools and equipment in the microgrid.

The goal of ecoCommunity tool is to bring together the residents with the energy system as members of an energy community. This tool helps the customers to be technology familiar and increases the friendliness of using other tools. The users can access this tool on their mobile phone or other electronic devices. The major functions of this tool follow:

- To allow the consumers to access their energy consumption data, billing information and facilitate to make payments. The variable electricity prices incentivise time-shifting of household loads in order to increase energy efficiency.
- To enhance energy community functions such as coordination of communal energy uses among its members (e.g., several farmers need to agree when and how much they will use the common pump for irrigation).
- To foster community engagement with functions like a forum where users can report problems, recommend suggestions, and share experience on the energy system.
- To provide easy-to-use training material in the form of multimedia and step-by-step guides for the information of customers and technicians. The ambition is that ecoCommunity becomes the contact point for anything related to the system, including how to use and maintain its various components. Security and privacy of personal information is central in the tool.

3.8 ecoResillience

The ecoResillience tool will focus on the development of the cyclone resistant support structures for both ground-mounted solar PV arrays and wind turbines. Most of the commercially available supports for ground-mounted solar and wind turbines are designed with a maximum wind speed of 50 m/s (~ 110 mph). Further, there is no any passive mechanism available to reduce cyclonic loads on the ground mounted solar panel. The RE-EMPOWERED project aims to optimize the PV configuration to reduce the aerodynamics wind loads through numerical simulations, wind tunnel testing, and field tests. Passive aerodynamic control surfaces will be incorporated on the PV arrays to minimize the wind loads, which helps in a significant reduction in the support systems cost. For wind turbines, cyclone resistive hybrid structure whose height can be reduced to minimize the wind loads and also to remove blades at extreme climatic conditions will be designed. The loads on the hybrid structure will be examined through numerical simulations to optimize its geometrical parameters. The wind turbine will be manufactured locally, using experience with the assistance of local technicians and community members using the available resources of the region, thus allowing for maintenance to be performed quickly with reduced down time and increased resilience.

In CSIR-CMERI, the effect of wind loads on several variants of solar trees, solar umbrella, and solar thermal concentrator disc was examined for different in-house projects. The optimal configurations of structures were proposed through numerical simulations and wind tunnel testing prior to the field deployment at the pilot sites. CSIR-CMERI had also performed failure analysis of the 225-ton Manitou crane boom at the SK mines project for Hindustan Zinc Ltd. ICCS-NTUA has extensive experience in the local manufacturing of small wind turbines for rural electrification. The Rural Electrification Research Group (RurERG) of ICCS-NTUA has developed and field tested a robust domestic wind turbine design (ranging from 500 W to 3 kW) that has been deployed in several projects around the world for the electrification of remote communities in collaboration with local partners, such as the National Institute of Wind Energy (NIWE) in India.

Through the RE-EMPOWERED project, passive self-adaptive solar array structures for ground-mounted solar PV and height adjusting hybrid support structure for wind turbines will be developed to reduce the severe wind loads during the cyclone. Additionally, already existing designs for locally manufactured small wind turbines will be upscaled for higher rated power and validated using the IEC 61400-12-1 standard in the small wind experimental facilities of ICCS-NTUA and will be demonstrated in the Kythnos and Ghoramara demo sites. Indian standard for wind and cyclone loads (IS: 15498:2004, IS: 875 (part 3): 1987) will be considered for designing the support structures. Usually, the foundation structures are made with M20 concrete as per IS456:2000. However, a minimum grade of concrete for Reinforced cement concrete (RCC) of M30 will be used in the present scenario as the Ghoramara island is filled with water during cyclone conditions. Further Sulphur resisting cement will be used for foundation to avoid chemical reaction with sea water.

3.9 ecoConverter

This tool deals with the development of Power Electronic Converters and their control for dc/ac microgrids to cater electricity to the community areas under consideration. Two power electronic converters, namely DC/AC inverter at 30 kW power level and DC/DC Partial Power Converter (PPC) for multi-string PV architecture (50 kWp) will be developed under this activity. The purpose of these converters is to form a local ac grid providing ancillary services and extracting maximum power from PV panels under partial shading conditions at improved efficiency. The converter should be modular, plug-and-play, reliable and compact with functions like, built-in communication, adequate protection, remote control, and display option. The power as well as control circuit will be mounted on PCB to increase modularity and power density. The converter will be first built with conventional MOSFET devices and later it will be replaced by SiC switches to further increase power density. Several such units may be connected in parallel to meet desired power rating. EMI and EMC generated by the converter should be kept within the specified limits.

The power electronic converters for dc/ac microgrids were previously developed at 10kW power level as part of Indo-UK projects, e.g. RESCUES (completed), UKICERI (ongoing). Various two-level and multi-level converter-based configurations were proposed for PV integration with the AC grid and were validated through experimental prototypes. A Dual Converter (DC) based inverter has been developed and demonstrated at 10 kWp power level where a low frequency converter is employed along with a high frequency converter to reduce losses and foot-print of the complete system. To improve power quality at improved efficiency, an asymmetric-CHB based multilevel inverter with single dc-link has been introduced which is also demonstrated in the laboratory. To achieve better power extraction during partial shading, a configuration of hybrid modular multilevel converter is developed and experimentally validated. In order to increase power density of the PV-converters, SiC switches have been used in place of conventional MOSFET switches and the converter is operated at 100 kHz switching frequency. The entire SiC based converter is built in a single PCB to address EMI/EMC related issues. Partner Lab Concern (India) has experience in grid tied inverters and their control in various parts of India. They also have the expertise to develop digital control platform using FPGA processors.

A plug-and-play type modular DC/AC inverter will be developed at 30 kW power level. Communication will be provided as an integral part of the converter so that data exchange can be possible between smart-meters, control-units, and inverters. All components of the converter will be mounted on a single PCB to minimize EMI/EMC related issues. SiC devices will be used to make the converter compact and highly power efficient. Relevant control algorithms (e.g. fast decoupled P-Q control, dc-bus voltage regulation, mitigation of power quality issues, inertia improvement considering 100% renewable integration, ancillary services) will be developed to provide various system requirements from the perspective of DC/AC microgrid. Apart from the inverter, a multi-string configuration will be developed which will integrate 50 kWp PV array with the dc-grid at improved efficiency. A Partial Power Converter (PPC) will be developed for such multi-string architecture to ensure MPPT operation under partial shading scenario. The use of PPC increases overall efficiency of the system as only a small portion (say 32%) of total PV power needs to be processed through this converter. This indicates that a PPC of 16 kW power rating is required to integrate 50 kW PV power into the DC grid. A DSP/FPGA based embedded control platform will be developed to implement the control algorithms, which are required for the operation of these converters. The above-mentioned converters will be first tested up to 30 kW power level in the laboratory according to standard test procedure as given in IEC 62477-2:2018, IEEE 519 -1992, ETD 31, and MNRE protocols.

3.10 ecoVehicle

ecoVehicle considers the development and deployment of power electronics and drives systems for electric boat, to facilitate green mode transportation to nearby islands from Ghoramara island, and the necessary charging infrastructure. Nearby islands such as, Nayachar, Kakdwip, Haldia, Gangasagar, Dimond Harbour and others are around 10-60Kms distant from Ghoramara. The onboard System of the electric boat will have three subsystems: i) supply system; ii) traction system; iii) control & Monitoring system. Charging system (Charging station and Battery Charger) is considered as off-board arrangement to support the mobility. Traction system includes a traction motor together with a voltage source inverter. Onboard energy and power sources, such as batteries and ultra-capacitors together with interface circuits are considered as the component of Supply system and can be assisted by solar energy through a PV-panel. Control and monitoring systems include the controllers, sensors, and the communication system for controlled operation. Whereas charging infrastructure receives energy from the PV-fed microgrid through a community charging station/charging point at residence. ecoVehicle will develop the sub-system for electric boat and electric four-wheeler as follows: i) sizing and structure design electric boat for island; ii) traction motor and VSI together with the required control; iii) mixed supply system (battery, ultra-capacitor and solar-panel) for improved performance for range extension and battery life improvement; iv) development of conductive and wireless charger for community charging station; v) suggestions to address the issue of micro-grid stability due to vehicle charging. Related power electronics will consider the conventional/ efficient semiconductor switches for energy efficiency and effective operation.

The above description of ecoVehicle will be updated based on the DST requests by the tool leader VNIT at the next stages of WP2.

4 Demonstration sites description

4.1 Survey about the status of demo sites

One of the core objectives of WP2 is the definition of project use cases, which will be implemented and tested in the demo sites. In the definition of use cases the following starting points are considered:

- Use cases shall represent testable functionalities of the proposed tools
- Use cases shall reflect the problems the demos are faced with
- Use cases shall be realistic, i.e., their implementation shall be feasible.

The process of identifying each of the demos' individual characteristics as well as the issues RE-EMPOWERED will be called to tackle is a crucial task, which will require a lot of iterations between the demos and the responsible partners for the technical development. Getting an overview of the characteristics and issues of each demo at the early stages of the project, will enable the development of tailor-made solutions for each demo. To achieve this, a survey was conducted, by distributing a custom questionnaire to the leaders of each individual demo. The analysis of the results provided information for the Use Cases and KPIs definition.

The questionnaire specifically aimed at acquiring information about the technical characteristics of each of the demos' local energy systems, available and planned energy related infrastructure, but also information regarding the problems the demonstration sites are facing in the development and operation of their local energy systems.

The questionnaire is divided in two main parts:

- Information about the energy infrastructure and data availability
- Information related to operation of LES and community engagement.

The complete questionnaire is attached as Annex 1 Questionnaire for the acquisition of demo sites' information.

In the following sections the demo sites are described, and the results of the survey are integrated into the descriptions.

4.2 Bornholm

4.2.1 General description

Figure 1 Bornholm Island

Bornholm is a Danish Island in the Baltic see (589 km2 – 40.000 inhabitants). The Island has a long history as “test-island” for energy technologies, and was in 2020 was rewarded with the EU “RESponsible Island Price” for the large share of renewables in the energy system and innovative projects. Bornholm is connected to the mainland electrical grid, but the CHP in Rønne is able to run the electrical system in island mode when the seacable is disconnected. All urban areas are supplied with District Heating, and the heat is generated with biomass-boilers, using locally produced woodchips and straw as fuel.

The Demo area comprises three towns in the eastern part of Bornholm connected with a District Heating Network (DHN): Østerlars, Østermarie and Gudhjem, and the heatplant in Østerlars, that uses straw as fuel.

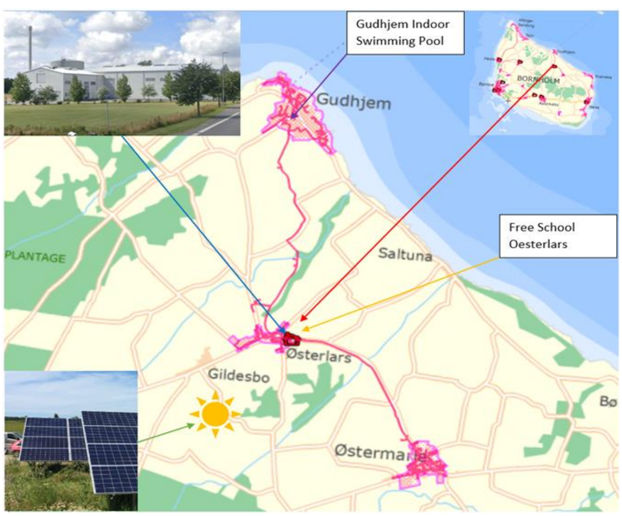

Figure 2 Bornholm demo diagram

The Demo will provide means for integrating more electricity from RES, in a community that already has a high penetration of RES. On Bornholm a group of citizens, with the support of the municipality, are now developing a 100 MW Windturbine park (offshore) based on local funding, to be ready in 2025. New PV-parks are also planned. This means that in the near future the seacable to the mainland will not have enough capacity to export electricity produced from RES in Bornholm, when the production from wind and sun is high. Therefore ways to integrate electricity with other energy carrying vectors, e.g. district heating and transport, has to be found, or else it will be necessary to curtail RES at certain periods and thus waste energy. Most of the communities will face this problem at some point of time in the future, and it is essential to develop a multitude of solutions for different energy systems and communities. In the EcoGrid projects partner BV has shown, that it is possible to engage the citizens and create flexibility in the power grid by controlling household electricity consumption. –In this demo we will expand the scope to create flexibility and synergy in both electrical grid and district heating network, and engage citizens and community to participate in the project.

Citizen engagement in general

Citizens in Bornholm have invested in energy production for the last 30-40 years. At present there are about 1.000 households with approximately 8 MW of rooftop PV panels. This high number is due to the PVTP Island project I-III and favorable support mechanisms up to 2015. There are 50 households with their own wind turbines of up to 25 kW. Both PV and wind turbines are grid connected.

Creation of local supply chain for renewable energy: a very important local impact is the local fuel supply for district heating and CHP - straw and woodchips. The current consumption in the heat plants and the power plant of local produced biomass is approximately 20.000 tons/year straw and approximately 50.000 tons/year woodchips. With the current price of straw at approximately 75 €/ton, and woodchips at 60 €/ton (at app. 45% water), the value of the locally produced fuels are around 4,500,000 €/year. Furthermore there is a lot of local labor involved in production and transportation of straw and woodchips.

A newer 50 kW PV installation at the public indoor swimming pool in Gudhjem has been raised by crowdfunding among local citizens.

4.2.2 General data about local energy system and energy vectors

Existing infrastructure

Table 3 Existing infrastructure in Bornholm Island

Bornholm island - power	**Østerlars District Heating system (Demo)**
• **37 MW** from 35 larger wind turbines. Private and public owned • **8 MW** from app. 1.000 rooftop PV stations • **15 MW** from two private PV production plants • **3 MW** from Biogas plant Central Heat & Power plant: • **35 MW** from woodchip fueled boiler • **58 MW** capacity of fossil fuel generation • **60 MW** capacity import/export via sea cable	Østerlars Heat Plant: • **4 MW** straw fueled boiler (with condensation) Production: 18.000 MWh/year • **2,4 MW** electric boilers (backup) • **1-2 MW** wood pellet boiler (backup) • **80 MWh** in hot water storage tank – 1.500 m3 • 93 kW power from rooftop PV • **20 MW** PV-plant near Østerlars (in planning) • **District Heating Network**: Østerlars, Østermarie, Gudhjem • **Loads**: households, trade, institutions, and a public swimmingpool – totally 600 consumers.

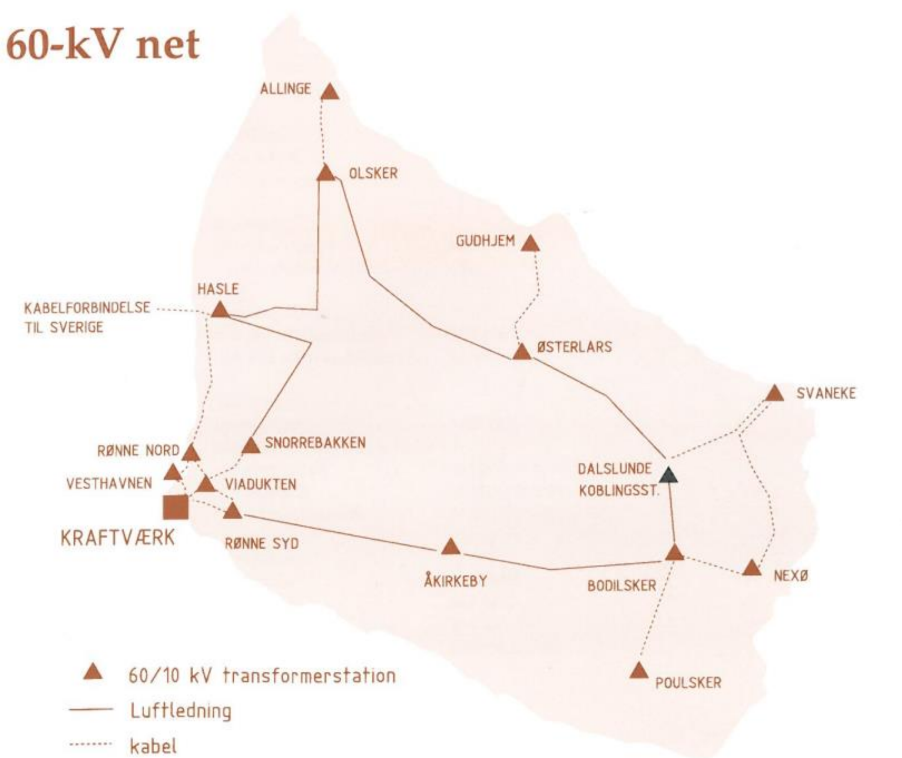

Figure 3 Bornholm Island 60-kV net diagram

Available energy vectors:

The optimized and decarbonized operation of four energy vectors - biomass, district heating, electricity, and transport - is highly recommended for the island, so it will be possible to integrate and fully use increased RES capacity from new PV-plants and wind turbines (offshore)

Biomass (local woodchips, straw, and manure) is a vector for heat- and electricity-production in district heating, CHP, and Biogas-plant. Electricity is a vector for district heating via electric boilers, heat pumps, and in the future waste heat from P2X-production. Electricity is also a vector for transport, directly via electric cars and ships, or indirectly via P2X fuel production.

Renewables:

Bornholm already has a very high penetration of RES today: District heating is based on local renewable biomass, and a little waste incineration (decreasing). Local electricity production is based on biomass, wind and sun, and covered 75 % of the electricity consumption in 2020 (see figure below). The small production on fossil fuels take place on the CHP, in periods when the sea cable is unconnected, or the Danish TSO, ENERGINET.DK calls for increased power input to balance the Danish grid.

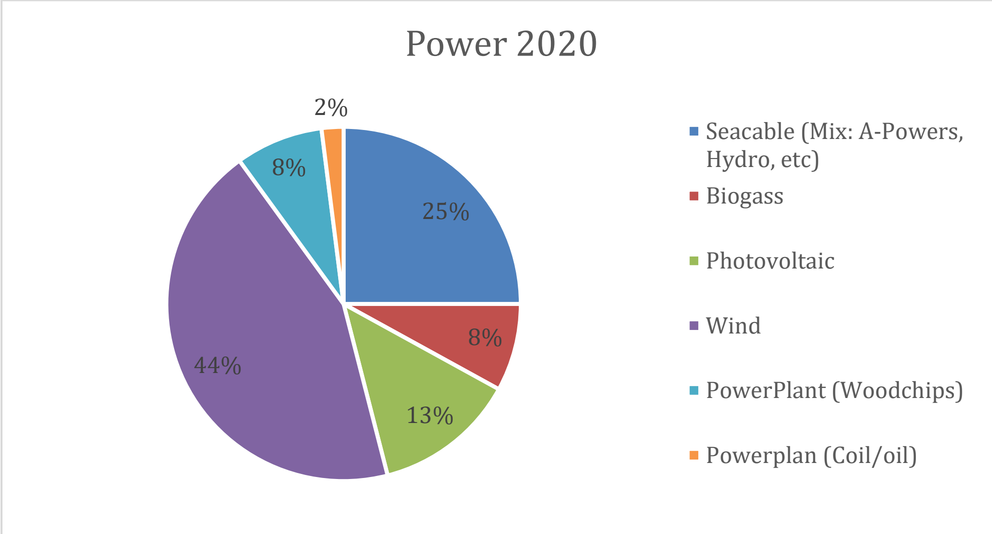

Figure 4 Energy mix in Bornholm Island for 2020

4.2.3 Planned installations

- Online data collection from Heat plant and remote control of Electric boilers
- Online data collection from smart meters at a few consumers
- Remote control of Danfoss ECL-computers at a few consumers

4.2.4 Actors involved

- Citizens organizations in the local community
- Consumers where remote control and online data collection are installed
- The Energy Company developing the 20 MW PV-plant near Østerlars
- Staff running the District Heating system
- Partner DTU

4.2.5 Re-EMPOWERED related activities

The Demo will explore the synergies of integrating the energy vectors: Electricity, District Heating and Biomass, by forecast, balancing, and integration of increasing PV-production via the heat plant and District Heating Network (DHN). Local services of power control, peak shaving and optimized use of renewable biomass and solar power, will be demonstrated by means of intelligent control capability. Forecast of production from PV will be used for the control of the supplementary 2.4 MW electrical boilers in Østerlars heat plant, for balancing and absorbing fluctuating electricity production, and store it as heat in the district heating system. The case is replicable in all Islands (and geographical areas) with district heating – with or without a power cable to the mainland.

Citizen engagement

All the District Heating consumers have digital smart meters, enabling detailed analysis of data about consumption, temperatures, and flow in the network. The consumers also have hot water storage tanks, of at least 100 liters, and in Gudhjem all consumers have a Danfoss ECL computer installed, that controls the charging of the hot water tanks, and the temperature level of incoming water to the household radiator system.

Several consumers in Gudhjem will be recruited for the demonstration, and the already installed Danfoss ECL computer will be upgraded with remote controls, to provide access for demand-response, for balancing heat input from PV via electric boilers. Two larger consumers are already recruited: The public indoor swimming pool in Gudhjem, and the local school in Østerlars.

Within the RE-EMPOWERED project, the demo aims to achieve a set of goals related to the project's objectives and high-level use cases. Through the survey a first idea of the importance of each objective, the goals and potential obstacles are identified. The following table summarizes these results.

Table 4 Bornholm Island demo's information related to the project's objectives

Objective	Relevance	To be tackled in RE-EMPOWERED	Goal for the future	Potential Obstacles
Optimal operation, high flexibility, and efficiency	Very important	Nice to have	Integration of sector coupling between PV production and district heating	The anticipated specific balancing/integration/sector coupling of PV production and the district heat system in the Demo will the first of its kind, and is expected to produce technical issues
Higher res penetration and utilization	Very important	Nice to have	CO2 neutral energy system (power and heating) by 2025	Not expected
Reliable and resilient operation	Very important	PV peak shaving, Coupling of power and heating: Very important	CO2 neutral energy system (power and heating) by 2025 and reliable and resilient operation	The anticipated specific balancing/integration/sector coupling of PV production and the district heat system in the Demo will the first of its kind, and is expected to produce technical issues
Digitization and ICT development	Very important	Mandatory	New smart systems for controlling integration of fluctuating energy from RES in the district heating system.	Cost and development of advanced control system, Upskilling employees
New competitive business models and financing tools	Important	Mandatory	The development of new business models, encouraging sector coupling is important to facilitate the integration of electricity from a growing capacity of RES.	Sector coupling calls for new digital solutions for control and forecast

Community engagement, training, and energy community development	Very important	Mandatory	Increased consumer flexibility that helps to optimize the District Heating System	Potential financial obstacles, Integration of optimization strategies for public infrastructure
Improved energy access and environment quality	Important	Nice to have	Increasing the effectivity of the District Heating System, by means of digitalization and flexibility, resulting in better economy and use of less fuel. Establishment of the 20 MW PV-park will increase biodiversity in the Demo-area and protect the ground water resources from pesticides and nitrate.	-

4.3 Kythnos Island

4.3.1 General description

Kythnos is a Greek island, (100.2km^2 – 1,456 inhabitants) part of Cyclades in the Aegean Sea. It is widely famous because of its long history in sustainable energy applications, since it hosts the first wind farm in Europe, which was constructed in 1982, and the first microgrid application in Europe, in **Gaidouromantra**. In addition, Kythnos has previous experience in smart grid technologies which have been developed in the frame of other European projects. For the abovementioned reasons and because it remains non-interconnected to the mainland electrical grid, which is translated to constraint RES integration, Kythnos is an ideal test bed and demonstration site for high TRL applications.

Figure 5 Kythnos island

Gaidouromantra is a settlement built in a small valley next to the coast, in the southern part of Kythnos. A permanently islanded microgrid operating on 100% renewables electrifies the settlement which consists of 14 vacation houses. It is the first microgrid in Europe developed through European projects and it's been operational since 2001.

4.3.2 General data about local energy system

1. **Kythnos** is a non-interconnected Island with the following energy mix:
   - Peak load: 3.118 MW
   - No. of electricity customers (end consumers / producers – LV): 3,353
   - Installed capacity of fossil fuel (diesel) Generation: 5.2 MW
     - MWM TBD603V12: 4 x 0,3 MW
     - MITSUBISHI S16R-PTA: 4 x 1 MW
   - Installed capacity of RE Generation units 908.65kW:
     - 3 PV power plants of 1x 98.4 + 1x 69.92 + 1x 69.93 = 238.25kW
     - 2 Roof units of 1x 19.875 + 1x 9.66 = 5.4 kW
     - Wind stations of 5x 33kW + 1x 500 kW = 665 kW

In 1982, the Installation of the 1st wind park (5 x 20kW) in Europe took place in Kythnos. In 1983, the first hybrid station comprising a PV system (100kW) coupled with battery storage (400 kWh) was installed. In 1989, the park's wind turbines were replaced by new ones (5 x 33 kW) and in 1992 the PV inverters were upgraded. Later, in 1998 a wind turbine of 500 kW was installed. Most of the systems installed back in 1980s are not in operation, a new project for repowering the 500kW wind turbine potentially coupled with battery storage to reduce curtailment is currently ongoing.

In the following table, the total yearly local energy production and the total yearly energy consumption of the Local Energy System (LES) of Kythnos, based on data of the year 2020, are presented:

Total yearly local energy production	Total yearly energy consumption
10,058.75 MWh (2020)	9,166.75 (MWh) (2020)

2. **Gaidouromantra** microgrid consists of the following assets:
   - 14 vacation houses
   - 6 PV arrays of 11 kW
   - Lead-Acid (FLA) battery bank with nominal capacity 1000Ah/48V
   - One back-up 3-phase diesel generator of 22kV
   - Loads (refrigerators, lamps and controllable water pumps) – Yearly peak load: 7.5 kW
   - Agent-based software/hardware for centralized and distributed control, composed of Intelligent Load Controllers (ILC) for protection against overloading or extreme battery discharge in each house.

In Figure 6, the topology of the Gaidouromantra microgrid is presented.

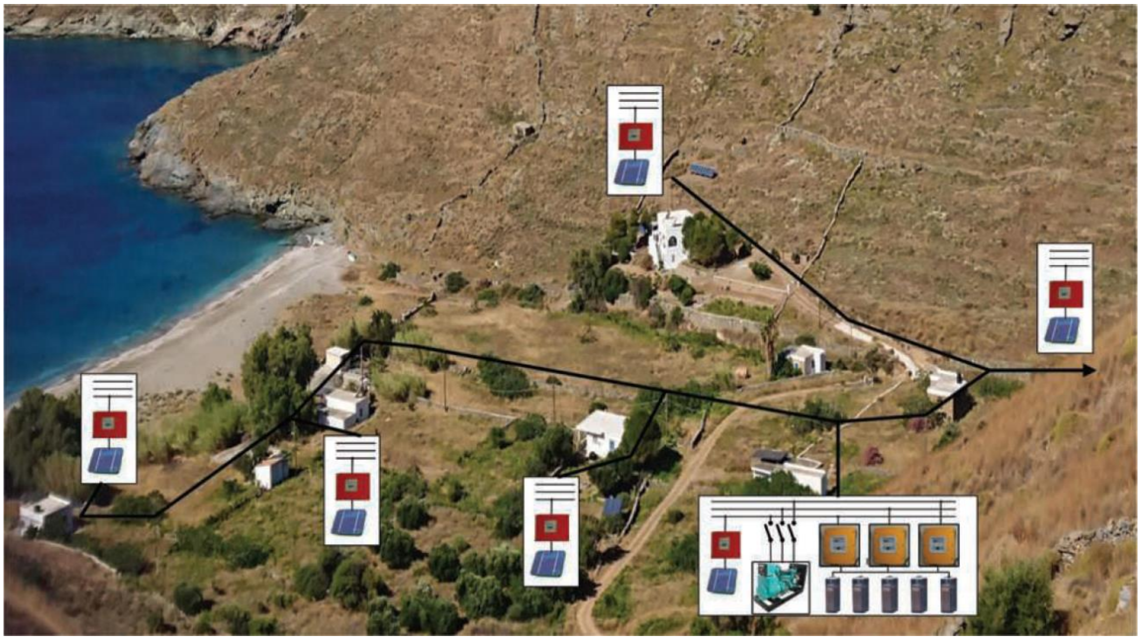

Figure 6: Overview of Gaidouromantra Microgrid..

Gaidouromantra microgrid was the first Microgrid in Europe (2001) supplied by almost 100% renewable generation. The system was built in the framework of two projects, PV-MODE (JOR3-CT98-0244) and MORE (JOR3CT98-0215), supported by the European Commission. In 2006, the Kythnos Microgrid was upgraded in the framework of the MORE MICROGRIDS project (FP6 019864) and used as a test field for the implementation of advanced control strategies. Currently, an upgrade of the existing infrastructure is under progress in the frame of KSI project.

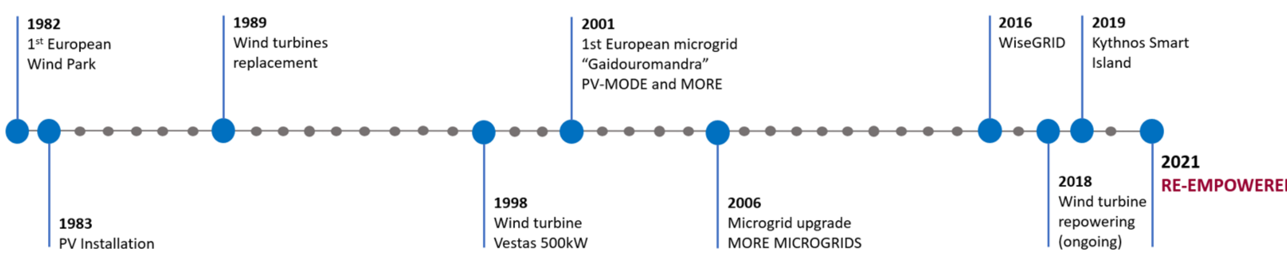

Figure 7: Timeline of EE projects implementation in Gaidouromantra Microgrid.

4.3.3 Available energy vectors for synergies

1. **Kythnos Island:** The island has embraced the electromobility and a few electric vehicles and charging stations have been deployed. However, the flexible charging and discharging of the EVs should be accomplished depending on the availability of “green” electricity and according to the technical requirements. Moreover, water treatment in Kythnos is achieved through desalination plants with high operational costs and energy consumption. The optimized and efficient operation of the three energy vectors, e-mobility, water, and electricity is highly recommended for the island in order to reduce energy costs, to better manage the energy demand and finally increase the RES capacity.

More specifically, Kythnos hosts the following other energy related infrastructure:

- Desalination plant of 1x 75 kW
- Number of Electric Vehicles deployed: 3 (more to be deployed by the municipality)
- Number of charging stations installed: 4x11kW + 1 wallbox (more to be installed)

2. **Gaidouromantra:** Each house in Gaidouromantra is equipped with a water pump, which is responsible for replenishing a water tank and in this way supplying water to the household. In addition, the residents use the water for some small scale agricultural activities and gardening. The two energy carriers can be combined and co-optimized for the efficient operation of the local energy system.

4.3.4 Actors and Stakeholders

As we mentioned earlier, the permanent population of Kythnos consists of 1,456 inhabitants, with the population in summer months to be even 8-10 time bigger than this. The island is administratively managed by the Municipality of Kythnos and it is part of the Regional Authority of South Aegean.

In the following table a list of the energy stakeholders of Kythnos island can be found.

Table 5 List of actors in Kythnos demo

Role	Actor
DSO	HEDNO
TSO	N/A
Energy Supplier	WATT AND VOLT, NRG, ELPEDISON, Mytilineos, PPC, ELTA, KEN, Zenith, Elinoil
Energy Producer	PPC (thermal station), PVs (private)
Electric Mobility Manager	N/A
Storage Manager	N/A
Aggregator	N/A
Support (technical, social, regulatory, etc.)	ICCS-NTUA, DAFNI, CRES

A major regulatory barrier is the specific spatial planning framework for renewable energy sources and the margins imposed for their penetration in non-interconnected systems. Limited public support to inclusive business models with collective ownership of energy projects (such as energy communities) leads to limited local acceptance of RES projects, especially in islands where issues such as land use conflicts and landscape impact are considered important. More targeted incentives and sources of funding should be offered at a local level, giving stakeholders the opportunity to participate in the energy transition as members of energy communities. The uptake of electromobility and demand side management requires a comprehensive legislative and regulatory framework.

4.3.5 Re-EMPOWERED related activities

Renewables penetration:

Even though Kythnos has a long history in renewables and low-carbon applications, still is quite dependent on diesel generators and fuel oil, making the variable cost of energy in the island very high, like most of the Non-Interconnected Islands. By applying “smart” and efficient techniques and technologies for energy management, there is a lot of headroom for renewables integration. Within “RE-EMPOWERED” advanced Energy Management System applying the technical restrictions and economic criteria, capitalizing on the available energy vector synergies, will be demonstrated to optimize the operation of the local energy system, allowing further renewable energy integration and cost reduction of energy production. In addition, innovative Demand Response techniques will be implemented for even better energy management through the engagement of local energy consumers and producers, leading in the development of new attractive business cases. The case of Kythnos can pose the prototype and can be replicable in all the NII of Greece.

Citizen engagement

1. **Kythnos Island:** Law 4513/2018 introduced the concept of energy communities in Greece as a step towards energy democracy. The law aims to enable local actors (citizens, municipalities, local businesses, universities etc.) to get actively involved in the clean energy transition with some special provisions for islands. Energy communities are the most ideal businesses model for clean energy projects in islands. However, Kythnos hosts no citizen-led energy initiatives. Key stakeholders such as the Municipality of Kythnos and commercial associations have already been engaged by DAFNI and are supportive to the project. One of the goals of Re-Empowered will be the establishment of Energy Communities on the island including local authorities, local citizens, and businesses to maximize the local benefit and accelerate the clean energy transition of Kythnos in a socially inclusive way.
2. **Gaidouromantra:** Studying the operation of Gaidouromantra’s Microgrid the main detected issue is that the batteries are frequently overloaded because of the concurrence of many houses’ maximum demand. Based on that and according to earlier studies, the users of the microgrid have shown a grid-oriented energy culture and not a culture of autonomous energy supply. Technical Demand Response in combination with behavioural Demand Response techniques adapted to small scale energy systems will be applied and demonstrated for optimized and efficient energy management. In addition, Microgrid Management System will be developed and demonstrated for optimal microgrid operation taking advantage of the flexible loads and the available energy vectors.

Within the RE-EMPOWERED project, the demo aims to achieve a set of goals related to the project’s objectives and high-level use cases. Through the survey a first idea of the importance of each objective, the goals and potential obstacles are identified. The following tables summarize these results.

In Kythnos Island:

Table 6 Kythnos Island demo's information related to the project's objectives

Objective	Relevance	To be tackled in RE-EMPOWERED	Goal for the future	Potential Obstacles
Optimal operation, high flexibility, and efficiency	Less important	Nice to have	-	Financial, Technical, Regulatory, NIMBY
Higher res penetration and utilization	Important	Mandatory	Due to regulatory issues, Kythnos cannot host more RES at the moment	Financial, Regulatory, NIMBY
Reliable and resilient operation	Important	Congestions: Important Outages: Very important Black outs: Very important	Reliable and resilient operation for the whole island is a significant objective along with improvement of SAIDI and SAIFI KPIs, protection of the grid against extreme weather conditions and better load and weather forecast.	Financial, Technical
Digitization and ICT development	Less important	Nice to have		
New competitive business models and financing tools	Less important	Nice to have		Financial, Technical, Regulatory, Poor citizen's interest
Community engagement, training, and energy community development	Very important	Mandatory	Establishment of Energy Communities on the island including local authorities, local citizens and businesses to maximize the local benefit and accelerate the clean energy transition of Kythnos in a socially inclusive way.	Financial, Technical, Organizational, Poor citizen's interest
Improved energy access and environment quality	Less important	Nice to have	Reduction of GHG emissions through optimization of the thermal station operation and the increase of RES penetration in electricity generation and mobility	Financial, Technical, Regulatory, NIMBY

In Gaidouromantra microgrid:

Table 7 Gaidouromantra demo's information related to the project's objectives

Objective	Relevance	To be tackled in RE-EMPOWERED	Goal for the future	Potential Obstacles
Optimal operation, high flexibility, and efficiency	Important	Nice to have	-	Financial, Poor citizens' interest, NIMBY counter movement
Higher res penetration and utilization	Less important	Not needed	Already 100% RES. Improve utilization of RES	Technical
Reliable and resilient operation	Important	Black outs: nice to have	Apply behavioral demand response techniques (load shedding) to avoid extreme battery discharge. Restore the operation of the load controllers	Poor citizens' interest, NIMBY counter movement
Digitization and ICT development	Important	Nice to have	Advanced communication scheme with protection devices and MGCC	-
New competitive business models and financing tools	Important	Nice to have	Establish a business model that will be able to support the financial needs for operation and maintenance of the microgrid. The final target is the establishment of a local energy community involving the residents of the MG to manage collectively all operational issues in the future.	Financial, Regulatory
Community engagement, training, and energy community development	Very important	Mandatory	Engagement of citizens to collectively operate their local system. Form energy community	Poor citizens' interest
Improved energy access and environment quality	Important	Nice to have	Engagement of citizens for DSM to avoid black outs	Poor citizens' interest

4.4 Ghoramara

4.4.1 General description

Ghoramara Island is located approx. 92 km south of Kolkata, in the Sundarban of the Bay of Bengal in India. A google image of the island is shown in Figure 8. The island comprises of five different villages as shown in Figure 8. The nearest mainland is Kakdwip which is approximately 5 km away and takes around 1 hour through diesel operated boats. This island is roughly five square kilometers in area with a population of 3,000 residents (1100 houses) as of 2016. Out of the whole population, 50% belongs to scheduled caste (SC) category, and 20-30% belongs to minority group. Around 3000 residents are staying there over 1100 houses. Two primary schools, one higher secondary school (420 students), and a primary health care center are available in the island. A few shops (around 30) are located at the central area of the island near to the schools. The administration of the entire island is controlled by an elected Gram-panchayat system.

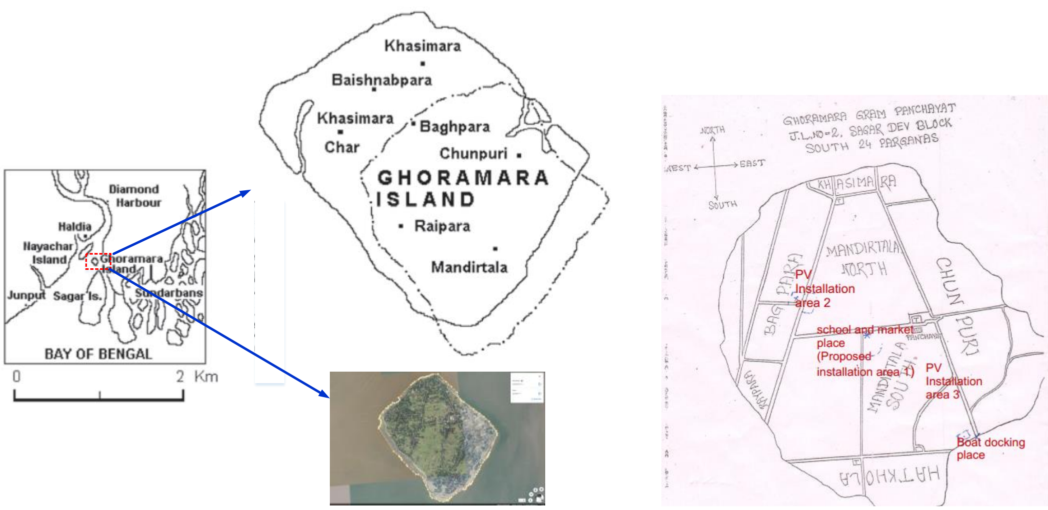

Figure 8 Ghoramara Island

4.4.2 General data about local energy system and energy vectors

The following infrastructures are available at Ghoramara island.

- Utility grid is not available in the island.
- A 2-kW wind turbine was installed near Ghoramara school, but the system was damaged during cyclone AMFAN which makes it inoperative.
- A few discrete solar panels are found on the roof-top of individual houses and shops which are mostly used for mobile charging and glowing of LED lamp (one/two in numbers using home lighting solution).
- Around 100 numbers of streetlights with solar panels are also found which are now inoperative.

The capacity of the existing energy vectors at Ghoramara island is mentioned in the following Table.

Table 8 Existing energy infrastructure in Ghoramara

Energy vectors	Type of installation	Capacity
Solar	A few solar PV panels are mounted on the roof-top of some individual houses to provide power to one/two LED lamp and mobile charging. In some cases, battery is damaged, and replacement is not yet done. Around 100 numbers of solar powered streetlights were installed across the island, but most of them are presently non-functional due to non-replacement of battery.	Power rating is corresponding to one PV module (30-70W). Note that PV module is mounted in only a few houses.
Wind*1	A 2-kW wind turbine is mounted at the vicinity of school which is not operational after the cyclonic storm "AMPHAN".	2 kWp

*1: The average wind speed on the island is 4.6 – 5.6 m/s which has the capability to generate 6800-7200 kWh wind energy per year from a 5kW wind turbine (i.e., 19-20 kWh per day).

4.4.3 Planned installations

Table 9 Planned installations in Ghoramara

	Proposed hardware facilities	Capacity
1.	A 250 kW microgrid system (230 kW with conventional technology + 20 kW with RE-EMPOWERED technology	240 kW PV + 10 kW Wind
2.	A Load flow controller	5 kW
3.	A Power Quality Conditioner (STATCOM)	20 kVA
4.	Deployment of electric three wheelers	2 Pay-load: 800 kg. Motor rating: 2 kW BLDC Millage: 60 – 70 Km per charge Speed: 25 km/hour
5.	An FPGA based digital control platform	Spartan-6 or higher version of FPGA IC will be used
6.	A charging station	A charging station with four charging ports. Each charging port is rated at 48 V with 1.5 kW capacity.
7.	Dimmable Street light	**80** streetlights will be deployed out of which 20 are energy efficient dimmable

8.	Smart meters with advanced features	50 smart meters with remote monitoring and management facilities Additionally, 5 advanced smart meters with features such as management of non-critical loads, and real time dynamic pricing
9.	Wind resilient structures	Wind resilient structure will be considered for 20 kW PV and 5 kW wind installation. The commercially available conventional structures will be used for rest of the installations.
10.	Electric boat	An electric boat will be deployed which can carry 15 persons with a speed of 6 Knots. The boat will have 3 kW on-board solar panel, 2X6 kW electric outboard motor and 2X12 kWh Li-Ion battery.

The electrical configuration of the microgrids which will be functioning at Ghoramara island is shown below in the following figure.

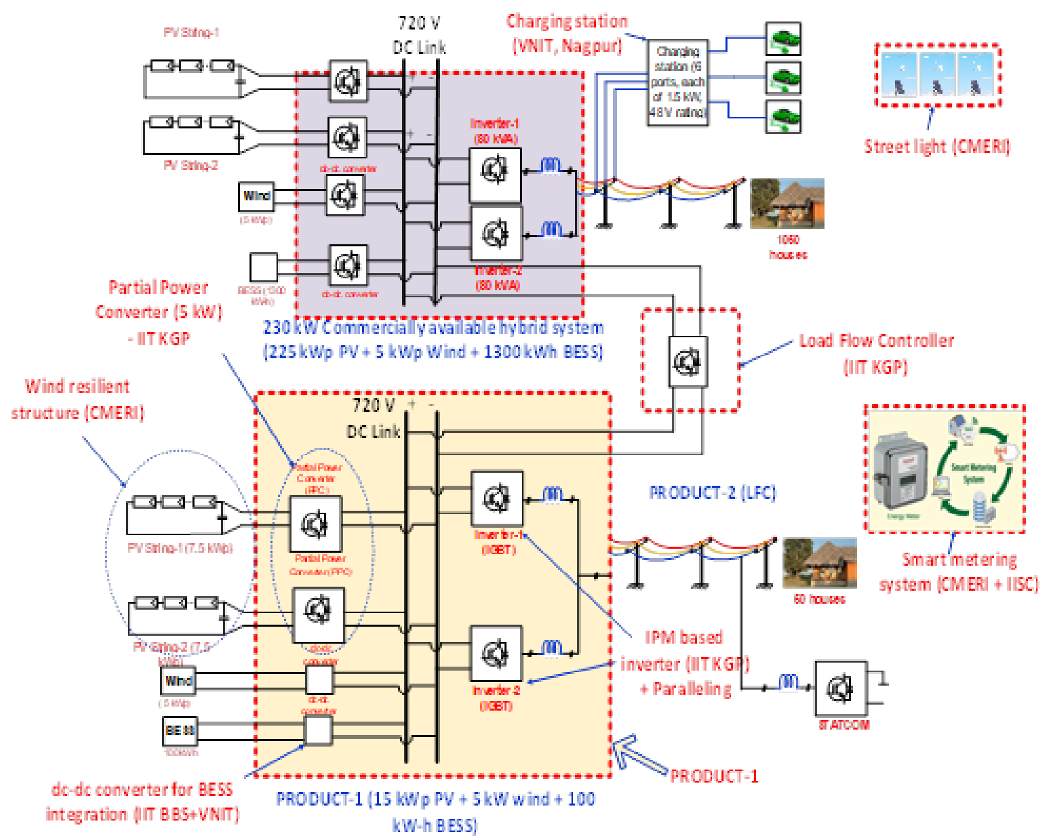

Figure 9 Configuration of the microgrid to be formed in Ghoramara island

4.5 Keonjhar

4.5.1 General description

Figure 10 Keonjhar demo site

Kanheigola, Nola and Ranipada are small Villages/hamlets in Harichadanpur-Tehsil reserve forest in Keonjhar District of Odisha State, India. It is located 54 km towards South from District headquarters Keonjhar and 180 km from state capital Bhubaneswar. At present these villages are not connected to the main utility grid. A total of 77 kWp (Kanheigola- 30 kWp, Nola -25kWp and Ranipada- 22 kWp) Solar PV installations are supplying to approximately 1000 villagers, living in 306 households. These solar PV installations are completely isolated and commissioned by the Odisha Renewable Energy Development Agency (OREDA) in 2017-18. The proposed site is ideal for the test bed and demonstration site case as it already has some basic renewable energy presence, which can be upgraded with various available energy vectors and improve the living standards of the community.

The climate of Keonjhar District is characterized by an oppressively hot summer with high humidity. Summer generally commences in the month of March. Temperature begins to rise rapidly attaining the maximum in the month of May. During the summer, maximum temperature touches around 380C. The weather becomes more pleasant with the advent of the monsoon in June and remains as such up to the end of October. The temperature in the month of December is lowest i.e. it hovers at around 110 C. Sometimes it even drops down to as low as 70C. The average annual rainfall is around 1534.5 mms.

4.5.2 General data about local energy system and energy vectors

The following infrastructures are available at Keonjhar Demo Site.

- **A total of 77 kWp (Kanheigola- 30 kWp, Nola -25kWp and Ranipada- 22 kWp) Solar PV installations**
- One high school and one primary school are available run by Tribal/Social Welfare Department.
- One sub center of primary health care center is also present in these villages to provide initial medical facility to the residents.
- The main source of income is agriculture (mainly rice) in which 80-90% peoples are involved. The water from the downstream is the major source for cultivation.
- Three rice-cum-hauler meals are present which are run by diesel engine (consuming 6-7 liters of diesel per day per machine)

- Government of Odisha started construction of roads from Harichandanpur to these remote villages and the same is expected to be completed in 2022. Currently very few autos are used for transportation between these village and nearest Block head quarter (Harichandanpur).
- Every house in these villages is provided with 100 W for meeting the basic facilities like 2 LED lights and fan only for 4 hours during night time (6 PM to 10 PM)

Table 10 Existing infrastructure in Keonjhar demo

No.	Village/ Block/ District	Kind of Source in each microgrid	Plant Capacity in kW	Load in kW	AC system/DC Systems:	No. of Household Connected
1	Kanheigola, Keonjhar	Solar	30	21	AC system	126
2	Nola, Keonjhar	Solar	25	17.5	AC system	105
3	Ranipada, Keonjhar	Solar	22	15.4	AC system	75

4.5.3 Planned installations

Table 11 Planned installations in Keonjhar demo

No.	Planned hardware facilities	Capacity
	A 50 kW microgrid system	30 kWp PV + 10 kW Biomass+ 10 kW Biogass
	Electrical Vehicles	2
	Smart Meters, with Fuse and MCCB/MCB	20
	Solar Dimmable Lights	20 out of which 5 are energy efficient dimmable
	Charging Facility, 2 Ports	1.5 kw, 48V
	IoT based remote measuring system	1

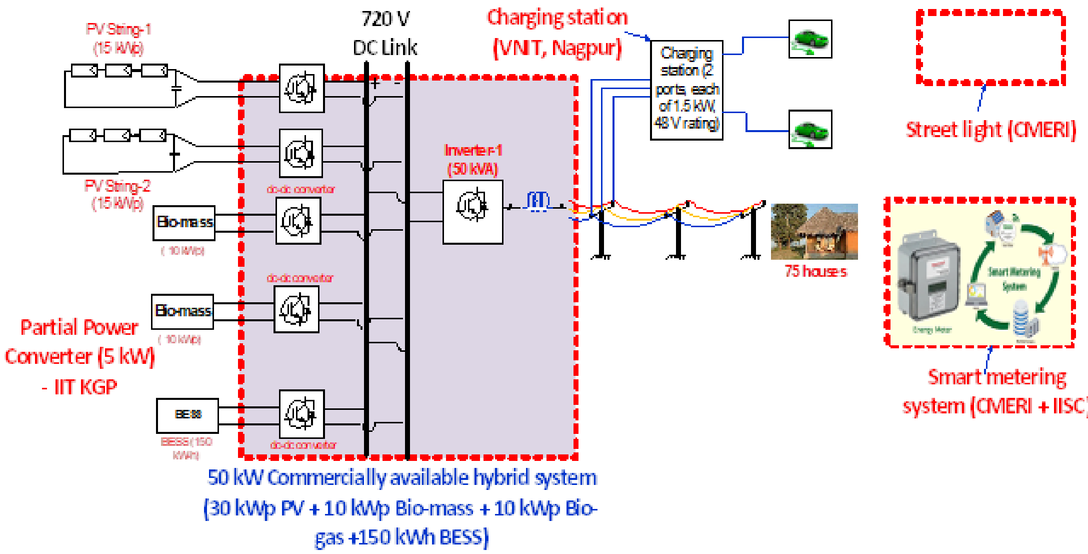

Figure 11 Configuration of microgrid system in Keonjhar demo

4.5.4 Re-EMPOWERED related activities

Renewables penetration

All the three villages in Keonjhar are isolated from the main grid and in the view of financial viability to connect these villages to the main grid is very difficult. This will give an ample opportunity to have higher penetration of the renewable energy sources in these remote places. The development in technology and efficient power converter system at low power levels, optimizing the various available energy vectors will increase renewable penetration to greater extent. Also by coordinating and engaging the village community, local livelihood activities need to be developed, which in turn will enable to build sustainable and profitable local energy systems. The success of this pilot project at Keonjhar can be a very good model to be replicable in other such remote locations in India.

Citizen engagement

The main issue in these remote villages is lack of reliable electric power. The present installed capacity of 22 kWp in Ranipada is barely serving the household activities. Another major challenge is the higher tariff of electricity. The proposed microgrid will control various energy vectors, metering, billing and differential tariffs for business, livelihood activities, and household. It schedules demands of microenterprises, irrigation pumps, streetlights, etc. The anchor loads are scheduled to match the solar generation profile. A village micro enterprise zone (MEZ) will be created to develop micro-industries for livelihood activities like Irrigation through “Field-Distributed-Pumps” and mobile pumps, Small enterprises such as Agro processing, electric three wheelers, etc.. Few Smart meters will be deployed to gather energy consumption data from the villagers to be used for further development of demand side management algorithms.

Within the RE-EMPOWERED project, the demo aims to achieve a set of goals related to the project’s objectives and high-level use cases. Through the survey a first idea of the importance of each objective, the goals and potential obstacles are identified. The following table summarizes these results.

Table 12 Keonjhar demo's information related to the project's objectives

Objective	Relevance	To be tackled in RE-EMPOWERED	Goal for the future	Potential Obstacles
Optimal operation, high flexibility, and efficiency	Very important	Nice to have	Upgrade the local energy system, improve operation and efficiency	Financial, Organizational, Poor citizens' interest
Higher res penetration and utilization	Very important	Mandatory	Increase RES capacity and utilization	Technical, Poor citizens' interest
Reliable and resilient operation	Very important	Congestions: Nice to have Outages: Mandatory	To provide an reliable supply to the commercial applications like rice huller machines, Charging of electrical vehicles etc., and make a the developed Microgrid a sustainable one. Demand response techniques (load shedding) to avoid extreme battery discharge	Technical, Poor citizens' interest
Digitization and ICT development	Important	Nice to have	To provide a basic ICT structure for acquiring various data related to power production and consumption	Poor citizens' interest
New competitive business models and financing tools	Very important	Mandatory	To provide electricity for commercial purpose by charging them with the existing tariff.	Financial, Poor citizens' interest
Community engagement, training, and energy community development	Very important	Mandatory	The local people should be trained to operate the Microgrid facility and also enable to them to use the facility with higher efficiency and sustainable way	Organizational, Poor citizens' interest
Improved energy access and environment quality	Important	Nice to have	To provide a reliable power to the commercial establishments in the morning hours and to increase the energy access to the domestic users.	Organizational

5 Use Case Definition

5.1 Methodology

As the design of complex systems, such as Smart Grids, requires an efficient way to manage the system level requirements, which are derived from different domains of expertise, a set of common methods and terms is necessary to support the development teams. The Use Case methodology is the current state of art to support engineering activities.

Originally defined in IEC 62559-2:2015 [1] to cover the needs of software design engineering, the advantages of the methodology have rendered it appropriate for applications in other areas such as smart grids. The advantages of the Use Case methodology for Smart Grids applications have been summarized by CEN-CENELEC Smart Grid Coordination Group [2]. Some of the advantages which impacted the decision of RE-EMPOWERED partners to follow this approach are listed next with the description adapted to the project's needs.

- **Use cases gather requirements**: Use cases gather requirements, information about functionalities, processes, and respective actors in a structured form.
- **Support standards development**: It is the intention that use case descriptions support development of standards in the design and definition phase, e.g., in areas like interoperability, terminology, safety, risk assessment, security and others.
- **Enable a common understanding between different stakeholder groups and its coordination Guidance for users of standards**: A discussion of these use cases with its requirements and descriptions should enable a common understanding between different partners co-developing solutions or contributing to linked tools.
- **Management of standards development in complex systems**: Depending on the level of granularity of the description the use cases support the assignment and management of tasks to project partners which are related to the respective use case as well as the coordination of the development of a project's solution.
- **Test use cases / Training:** Beneath these basic functions, validated use cases can be used for testing or demonstration purposes. Therefore, use cases will not only have preparatory and administrative functions for project partners and the development of tools. They will be used to test and assess the success of the developed solutions.

The template for the use cases definition as defined by IEC 62559-2 is a structured format to support in describing, comparing and administer use cases. The original template mainly consists of administrative information, description of the function(s), the system under discussion and the design scope, the actors linked to the function and the activities as well as extended information for classification of the use cases such as the link between use cases and standards or to the SGAM [1]. Nevertheless, the authors of the use cases decide the granularity of their description according to the specific needs of the project. For the RE-EMPOWERED project, a template was developed based on the original by IEC, to acquire the necessary information for the project's solutions functionalities and scope.

The RE-EMPOWERED template contains the following information:

- Use case identifier (ID)

- Description
- Scope
- Requirements
- Related KPIs
- Actors
- Triggering event
- RE-EMPOWERED tools involvement
- Pre-condition and post-condition
- Step by step analysis and exceptions
- Contributing partners

The RE-EMPOWERED use cases are defined at the tool level basis, since each developed solution will both individually and collectively contribute to the realization of the project's objectives, yet the maturity level and individual applications are different. Also, this approach will foster and support the administration and management of the development of each solution, and furthermore, the assessment of the realization and success of the different functionalities of each solution.

The use cases for each tool are hierarchically structured to further enable the management of the development phase, and the testing process. Primary Use Cases, identified as 1UC describe the higher-level testable functionality of the solution, while the Secondary Use Cases, identified as 2UC, deal with the corresponding sub-functionalities, which compile the 1UC. Each developed solution's Use Cases, are characterized by an acronym accompanying the Use Case ID. For example the ID of the first primary use case of the ecoMicrogrid tool is defined as: MG_1UC1, while the first corresponding secondary use case is defined as: MG_2UC1.1.

5.2 Description of the Use Cases

The tables presented in this section, contain the basic description for each of the Use Cases, so that the reader will be able to get an overview of the targets for each RE-EMPOWERED solution. The complete analysis, integrated in the developed IEC 62559-2 based template are presented as Annexes at the end of the report. The descriptions, requirements and step-by-step analysis depend on the maturity level of each tool. The final descriptions integrated in the systems' technical architecture will be presented in the following RE-EMPOWERED deliverable D2.3 *Report on technical architecture and specifications.* The following tables that provide the description of the Use Cases, are color coded, where the primary use cases have a darker shading color, while the secondaries have light colored backgrounds. Also, for a certain tool, the different UC families (primaries with their corresponding secondaries), are identified using different colours.

The use-case description of ecoConverter and the tool-demo mapping of ecoConverter and ecoVehicle will be provided by the responsible tool leaders IIT KGP and VNIT respectively at the next stages of WP2.

5.2.1 ecoEMS

EMS_1UC1: Real time monitoring and system data visualization	
This 1UC addresses the observability of the system, meaning the active monitoring of the assets. It consists of four main data components; The first component is responsible for the real-time acquisition of measurements (Active Power [P], status, hours of operation, etc.) while the second deals with static data, such as generators datasheets, including information such as Nominal Capacity, Ramping Rates, etc. The third component concerns historical data storage, retrieve and visualization, to perform estimation about outages and other contingencies. Finally, cross communication between modules is crucial, to retrieve RES and load forecasts, or the Day Ahead Scheduling program.	
EMS_2UC1.1	**Real time system monitoring and data acquisition and visualization**
A variety of measurements are necessary for the sufficient data acquisition concerning EMS operation, as well as static technical data for each asset. It is highly important for the measurements and to be reliably, securely, and effectively transmitted from the SCADA to datalek/database (preferably a MSSQL database), via which the data are used by the Energy Management System. Static data also need to be reliable and crosschecked and should not be altered if any actual change does not take place. Communication protocols are an important issue due to the necessity to integrate different vendors. The objective of this 2UC is to ensure the effective development and implementation of the on-line data transferring and near real-time monitoring system for the EMS performance overview.	
EMS_2UC1.2	**Module manager: intercommunications and data exchange**
This 2UC addresses the second role of the Orchestrator (the first role is the Data Manager, described in 2UC1.1), which is the Module Manager that takes over the execution of the algorithms in the correct order, so that exceptions will not be throwed. Clarifying this, this manager is consisted by two pillars; primarily the scheduler periodically executes the forecasting modules, every hour for 48 hours horizon with hourly step and every 15 minutes for 4 hours horizon with 15 minutes step. Secondarily, unit commitment and economic dispatch are also scheduled to be executed with the corresponding horizons and steps, after the forecasts are available from the forecasting models. This way, the module manager ensures that the output data from one algorithm and that will be required from another algorithm, are available for module intercommunication and transferred without execution delays.	

EMS_1UC2: Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization
This 1UC addresses the heartbeat of the ecoEMS tool, which consists of the algorithms for the forecasts and the optimization algorithm of optimal unit commitment and dispatch. Concerning the RES and load forecasting modules, firstly the forecasting algorithms have to be fed with data in order for the training to be completed. Training phase includes the combination of different forecasting models. After the training phase, the models are automatically executed every hour, providing 48hours ahead hourly forecasts. The dispatching optimization consists of two pillars; primarily the hourly output for day ahead the unit commitment, and secondarily the 15minute redispatch correcting the orders based on unit commitment, based on RES, load fluctuations and updated forecasts, or other reasons, e.g.

contingencies. It is a multi objective algorithm, providing a single optimal solution, where RES penetration levels and social welfare are maximized, under the secure operation of the electrical system.	
MG_2UC2.1	**Mid-term and short-term RES and load forecasting**
Estimation of future behaviour of the demand is of paramount importance for the optimal scheduling and unit commitment. This 2UC concerns the ecoEMS functionality of load and RES forecasts. The forecasts will be used in terms of two different horizons: a 24/48h ahead horizon and a 4h ahead horizon. Short and mid term unit commitment and economic dispatch of the assets shall be defined under minimized uncertainty.	
MG_2UC2.2	**Forecasting model training**
Forecast algorithms are produced from a combination of three different forecasting training models; using self-organizing maps (Kohonen maps) and Radial Basis Function neural networks, optimized through a genetic algorithm hyper-parameter tuning, Machine learning Forecasting model and a Recursive Least Squares Forecasting model. The estimated load/RES production curve is a series of discrete points of consecutive predicting values, along with the intervals of XX% of confidence.	
MG_2UC2.3	**Unit Commitment and Economic Dispatch algorithms**
This 2UC addresses resources management, e.g., dispatchable loads, storage Units, RES Units, thermal generators, are being committed to primarily satisfy the energy balance constraint, based on the load forecast, aiming to achieve various goals such us the cost minimization, increased RES utilization, etc. To this end, the ecoEMS module should be able to run simulations under hyper-parameter definition, after communicating with other services, such as RES and Load forecast services, and then execute the optimization algorithm to calculate the optimal unit commitment. Those dispatch orders are sent to the various system assets. Economic Dispatch algorithm, is following the Unit Commitment, executed time-closer to the dispatch hour, with larger time granularity, quarter hour time step, producing redispatch orders.	
MG_2UC2.4	**Multi-energy vector management of operation**
Power System management of operation should utilize the flexibility of multi energy vectors aiming at most economical operation. This 2UC aims to operate the Power System economically by scheduling different energy vectors while satisfying the wide range of operational, security and availability constraints. The flexibility of different energy vectors like cold storage, boilers for hot water, water pumping, water treatment, electric four-wheelers and electric boats etc. will be tapped and scheduled for the most efficient and economic operation.	

5.2.2 ecoMicrogrid

MG_1UC1: Microgrid monitoring

This 1UC addresses the observability of the microgrid, meaning the active monitoring of its assets. It consists of three main components. The first component is responsible for the real-time acquisition of measurements (Voltage [U], Active Power [P], Reactive Power [Q]....) while the second deals with data management, such as aggregation, storage and visualization. The third component utilizes the data from the other components to perform estimation of RES production and load, both electrical and thermal where it is available/possible. A fourth component detects power outages in the microgrid and identifies the location.	
MG_2UC1.1	**Real time microgrid monitoring and data acquisition**
A variety of metering devices and sensors are necessary for the sufficient data acquisition concerning microgrid's operation. Those captured data and measurements it's highly important to reliably, securely, and effectively be transmitted to an access point (Data Concentrator), via which the data are further elaborated by the microgrid management system. Communication protocols are an important issue due to the necessity to integrate different vendors. The objective of this SUC is to ensure the effective development and implementation of the on-line data transferring and near real-time monitoring system for the microgrid performance assessment and observation.	
MG_2UC1.2	**RES production estimation**
Estimation of future behaviour of production is important for the optimal operation of a microgrid. This 2UC concerns the ecoMicrogrid functionality of RES forecast based on meteorological, historical, and real time data. By knowing the RES production for the entire day, the optimization module can account with greater certainty for the required number of units starts and stops as well as for keeping generation units near the most efficient operating point. Storage units, allow the optimization module to calculate the most cost-beneficial periods to charge and discharge.	
MG_2UC1.3	**Data concentration, storage and management**
The implementation of advanced microgrid features, like the extensive use of sensors, protection equipment and metering devices, imply the need of an infrastructure capable of dealing with high velocity and important storage capacity to allow for efficient data management. Ultimately, the data can be used for forecasting, advanced protection functions and optimal management of the assets as well as of keeping track of downtime and power failures. The objective of this SUC is to ensure the increased storage capacity and the efficient management of data volume in the microgrid. Cyber-security of data collection will be also considered.	

MG_1UC2: Microgrid optimal management of operation
This 1UC addresses the controllability and management of microgrid assets. It consists of 3? main functionality The first is responsible for the optimal management of microgrid components using real-time measurements and estimation of future demand and RES production. The second module is performed in a faster time scale and ensures that the microgrid as can respond in active/reactive power setpoints, requested by the DSO, or/and guarantee that ancillary service provision meet existing grid

codes requirements at its point of common coupling. The third component ensures that the power restoration in the microgrid is performed in an optimized manner.	
MG_2UC2.1	**Effective communication with controllable assets**
The objective of this SUC is to ensure the effective communication and conveyance of commands to different controllable assets of a microgrid. The communication scheme, designed according to recommended/used protocols and standards for such applications (Modbus, DNP3, IEC 61850 series of standards), achieves interoperability between vendor-agnostic devices and enables secure and effective dispatch of commands to controllable assets.	
MG_2UC2.2	**Multi objective microgrid management - Optimization of Energy Production, Storage and Purchase**
Microgrid operation should exploit its assets in a way that financial and environmental objectives are met. This 2UC aims to evaluate, in real-time, the microgrid management functionality. Real-time measurements and estimation of future RES production/demand will be considered by a sophisticated algorithm to compute optimal commands for controllable loads, storage Units, RES Units and thermal generators. The functionality will be compared with existing microgrid operation policies to clarify its benefits in term of cost and RES exploitation.	
MG_2UC2.3	**Multi-energy vector microgrid management of operation**
Microgrid management of operation should utilize the flexibility of multi energy vectors aiming at most economical operation. This 2UC aims to operate the microgrid economically by scheduling different energy vectors while satisfying the wide range of operational, security and availability constraints. The flexibility of different energy vectors like cold storage, boilers for hot water, water pumping, water treatment, electric four-wheelers and electric boats etc. will be tapped and scheduled for the most efficient and economic operation.	

5.2.3 ecoPlanning

PN_1UC1: 7-Year Energy Planning	
This 1UC addresses the 7-Year Energy Planning for assessing the deployment plan of new conventional production units, the evolution of a series of indexes such as thermal and RES production, demand, annual RES penetration, maximum instantaneous penetration of Non-Dispatchable RES Units, WPs capacity factor, fossil fuel consumption, hours of not served load, thermal underload hours etc. Depending on a series of parameters that the user must take into consideration, like the mid to long-term evolution of the demand curve, the normalized RES available generation timeseries, the need of reserves. This UC supports DSO to the decision making for system growth or new capacity installations through the critical output.	
PN_2UC1.1	**Data collection and storage**
A list of conventional units and RES stations must be fulfilled, along with the respecting datasheets; categories of the generation technologies are conventional unit based on type,	

dispatchable (Hybrid stations, Biomass/Biogas, CSPs) and non dispatchable (WFs, PVs) RES stations. All data, must be collected and stored efficiently in a MSSQL database, so that can be retrieved by all scenarios/models that will be built for the appropriate simulations.	
PN_2UC1.2	**Electrical models & demand peak models design, RES & Load estimation**
In this 2UC, firstly a forecast/estimation must be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC1.2, and any new designed generation units and general system parameters, an Electrical System model is designed. Afterwards, with a selected load curve, and past system data concerning the peak and demand, an estimation is made through a series of statistical processes for the peak and demand of the next 7 years, and the selected load curve is appropriately adjusted, and saved as a Demand/Peak model. Both models are stored in a .json format in the database.	
PN_2UC1.3	**Optimization algorithm for mid to long term horizon (1 to 7 years), for hourly Unit Commitment, maximizing RES penetration and securing normal operation**
In this UC a simulation is performed for the Energy Planning study, combining the stored static data and the designed models, also stored in a json format in the database. Each year of the simulation has a separate file per category, and a unique column in the aggregated results.	

PN_1UC2 -RES Hosting Capacity	
This 1UC addresses the assessment of the hosting capacity of Renewable Energy Sources in the electric system, to define the RES Capacity thresholds and limits of each generation technology, that can be adapted to the system, in a cost-effective way. This UC will simulate a list of predetermined scenarios for examining various installed capacity of each RES production technology, providing indexes about the technical and economical sustainability.	
PN_2UC2.1	**Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds**
In this 2UC, firstly a forecast/estimation must be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC2.1, and any new designed generation units and general system parameters, an Electrical System model is designed. Afterwards, with a selected load curve, and past system data concerning the peak and demand, an estimation is made through a series of statistical processes for the peak and demand of the next 7 years, and the selected load curve is appropriately adjusted, and saved as a Demand/Peak model. Both models are stored in a .json format in the database.	
PN_2UC2.2	**Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment.**
In this UC series of annual simulations are performed for the RES Hosting Capacity study, combining the stored static data and the designed models, also stored in a json format in the database. Through the output post process, Operator will be able to locate the overall optimal RES energy mix, concerning both technical and economic aspects of each project.	

PN_1UC3: Interconnections	
This 1UC addresses the Interconnection Assessment by performing steady state (DC power flow) simulations of the electric system to evaluate the interconnection advantages. The UC reports the operation of the production units and several results pertaining to the energy production in terms of quantity, fuel consumption and cost, CO2 emissions, etc. The optimization can be executed for maximum 7 years, defining which year the interconnections take place, and calculating the energy flows in and out hourly	
PN_2UC3.1	**Electrical models, demand peak models & interconnections design, RES & Load estimation**
In this 2UC, firstly a forecast/estimation must be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC3.1, and any new designed generation units and general system parameters, an Electrical System model is designed. Afterwards, with a selected load curve, and past system data concerning the peak and demand, an estimation is made through a series of statistical processes for the peak and demand of the next 7 years, and the selected load curve is appropriately adjusted, and saved as a Demand/Peak model. Both models are stored in a .json format in the database. In addition, the interconnection(s) characteristics must be given by the Operator, as well as choose the desirable Electrical Systems to interconnect, either between them, or with the mainland system.	
PN_2UC3.2	**Hourly Unit Commitment, through optimization algorithm for mid to long term horizon**
In this UC a simulation is performed for the Optimization study, combining the stored static data and the designed models, also stored in a json format in the database. Each year of the simulation has a separate file per category and per interconnection. Unit Commitment algorithm considers the interconnection deployment, to enable the maximization of the overall (interconnected power systems) social welfare.	

PN_1UC4: Multi-energy vectors	
PN_2UC4.1	**Energy carriers identification, data collection and quantification of impact on total load (hourly)**
A list of all energy carriers has to be fulfilled, with the primary energy input, the final energy outcome, and the best suitable conversion to energy demand (MWh) measurement units; energy carriers that have to be necessarily listed are conventional units, RES stations, demand side management, electric vehicles charging profiles, cooling, water pumping, and any other process depending on the needs of each island, e.g., desalination. The list needs to include all features reported at the respecting datasheets. All data, must be collected and stored efficiently in a MSSQL database, so that can be retrieved by all scenarios/models that will be built for the appropriate simulations.	

PN_2UC4.2	Electrical models & demand peak design, RES & Load estimation, energy carriers scenarios integration
In this 2UC, firstly a forecast/estimation must be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC4.1, and any new designed generation units and general system parameters, an Electrical System model is designed. The impact of energy carriers (DSM, cooling, etc) is being quantified in MWh and incorporated in the electrical system load. Afterwards, with the adjusted load curve, past system data concerning the peak and demand, an estimation can be made through a series of statistical processes for the peak and demand of the next 7 years, and saved as a Demand/Peak model, or with the direct use of the adjusted system load timeseries. Both models are stored in a .json format in the database.	
PN_2UC4.3	Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers
In this UC simulations can be performed for all the studies of the previous UCs, combining the stored static data and the designed models and the adjusted load curves that information of the energy vectors.	

5.2.4 ecoDR

DR_1UC1: Increased energy monitoring at demand side	
This 1UC forms the base for visibility of consumed electrical energy by the users/community. This UC will include interface of ecoDR tool to ecoPlatform to receive Real time pricing/dynamic pricing data. Using this Real time pricing/dynamic pricing data and measured value for electrical energy consumed, ecoDR will compute cost of consumed electrical energy. The computed cost of consumed electrical energy along with measured values of consumed electrical energy will be transmitted to ecoPlatform for its storage in database and subsequent use by ecoCommunity tool. Also, the total consumed electrical energy value from the first use of energy monitoring unit will be stored in local non-volatile memory.	
DR_2UC1.1	Real time monitoring of energy consumption
Real-time usage data allows to optimize distribution and empowers consumers to make smarter usage decisions. ecoDR will provide access to real-time data to boost new service and functionalities, providing energy consumption data and other electrical parameters like active power, power factor etc. This 2UC deals with the effective development and implementation of the near real-time data acquisition process.	
DR_2UC1.2	Dynamic pricing-based energy cost computation
Better alignment of the cost of electricity supply with demand, using dynamic pricing tariffs, can potentially yield multiple benefits. Real Time Pricing allows end users to make better choices - benefitting both energy provider and end users. This UC describes the process of real time pricing of energy cost based on received dynamic pricing data.	

DR_1UC2: Integration Interfaces for Load Management	
This 1UC deals with the development of advanced energy meter infrastructure with programmable load limiter to regulate the output load connected via meter to maximum permissible load to be powered through meter output. It also deals with management of critical and non-critical load based on scheduling information received via eco platform tool.	
DR_2UC2.1	**Scheduling of loads**
This UC deals with the scheduling of non-critical and flexible loads. The proposed scheme attempts to coordinate the available flexibility to increase the operational effectiveness of the network. The ecoDR receives the information regarding the load schedule and is responsible to implement it. This UC will also deal with the design of supporting hardware and software to implement the scheduler shared by ecoCommunty tool. This UC will also ensure manual override.	
DR_2UC2.2	**Programmable Load shedding controller**
This UC deals with control to regulate the output load connected via meter to max permissible load to be powered through meter output. It does this by comparing the sampled value of power consumed by load via output terminal of meter with the received value of max permissible load. if measured value of the load is greater then max permissible load then the meter will disconnect the output electrical power for fixed duration of time. After the fixed duration of time is over, meter will resume the output electrical power and again compare the output power and max permissible power and repeat the same actions as detailed before. On receiving the command for new value for max permissible load meter will store the new value in its non-volatile memory and compare the measured value of output power and max permissible load and take actions based on result as already detailed.	

5.2.5 ecoPlatform

PT_1UC1: Microgrid data acquisition	
This use case addresses the data acquisition in the microgrid. This use case consists of two main components. 1. Communication should be in place to connect sensors and acquire data that are used by the other tools. 2. Data cleansing	
PT_2UC1.1	**Data acquisition and monitoring**
This use case concerns ecoPlatforms' functionality of acquiring data from various developed solutions. Communication interoperability from the data derived from ecoMicrogrid, intelligent electronic devices, and smart meters will be ensured based on the conclusions of Task 5.1. In addition, sensed weather data, including the solar irradiance, could also be integrated using MQTT over LoRaWAN.	
PT_2UC1.2	**Data cleansing to ensure consistency and visualization**
As an interface platform that interacts and collects data from various components, a data filtration functionality is necessary for ecoPlatform. The data filtration function will filter out the outliers and fill in missing data due to uncertainties in the sensors or communication	

channels and prevent penetration of corrupted data into the applications enhancing the reliability and efficiency of the system. A human-machine interface that facilitates the operators to choose the functions to run will also be implemented

PT_1UC2: Platform as a service for dependent tools integration	
One of the major functionalities of the ecoPlatform is to serve as a Platform as a Service (PaaS) that can integrate all the solutions in one software structure. In this way, it can assist the operation of the other tools for data exchange and cooperation.	
PT_2UC2.1	**Facilitate data exchange between dependent tools**
ecoPlatform will serve as a platform for data transfer between the dependent tools. The provision of data transfer in near-real-time with low latency and slower archived data will be available. The transfer access will be authenticated and authorized by the ecoPlatform	
PT_2UC2.2	**Facilitate access to controllable assets for dependent tools**
There are several controllable assets in the planned demos. The Eco platform can serve as an intermediary for software-based tools to convey commands to controllable assets, either directly integrated into the ecoPlatform or indirectly via other tools developed in the project. In the response, the ecoPlatform also notifies the status of the controllable assets back to the entity sending the commands.	

PT_1UC3: Data storage and cloud server	
ecoPlatform will also serve as a data storage hub for dependent tools. ecoPlatform will facilitate short-term storage for data and command stream requiring low latency. Also, it is possible to archive the data to be used by other tools or for research. Both Data from the cloud server should be able to be queried by other tools.	
PT_2UC3.1	**Data cloud storage**
The data stream, microgrid states, and commands necessary for real-time processing need to be routed to storage optimized for fast access. Such storage can also be accessed for disaster recovery. However, longer-term data that are not time-critical will be routed to cost-effective storage, which is comparatively slow to access.	
PT_2UC3.2	**Facilitate archived data access for dependent tools using API**
API's will be provided for accessing the data archived by ecoPlatform. Archived long term data could be utilized in improving the effectiveness of forecasting	

5.2.6 ecoMonitor

MN_1UC1: Drinking water quality surveillance
Monitoring drinking water is critical for securing health gains for the rural communities which have less access both to safe water and to water quality information. Monitoring water safety

includes two main components: The first component is responsible for the acquisition of Water quality parameters based on the desired water parameters of concern (temperature, dissolved oxygen, pH, conductivity, ORP, etc.). The second aspect involves processing and evaluation of the collected data. Monitoring data must be available for both decision makers and end users. This 1UC describes the community level solar powered monitor and analysis tool for water quality surveillance.	
MN_2UC1.1	**Acquisition and monitoring of water quality**
This 2UC deals with the collection of water samples from the field at regular interval.	
MN_2UC1.2	**Data processing and evaluation**
This UC deals with the analysis of water quality parameters in laboratory environment.	

5.2.7 ecoCommunity

CM_1UC1: Dynamic pricing of electricity	
This 1UC1 addresses the dynamic pricing of electricity. Varying price signals with colour coding and time slots will be displayed to the consumers in this platform. This increases the flexibility potential of consumers. Dynamic pricing structure incentivises the consumers to modify their behaviour and time-shift their energy usage. This will provoke high consumer engagement. This platform also displays the billing information to consumers and allows them to pay the bills online. Security and privacy of the sensitive consumers data will be ensured. The data models of dynamic pricing will be based on the international standard IEC-62746-10-1.	
CM_2UC1.1	**Displaying the dynamic pricing based on shape of energy profile**
The 2UC1.1 is about displaying the dynamic pricing of electricity based on shape of energy profile. The information about the shape of energy profile will be obtained from the DSM mechanism implemented in Task 3.2. Varying price signals with colour coding and time slots will be displayed to the consumers through this platform. This increases the flexibility potential of consumers.	
CM_2UC1.2	**Billing and payments**
This 2UC1.2 addresses the billing and payments. The electricity consumption based on the dynamic pricing will be calculated and the billing information will be displayed to the consumers. A secured payment gateway will be present which allows the customers to pay the bills seamlessly.	
CM_2UC1.3	**Data security and privacy**
This 1UC1 addresses the data security and privacy. This is important because the personal and sensitive information of the customers is involved. In this platform both security and privacy of the consumers data will be ensured. The data models of dynamic pricing will be built according to the international standard IEC-62746-10-1.	

CM_1UC2: Scheduling and Coordination	
This 1UC2 addresses the scheduling and coordination of loads. Here, the information about availability time slots for different non-critical loads will be displayed. This increases the consumers' flexibility in scheduling the loads. This tool will facilitate(display) scheduling and coordination of communal energy usage information among its members, such as irrigation pumping, to address challenges in sharing communal resources. Coordination helps in optimal operation and reduced variable operating costs for the energy system.	
CM_2UC2.1	**Facilitating(display) of the scheduling and shifting of non-critical and flexible loads**
This 2UC2.1 addresses the scheduling of loads. There will be different types of loads in the system like critical, non-critical and flexible loads. The information about availability time slots for different non-critical and flexible loads will be displayed. This increases the consumers' flexibility in scheduling the loads.	
CM_2UC2.2	**Coordination of communal/shared loads**
This 2UC2.2 addresses the coordination of communal loads. The communal loads like irrigation pumps will be shared among the communal members - a booking fixed time slot-based matrix tool will be developed to realize this functionality. This tool will facilitate(display) coordination of communal energy usage information among the members. This address challenges in sharing communal resources. Coordination helps in optimal operation and reduced variable operating costs for the energy system.	

CM_1UC3: Outreach forum	
The 1UC3 is related to building a forum where users can share experience, which will increase the communal engagement. Also, consumers can report issues, register suggestions for improvements and interact with each other with respect to the energy system as a community. Consumers will have the provision to report the problems like repair works and to call for immediate response. This use case helps in modifying the tools according to customer needs and further development of the tools.	
CM_2UC3.1	**Feedback and suggestions from users about the tools**
The 2UC3.1 is about collecting feedback and suggestions from the customers about the tool. Here the customers can provide feedback, register suggestions for improvements.	
CM_2UC3.2	**Reporting of problems**
The 2UC3.2 is related with development of an interface to report problems. Here, consumers can report issues about the tool, also they will have the provision to report the problems like repair works and to call for immediate response.	
CM_2UC3.3	**Forum to share experiences**
The 2UC3.3 is related to building a forum where users can share experience about the energy system, which will increase the communal engagement.	

CM_1UC4: Guidance and Training	
The 1UC4 is related to guidance and training platform development. This platform will have guidance and training material on how to use various equipment. The service manuals will help the local technicians to learn about different equipment easily. Different multimedia material and step-by-step guides will be provided to help the consumers in using the tool easily.	
CM_2UC4.1	**Training material (troubleshooting)**
The 2UC4.1 is related to storing of training material. This platform will have training material on how to use various equipment. Various service manuals will be made available so as to help the local technicians to learn about different equipment easily.	
CM_2UC4.2	**Easy-to-use multimedia material and step-by-step guides (walkthroughs)**
The 2UC4.2 is related to storing of multimedia material and step-by-step guides. In this platform, different multimedia material and step-by-step guides will be provided to help the consumers in using the relevant tools, viz ecoCommunity, easily.	

5.2.8 ecoResilience

RS_1UC1:Optimal passive resilient support structure for solar photovoltaic system	
This 1UC1 addresses the optimal design procedure for the development of self-adaptive passive solar photovoltaic systems to minimize the wind loads during severe cyclonic conditions. A mechanism will be developed to bring the incident angle of the solar panels to near zero to minimize the drag and lift forces. This subsequently reduces the overall load on the support structures and foundation.	
RS_2UC1.1	**Optimal selection of parameters**
This 2UC1.1 addresses the preliminary design of wind adaptive support structure for solar photovoltaic system based on the selected wind velocity and optimization of the geometrical parameters based on the available aerodynamic data.	
RS _2UC1.2	**Computational fluid dynamics (CFD) and structural analysis (CSA) of support structures**
This 1UC1.2 addresses the optimization of the adaptive support structure through CFD and CSA performed using ANSYS Fluent. These simulations help in finalizing the size of addon structures based on the loads, moments, deformation and stress distribution.	
RS _2UC1.3	**Experimental validation of the designed structure through wind tunnel testing**
This 1UC1.3 addresses the scaledown model testing of the designed resilient support structure in the wind tunnel. A scale down model of the optimized support structure will be prepared initially based on the blockage ratio of wind tunnel. Next, the functionality of the resilient	

structure at both on and off-design wind velocities are examined through force and moments measurement through 6 component F/T transducer.	
RS _2UC1.4	**Design of resilient foundation for solar photovoltaic system**
This 2UC3.1 addresses the design of foundation for solar photovoltaic system support structure. First, soil load bearing capacity data is collected from the government officials. Next, the total loads acting on the support structure is examined. The depth and width of the foundation is determined from the above loads and moments. Finally, the designed foundation strength is determined through rope test at the simulated soil environment before implementing at the actual demo site.	

RS_1UC2: Improved resilient tower and passive mechanism for wind turbine blades	
This 1UC2 addresses the detailed survey of methods used to reduce wind loads on tower truss and wind turbine blades during cyclones and the design of tower truss and a mechanism to reduce loads on wind turbine blades at adverse environmental conditions. CFD simulation of flow past the wind turbine blades will be performed at different angle of attacks and free stream velocities. Stress distribution on the tower truss and the wind turbine blades will be examined through CSA from hydrostatic pressure obtained from simulations to optimize the support structures.	
RS _2UC2.1	**Preliminary design of a tower truss structure and its optimization**
This 2UC2.1 addresses the design of the tower truss to support the wind turbine. First, existing methods used in tower design will be reviewed and it will be followed by theoretical design of the tower based on wind turbine total weight (dead load) and loads acting on the wind turbine (live load). The size and different parameters of the tower is optimized through CSA tool in ANSYS commercial software	
RS _2UC2.2	**Design of a resilient mechanism to reduce wind loads on blades and its optimization**
This 2UC2.2 addresses the design of a mechanism to reduce loads on wind turbine blades during severe cyclone. The wind loads acting on the blades will be calculated for different wind velocities and angle of attacks using numerical simulations (CFD). These loads and moments are transferred to blades and static structural analysis is performed using ANSYS software.	
RS _2UC2.3	**Laboratory and field testing of the mechanism**
This 2U2.3 addresses the laboratory testing of the function of the mechanism. First, the working of the mechanism will be tested after fabrication. Next, the designed mechanism will be integrated with the wind turbine system with model tower. Functionality of the mechanism will be tested in the laboratory for multiple operations.	
RS _2UC2.4	**Resilient foundation for wind turbine tower structure**
This 2UC3.1 addresses the design of foundation for the tower truss and wind turbine system. As mentioned in the earlier use case, the soil load bearing capacity data of the installation site is collected from the government officials. Next, the total loads (structural and wind) and	

moments acting on the support structure is examined. The depth and width of the foundation is determined from the above loads and moments. Finally, the designed foundation strength is determined through rope test at the simulated soil environment before implementing at the actual demo site.

RS_1UC3: WT Local Manufacturing and Testing	
This 1UC addresses the local manufacturing of residential small wind turbines (SWT). Local manufacturing will allow increased resilience of the wind energy conversion systems, by using the available material and human resources of the region, as part of a sustainable process that strengthens local economies, creates income sources, and facilitates knowledge sharing, while also increasing the resilience of the system. Additionally, already existing designs for locally manufactured small wind turbines will be upscaled for higher rated power and validated using the IEC 61400-12-1 standard as a guide, in the small wind experimental facilities of ICCS-NTUA and will be demonstrated in the Kythnos and Ghoramara demo sites.	
RS _2UC3.1	**Testing of Small Wind Turbines using Standards**
This 2UC addresses the testing of locally manufactured small wind turbines, that have been upscaled for higher rated power, with the use of the IEC 61400-12-1 standard as a guide, in the facilities of ICCS-NTUA.	

5.2.9 ecoVehicle

VH_1UC1: Tailor-made Electric Vehicle (EV) charging facility	
This 1UC refers to the development and deployment of EV charging facilities in the Ghoramara Island and Keonjhar, designed for improved performance, tailored for each of the demo sites. The first component of this UC is to address issues, such as DC-link voltage regulation, through effective control strategies. The second component deals with the estimation of SOC and other performance parameters of the batteries, to select the appropriate charging patterns. The third component addresses temperature regulation to ensure improved battery life, which is affected by the charging at higher rate.	
VH_2UC1.1	**Effective control strategies for dc-bus voltage regulation**
The charger and the charging station to be deployed, must support charging at faster rate. This type of operation affects the bus voltage and indirectly the grid. Therefore, it is important to address the bus voltage regulation. Sudden connection and the disconnection of the load which is a constant current type because of CC charging, results in the large fluctuation at the dc-bus. Particularly for the case of temperature regulated charging, current profile is pulse in nature and results in more severe bus voltage fluctuation. Different control strategies are to be implemented.	
VH_2UC1.2	**State of charge and temperature estimation**
The state of charge (SOC) of the battery plays an important role in the selection of the charging profile. Therefore, a charger must perform SOC estimation. This is to be carried out through	

the most basic approach of coulomb counting. Charging at faster rate results in the increase of battery temperature which requires to be regulated, to improve the battery life. For this purpose, electrothermal model of the battery pack is to be used as a temperature estimator. Both SOC and the temperature estimation requires information of charging/discharging current information.

VH_2UC1.3	**Temperature regulated charging strategies**
Operating temperature of the battery during the charging/discharging is always a concern with respect to the life of the battery and is the limiting factor on the charging rate of the battery. Temperature regulation during the charging process can be achieved through the temperature estimator and according switching between conventional cc/cv or pulse charging profile.	

VH_1UC2: Selection and customization of rickshaw	
This UC deals with the custom design and deployment of electric three wheelers, for commutation and transportation of goods and passengers. Customization and sizing of power train components will be performed to meet different gradability and loading conditions. Customization of vehicles with foldable seating arrangement will be carried out, to accommodate passengers with full capacity or with partial loads.	
VH_2UC2.1	**Sizing and Selection of the power train components**
This secondary UC deals with the proper selection and sizing of the power train components to meet different gradability and loading conditions at demo sites.	
VH_2UC2.2	**Customization of the vehicle to the demo site requirements**
This US deals with customization in electric three wheelers with foldable seating arrangement such as to accommodate only passengers with full capacity or passengers with partial loads.	

VH_1UC3: Onboard energy management for e-Boat	
This UC considers design, development and deployment of solar powered battery operated electric boat at Ghoramara demo site. Considering harsh environmental conditions and high stream conditions in the river Ganges, the motor and power train will be customized accordingly. The overall design and construction of the boat will be such as to optimal use and management of renewable energy through harnessing maximum solar energy from onboard roof mounted solar panel and improvement propulsive efficiency.	
VH_2UC3.1	**PV Integration with e-Boat**
This UC deals with the integration of solar energy with the propulsion system of battery-operated electric boat. Special focus will be given to maintain stability of the system while integrating roof top PV system.	
VH_2UC3.2	**Optimal Energy management algorithms**

Under this UC an optimal energy management to efficiently use the various energy mix such as PV and battery will be developed. Integration of this energy vector requires a robust control of power electronic converter to control the power injection due to the dynamic behaviour of the system. Algorithms to deal with nonlinear systems will be developed.

5.3 Use Cases and Demo sites mapping

In this section, the Use Cases to be demonstrated in each of the four pilot sites are documented. Based on the available information for each demo site, their needs and potential issues, the RE-EMPOWERED partners identified potential applicability of each the use cases in each demo. This is strongly related with the information and data that will be available in the end for each demo, thus, minor modifications may be done in the demonstration phase.

I. ecoEMS

ID	UC name	Demo sites			
		Bornholm	Kythnos	Ghoramara	Keonjhar
EMS_1UC1	**Real time monitoring and system data visualization**	▲	▲		
EMS_2UC1.1	Real time system monitoring and data acquisition and visualization	▲	▲		
EMS_2UC1.2	Module manager: intercommunications and data exchange	▲	▲		
EMS_1UC2	**Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization**	▲	▲		
EMS_2UC2.1	Mid-term and short-term RES and load forecasting	▲	▲		
EMS_2UC2.2	Forecasting model training	▲	▲		
EMS_2UC2.3	Unit Commitment and Economic Dispatch algorithms	▲	▲		
EMS_2UC2.4	Multi-energy vector management of operation	▲	▲		

II. ecoMicrogrid

ID	UC name	Demo sites			
		Bornholm	Kythnos	Ghoramara	Keonjhar
MG_1UC1	**Microgrid monitoring**		▲	▲	▲
MG_2UC1.1	Real time microgrid monitoring and data acquisition		▲	▲	▲
MG_2UC1.2	RES production estimation		▲		
MG_2UC1.3	Data concentration, storage, and management		▲	▲	▲
MG_2UC1.4	Outage detection and location identification			▲	▲

MG_1UC2	**Microgrid optimal management of operation**		▲	▲	▲
MG_2UC2.1	Effective communication with controllable assets		▲	▲	▲
MG_2UC2.2	Multi objective microgrid management - Optimization of Energy Production, Storage and Purchase			▲	▲
MG_2UC2.3	Multi-energy vector microgrid management of operation		▲	▲	▲

III. ecoPlanning

ID	UC name	Demo sites			
		Bornholm	Kythnos	Ghoramara	Keonjhar
PN_1UC1	**7-Year Energy Planning**		▲		▲
PN_2UC1.1	Data collection and storage		▲		▲
PN_2UC1.2	Electrical models & demand peak models design, RES & Load estimation		▲		▲
PN_2UC1.3	Optimization algorithm for mid to long term horizon (1 to 7 years), for hourly Unit Commitment, maximizing RES penetration and securing normal operation		▲		▲
PN_1UC2	**RES Hosting Capacity**		▲		▲
PN_2UC2.1	Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds		▲		▲
PN_2UC2.2	Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment.		▲		▲
PN_1UC3	**Interconnections**		▲		▲
PN_2UC3.1	Electrical models, demand peak models & interconnections design, RES & Load estimation		▲		▲
PN_2UC3.2	Hourly Unit Commitment, through optimization algorithm for mid to long term horizon		▲		▲
PN_1UC4	**Multienergy vectors**		▲		▲
PN_2UC4.1	Energy carriers identification, data collection and quantification of impact on total load (hourly)		▲		▲
PN_2UC4.2	Electrical models & demand peak design, RES & Load estimation, energy carriers scenarios integration		▲		▲
PN_2UC4.3	Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers		▲		▲

IV. ecoDR

ID	UC name	Demo sites			
		Bornholm	Kythnos	Ghoramara	Keonjhar
DR_1UC1	**Increased energy monitoring at demand side**	▲	▲	▲	▲
DR_2UC1.1	Real time monitoring of energy consumption	▲	▲	▲	▲
DR_2UC1.2	Dynamic pricing-based energy cost computation			▲	▲
DR_1UC2	**Integration Interfaces for Load Management**			▲	▲
DR_2UC2.1	Scheduling of loads			▲	▲
DR_2UC2.2	Programmable Load shedding controller			▲	▲

V. ecoPlatform

ID	UC name	Demo sites			
		Bornholm	Kythnos	Ghoramara	Keonjhar
PT_1UC1	**Microgrid data acquisition**	▲			
PT_2UC1.1	Connect to sensors and acquire data through designated communication network and protocols	▲			
PT_2UC1.2	Data cleansing to ensure consistency and human machine interface	▲			
PT_1UC2	**Platform as a service for dependent tools integration**	▲	▲	▲	▲
PT_2UC2.1	Facilitate data exchange between dependent tools	▲	▲	▲	▲
PT_2UC2.2	Facilitate access to controllable assets for dependent tools	▲			
PT_1UC3	**Data storage and cloud server**	▲	▲	▲	▲
PT_1UC3.1	Route the microgrid data and data from dependent tools to cloud database	▲	▲	▲	▲
PT_1UC3.2	Facilitate archived data access for dependent tools using API	▲	▲	▲	▲

VI. ecoMonitor

ID	UC name	Demo sites			
		Bornholm	Kythnos	Ghoramara	Keonjhar
MON_1UC1	**Drinking water quality surveillance**	▲	▲	▲	
MON_2UC1.1	Acquisition and monitoring of water quality	▲	▲	▲	

MON_2UC1.2	Data processing and evaluation	▲	▲		

VII. ecoCommunity

ID	UC name	Demo sites			
		Bornholm	Kythnos	Ghoramara	Keonjhar
CM_1UC1	**Dynamic pricing of electricity**		▲		▲*
CM_2UC1.1	Displaying the dynamic pricing based on shape of energy profile		▲		▲*
CM_2UC1.2	Billing and payments		▲		▲*
CM_2UC1.3	Data security and privacy		▲		
CM_1UC2	**Scheduling and Coordination**		▲		
CM_2UC2.1	Facilitating(display) of the scheduling and shifting of non-critical and flexible loads		▲		
CM_2UC2.2	Coordination of communal/shared loads		▲	▲	▲
CM_1UC3	**Outreach forum**	▲	▲	▲	▲
CM_2UC3.1	Feedback and suggestions from users about the tools	▲	▲	▲	▲
CM_2UC3.2	Reporting of problMG	▲	▲	▲	▲
CM_2UC3.3	Forum to share experiences	▲	▲	▲	▲
CM_1UC4	**Guidance and Training**	▲	▲	▲	▲
CM_2UC4.1	Training material (troubleshooting)	▲	▲	▲	▲
CM_2UC4.2	Easy-to-use multimedia material and step-by-step guides (walkthroughs)	▲	▲	▲	▲

*Depending on the installations

VIII. ecoResillience

ID	UC name	Demo sites			
		Bornholm	Kythnos	Ghoramara	Keonjhar
RS_1UC1	**Passive resilient support structure for solar photovoltaic system and its optimization**			▲	
RS_2UC1.1	Optimal selection of parameters			▲	
RS_2UC1.2	Computational fluid dynamics (CFD) and structural analysis (CSA) of support structures			▲	
RS_2UC1.3	Experimental validation of the designed structure through wind tunnel testing			▲	
RS_2UC1.4	Design of resilient foundation for solar photovoltaic system			▲	
RS_1UC2	**Resilient tower and a passive mechanism for the wind turbine blades**			▲	

RS_2UC2.1	Preliminary design of a tower truss structure and its optimization			▲	
RS_2UC2.2	Design of a resilient mechanism to reduce wind loads on blades and its optimization			▲	
RS_2UC2.3	Laboratory and field testing of the mechanism			▲	
RS_2UC2.4	Resilient foundation for wind turbine tower structure			▲	
RS_1UC3	**WT Local Manufacturing and Testing**		▲	▲	
RS_1UC3.1	Testing of Small Wind Turbines using Standards		▲	▲	

6 Preliminary definition of Key Performance Indicators (KPIs)

6.1 General information

The evaluation of projects related the energy grids, should reflect not only on the technical attributes of the system, but also on economic, environmental, and social benefits that are integrated within the systems. The evolution of traditional power grids, with the integration of ICT technologies and advanced control strategies, leads to the development of Smart Grids.

Due to the rapid development of smart grid technologies and the rise in the number of related projects, the need to assess their comprehensive benefits and identify the opportunities and challenges has emerged. The impact of the development and operation of smart grid technologies has great significance on the affected communities, so when this impact is measured, several aspects should be considered.

The process of scientifically assessing such complex and large systems is a challenging activity, which requires a methodological approach and certain metrics to be defined. On the technical aspect, smart grids are the evolution of traditional grids, which maintain all their features, while new aspects are introduced, such as information, automation, and interoperability, which enhance the traditional power grid's functions. Therefore, it is important to assess both the traditional power functions and the impact that is provided by the introduction of new technologies. Additionally, the introduction of new technologies gives birth to new business models which affect the economic, environmental, and social aspects that should also be considered.

In cases where the development of high-level solutions for smart grid technologies has matured enough, there is also accumulated experience in the evaluation process. This has led to several initiatives presenting methodologies for the accurate assessment of such projects and technologies. Some worth mentioning are the IBM Smart Grid Maturity Model, the DOE Smart Grid Development Evaluation System, the EPRI Smart Grid Construction Assessment Indicators and the EU Smart Grid Assessment Benefits Systems [3]-[7]. Moreover, the Join Research Center (JRC) has published several reports and updates on a framework for assessment, namely the "Assessment framework for projects of common interest in the field of smart grids"[8][9]. Also, the EC published in 2017 the "Guidelines for the Calculation Project Performance Indicators" [10] aiming to support H2020 projects in assessing the impacts of their projects in some key indicators such as Energy savings, renewable energy production, GHG emissions and cumulative investment by European stakeholders in sustainable energy.

A common characteristic of these approaches if the definition of metrics or indicators that can be measured, to quantify the impact in the corresponding area (technical, social, economic, environmental).

6.2 Evaluation plan – methodology

With respect to these initiatives for the assessment of smart grid projects and technologies, the RE-EMPOWERED partners developed a preliminary methodology for measuring the impacts of the project. It was decided that Key Performance Indicators (KPIs) will be utilized to quantify the benefits offered by the tools' functionalities and their application in the demo sites. The KPIs are then linked with the defined UCs, so that it is possible to evaluate the success of each of the UCs, which in turn will lead to the evaluation of the tools. Starting the process, after having defined the UCs for the whole RE-EMPOWERED toolset, a draft pool of KPIs was used, utilizing standard KPIs that are proposed in the initiatives described in the previous section i.e., [11]. An iterative process was initiated, where the responsible partners for each of the tools, indicated which KPIs are relevant and can be used for the evaluation of the corresponding functionalities. When needed, new KPIs were introduced in the list, to cover the whole operational spectrum of the tools.

A preliminary methodology on the assessment of the impact is depicted in Figure 12. Based on the available data, the finalized functionalities of the tools and standardized practices, the KPIs' calculation formulas will be defined within the framework of the project's WP8 "Business models, Impact assessment and Replication". By gathering inputs from the tools within the demos, the indicators will be calculated, and the benchmark values will be defined. Through the calculation and benchmarking the evaluation process will initiate. Due to the nature of the defined KPIs, it will be possible to assess the different aspects of impact, namely technological, social, economic, and environmental. Particularly for certain social and environmental aspects, KPIs are introduced that are qualitative rather that quantitative. These will be assessed in a different manner, based on international approaches on social and environmental impact assessment, in the framework of WP8.

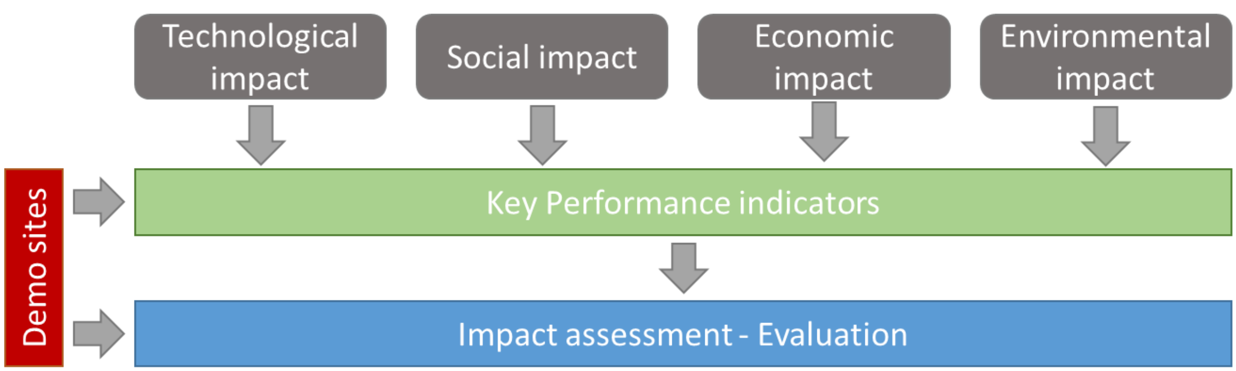

Figure 12 Draft methodology for impact assessment

6.3 KPI description and UC mapping

In previous chapters the high-level objectives and the UCs were defined, which represent the targets and solutions to be accomplished through the development of the proposed toolset, in the framework of the project. In this section, KPIs are defined to provide qualitative and quantitative metrics for the practical assessment of the level at which the various higher-level goals are being achieved. The KPIs are divided into three major categories: Technical, Replication and Organizational. The list of KPIs below is a preliminary list of possible KPIs to be used for the project's assessment.

The final list of KPIs will be formed at a later stage, based on the actual development of the solutions and the available infrastructure and data in the demos, together with the work on defining functional specifications of the tools and solutions, as part of the Task 2.5, and after the related detailed KPIs feasibility analysis. In this framework, the mapping of the primary and secondary UCs will be performed. The KPI analysis will exactly define the methodology for the acquisition of input data together with appropriate methods and formulas for the final calculation of the KPIs. In addition, a general monitoring KPI methodology will be defined, that will enable the assessment of the impact of the deployed RE-EMPOWERED solutions and business models at the demonstration sites, from a technical, economic, organizational and replication point of view.

Table 13 Preliminary list of KPIs and mapping with UCs

ID	KPI Name	Description	Mapping to 1UCs	Mapping to 2UCs
Technical				
1	Islanding	The ability to achieve transition to island mode whilst keeping the power quality requirement. This KPI measures the capacity of islanding to last as long as required. This KPI is calculated as the percentage of the relation between the duration of single islanding and the required duration of islanding after an intentional or unintentional disconnection from the grid.	MG_1UC1,	
2	Voltage variation	This indicator measures the voltage deviation on the network nodes. The nominal voltage of each node will be used as the basis voltage.	MG_1UC2,	VH_2UC3.2
3	Number of voltage dips or swells	This KPI estimates the number of voltage dips or swells based on the measurements of the voltage magnitude that should be within EN50160 limits.		MG_2UC2.2
4	SAIFI	This KPI measures the reduction in System Average Interruption Frequency (SAIF) when smart grid actions are taken in relation to a baseline scenario where not smart action is implemented. This indicator assesses the reliability and power quality	DR_1UC2,	MG_2UC2.2, DR_2UC2.1, DR_2UC2.2,

		improvement in terms of number of interruptions that a customer would experience.		
5	SAIDI	This KPI measures the reduction in System Average Interruption Duration (SAID) when smart grid actions are taken in relation to a baseline scenario where not smart action is implemented. This indicator assesses the reliability and power quality improvement in terms of average outage duration for each customer served.	DR_1UC2,	DR_2UC2.1, DR_2UC2.2,
6	Improvement in system energy efficiency	This KPI estimates the increase of overall system efficiency through the exploitation of co-optimization of different energy vectors and uses.	MG_1UC2,	MG_2UC2.2, MG_2UC2.3,
7	DER hosting capacity	This KPI estimates the potential increase of hosting capacity for DERs when Smart Grid solutions are utilized, compared to the baseline scenario where no “smart” actions are performed on the network. The indicator gives an estimation about the additional DERs penetration in the network thanks to Smart Grid solutions without the need for conventional reinforcements (i.e. new grid lines).	PN_1UC2,	PN_2UC2.2,
8	Peak load reduction	This KPI calculates the demand peak reduction due to the application of “smart” load management techniques, in comparison to the baseline value, for a period/event.	EMS_1UC2, MG_1UC2, PN_1UC1, PN_1UC2, PN_1UC3, CM_1UC1,	CM_2UC1.1,
9	Load peak-to-average	This KPI identifies how extreme the peak consumption is and compares it to the consumption during off-peak hours and provides information about the characteristic curve of the load.	PN_1UC1, PN_1UC2, PN_1UC3, CM_1UC1,	CM_2UC1.1,
10	Absolute peak hour change	This KPI calculates the difference between the peak consumption when "smart" techniques are implemented compared to a baseline scenario, where no action is taken.	PN_1UC1, PN_1UC2, PN_1UC3,	
11	Absolute off-peak hour change	This KPI calculates the difference between the off-peak consumption when "smart" techniques are implemented compared to a baseline scenario, where no action is taken.	PN_1UC1, PN_1UC2, PN_1UC3,	
12	Hours with non-served load or non-observed reserve (h)	This KPI estimates the total annual hours that the forecasted load will not be met (generation is less than load) or the requested reserves will be available.	EMS_1UC2, PN_1UC1, PN_1UC2, PN_1UC3,	
13	Total non-served load and non-observed reserve (MWh)	This KPI estimates the energy quantity annually that the forecasted load will not be met (generation is less than load) or the requested reserves will be available.	EMS_1UC2, PN_1UC1, PN_1UC2, PN_1UC3,	PN_2UC2.2, PN_2UC3.2,
14	Hours with underload of conventional units (h)	This KPI calculates the total annual hours (based on simulations) that the conventional (thermal) units will be at	EMS_1UC2, PN_1UC1,	

		operating level lower than their technical minimum.	PN_1UC2, PN_1UC3,	
15	Total non-served load (MWh)	This KPI estimates the energy quantity annually that the forecasted load will not be met (generation is less than load). In this case, requested reserves unavailability is excluded.	EMS_1UC2, PN_1UC1, PN_1UC2, PN_1UC3,	PN_2UC1.3, PN_2UC4.3,
16	RES curtailment reduction (annual)	This indicator compares the amount of energy from RES that is not injected to the grid due to operational limits, such as voltage violations or congestions, when "smart" techniques are utilized in relation to a baseline scenario where no “smart” techniques are applied.	EMS_1UC2, MG_1UC2, PN_1UC1, PN_1UC2, PN_1UC3,	EMS_2UC2.3, EMS_2UC2.4, MG_2UC2.2, PN_2UC1.3, PN_2UC2.2, PN_2UC3.2, PN_2UC4.3,
17	RES increase in the energy mix (annual)	This KPI calculates the increase of the RES penetration annually when "smart" techniques are implemented (i.e. multi-energy coupling, demand-side flexibility) compared to a baseline scenario, where no action is taken.	PN_1UC1, PN_1UC2, PN_1UC3,	PN_2UC1.3, PN_2UC2.2, PN_2UC3.2, PN_2UC4.3,
18	Reduction in CO2	This indicator measures the difference between the total amount of CO2 emissions calculated respectively for a baseline scenario in which no “smart” action has been applied and the scenario when a control technique is utilized.	EMS_1UC2, MG_1UC2, PN_1UC1, VH_1UC2, VH_1UC3,	EMS_2UC2.3, EMS_2UC2.4, MG_2UC2.2, MG_2UC2.3, VH_2UC2.1, VH_2UC2.2, VH_2UC3.1,
19	Increase of environmental awareness	This KPI estimates the increase of environmental awareness (Climate change, RES technologies) in terms of people engagement or participation in related activities.	RES_1UC1, VH_1UC2, VH_1UC3,	VH_2UC2.1, VH_2UC2.2, VH_2UC3.1,
20	Compliance with GDPR	This KPI estimates the level in which the collected data in the project meets GDPR requirements (2016/679/EC) [5].	MG_1UC1,	
21	Safety	This KPI assesses the impact on the safety of employees, users or local residents.	RES_1UC1, RES_1UC2,	RES_2UC1.1, RES_2UC1.2, RES_2UC1.3, RES_2UC1.4, RES_2UC2.1, RES_2UC2.1, RES_2UC2.2, RES_2UC2.3, RES_2UC2.4, RES_2UC3.1
22	Increased access to own metering data	This KPI estimates the increase in the number of consumers (both households and organizations) that can access their electricity meter data through a single access point.		EMS_2UC1.1, EMS_2UC1.2, MG_2UC1.1, MG_2UC1.3, PN_2UC1.1, PN_2UC1.2, PN_2UC2.1, PN_2UC3.1, PN_2UC4.1,

				PN_2UC4.2, VH_2UC1.1,
23	Automatic metering of consumers	This KPI compares the number of consumers which have their meter information remotely gathered by the DSO, in relation to the data collection in business as usual scenario.	DR_1UC1, CM_1UC1,	DR_2UC2.1, DR_2UC2.2, CM_2UC1.2,
24	MAPE (forecasting accuracy)	This KPI assesses the accuracy of the developed forecasting algorithms based on the calculation of the Normalized Mean Absolute Percentage Error (MAPE) of power generation or load forecasting.	EMS_1UC1, EMS_1UC2, MG_1UC1, CM_1UC2, VH_1UC1,	MG_2UC1.2, EMS_2UC2.1, EMS_2UC2.2, CM_2UC2.1, CM_2UC2.2, VH_2UC1.2,
25	MAE (forecasting accuracy)	This KPI assesses the accuracy of the developed forecasting algorithms based on the calculation of the Normalized Mean Absolute Error (MAE) of power generation or load forecasting.		MG_2UC1.2, EMS_2UC2.1, EMS_2UC2.2,
26	MAD (forecasting accuracy)	This KPI assesses the accuracy of the developed forecasting algorithms based on the calculation of the Median Absolute Deviation (MAD) of power generation or load forecasting.		MG_2UC1.2, EMS_2UC2.1, EMS_2UC2.2,
27	Energy losses	This KPI measures the percentage reduction of technical energy losses when "smart" actions are applied, and compares it to a baseline scenario where no “smart” techniques are applied.		VH_2UC3.2
28	Energy savings	This KPI compares measured consumption data to reference consumption data, for a predefined period of time in order to evaluate the project and the changes in the consumers' behaviour.	DR_1UC1, DR_1UC2, CM_1UC1,	DR_2UC2.2, DR_2UC2.1, DR_2UC2.2, CM_2UC1.2,
29	(Buildings) Final consumption	This KPI calculates the total amount of energy consumed in a building within a predefined time period.	DR_1UC1, CM_1UC1,	DR_2UC2.2, CM_2UC1.2,
30	Self-consumption ratio	This KPI identifies the efficiency of load shifting mechanisms and energy storage, by estimating the electricity produced and consumed locally in relation to the total production from on-site generation units.	CM_1UC2,	CM_2UC2.1, CM_2UC2.2,
31	Availability of the communication infrastructure	This KPI estimates the communication's system reliability in terms of frequency of failures and required time to repair and restore the operation.	EMS_1UC1, MG_1UC1, PF_1UC1, PF_1UC2, PF_1UC3,	EMS_2UC1.1, EMS_2UC1.2, MG_2UC1.1, MG_2UC1.3, MG_2UC2.1, PN_2UC1.1, PN_2UC1.2, PN_2UC2.1, PN_2UC3.1, PN_2UC4.1, PN_2UC4.2, PF_2UC2.1, PF_2UC2.2,

				CM_2UC1.2, VH_2UC1.1,
32	Data reliability	This KPI calculates the percentage of reliable data compared to the total amount of data received in a time period.	PF_1UC1, PF_1UC3, CM_1UC1, CM_1UC2,	EMS_2UC1.1, EMS_2UC1.2, MG_2UC1.1, MG_2UC1.3, MG_2UC2.1, PN_2UC1.1, PN_2UC4.1, PF_2UC1.1, PF_2UC1.2, PF_2UC3.1, PF_2UC3.2, CM_2UC1.1, CM_2UC1.3, CM_2UC2.1, CM_2UC2.2, VH_2UC1.1,
33	Data security control	This KPI estimates whether a security vulnerability analysis has been completed and achieved to identify and resolve the issues, before the system went online.	CM_1UC1,	EMS_2UC1.1, EMS_2UC1.2, MG_2UC1.1, MG_2UC1.3, PN_2UC1.1, PN_2UC4.1, CM_2UC1.3, VH_2UC1.1,
34	Energy data transfer	This KPI estimates the capability of a data exchange platform to transfer different types of data.	PF_1UC2,	PF_2UC2.1,
35	DR scheme impact on load	This KPI compares the load consumption when DR scheme is implemented in relation to a baseline scenario where no DR techniques are used.		DR_2UC1.3, DR_2UC2.2,
36	DR scheme impact on load	This KPI estimates the load consumption change during a predefined period when DR scheme is implemented in relation to the total baseline consumption.		DR_2UC1.3, DR_2UC2.2,
37	WPs capacity factor (%)		PN_1UC1, PN_1UC2, PN_1UC3,	PN_2UC1.3, PN_2UC2.2, PN_2UC3.2, PN_2UC4.3,
38	Wind-resilient infrastructure	This KPI determines the successful operation of the resilient structure at the normal and adverse environmental conditions. Deflection of the photovoltaic panels and wind turbine blades ensure safety during adverse environment and reliable operation at off design condition.	RES_1UC1, RES_1UC2,	RES_2UC1.1, RES_2UC1.2, RES_2UC1.3, RES_2UC1.4, RES_2UC2.1, RES_2UC2.2, RES_2UC2.3, RES_2UC2.4,
39	Ancillary services cost	This KPI calculates the cost when assets provide ancillary services to the network.	PN_1UC1, PN_1UC2, PN_1UC3,	
40	Energy cost	This KPI measures the electricity price per kWh.	PN_1UC1, PN_1UC2, PN_1UC3,	PN_2UC1.3, PN_2UC2.2, PN_2UC4.3,

			DR_1UC1, CM_1UC1,	DR_2UC2.1, DR_2UC2.2, CM_2UC1.2,
41	Reduced overall cost	This KPI provides an indication about the overall cost reduction when "smart" solutions are applied, compared to a baseline scenario where no "smart" actions are taken.	EMS_1UC2, MG_1UC2, PN_1UC1, PN_1UC2, PN_1UC3,	EMS_2UC2.3, EMS_2UC2.4, MG_2UC2.2, MG_2UC2.3, PN_2UC1.3, PN_2UC2.2, PN_2UC3.2, PN_2UC4.3,
42	CAPEX ratio	This KPI estimates the difference between the upfront investment required to purchase, manufacture, install, initial operate the required equipment and activate service operation (excluding ICT) when the developed solutions are employed in relation to other comparable demonstrations.	VH_1UC3,	
43	OPEX ratio	This KPI compares the annual recurrent costs for operation and maintenance of the installed equipment when the developed solutions are employed in relation to other comparable demonstrations.	VH_1UC3,	
44	Increase of demand flexibility	This KPI estimates the increase of demand flexibility.	CM_1UC2,	
45	Digital solutions integrated	This KPI tracks the number of digital solutions integrated in the various pilot sites.	CM_1UC1, CM_1UC2,	
46	Customers engaged with digital solutions	This KPI measures the customers engagement with the various developed tools	CM_1UC1, CM_1UC3,	DR_2UC1.2,
47	"Solutions to be: Plug&play / developed via customer	This KPI tracks the number of solutions to be plug&play, developed via customer feedback, and receive basic maintenance locally.	CM_1UC3,	CM_2UC3.1, CM_2UC3.2, CM_2UC3.3,
48	feedback / receive basic maintenance locally"	This KPI tracks the quality of various environmental indexes, like improved air, RES-desalinated or purified drinking water.	MG_1UC1,	
		Organizational		
49	Employment	This KPI estimates the additional number of jobs and vacancies created because of the project.	CM_1UC3, CM_1UC4,	CM_2UC3.1, CM_2UC3.2, CM_2UC3.3, CM_2UC4.1, CM_2UC4.2,
50	Participant recruitment	KPI about the number of consumers that accept their participation in the different demos compared to the total number of those who initially contacted.	CM_1UC3, CM_1UC4, RES_1UC3,	CM_2UC3.1, CM_2UC3.2, CM_2UC3.3, CM_2UC4.1, CM_2UC4.2,
51	Active participation	KPI about the number of consumers that actively participate in the different demos compared to the total number of those who initially accepted to participate.	CM_1UC3, RES_1UC3,	CM_2UC3.1, CM_2UC3.2, CM_2UC3.3,

52	Customer acceptance	This KPI identifies customers' engagement in grid stabilization.	CM_1UC4,	CM_2UC4.1, CM_2UC4.2,
53	EnC participation/ adoption	This KPI tracks the increase of active participation in EnC in terms of number and diversity of members, establishment of a governance structure, people's participation in general assemblies, number of services provided.	DR_1UC2, MON_1UC1, CM_1UC3, CM_1UC4, RES_1UC3,	DR_2UC2.1, DR_2UC2.2, MON_2UC1.1, MON_2UC1.2, CM_2UC3.1, CM_2UC3.2, CM_2UC3.3, CM_2UC4.1, CM_2UC4.2,
54	User satisfaction contributing to aggregated flexibility	This KPI identifies the satisfaction of small consumers and producers regarding the contribution to the aggregated flexibility.	RES_1UC1, RES_1UC2, RES_1UC3,	RES_2UC1.1, RES_2UC1.2, RES_2UC1.3, RES_2UC1.4, RES_2UC2.1, RES_2UC2.2, RES_2UC2.3, RES_2UC2.4,
55	Skill/Knowledge acquirement	This KPI estimates the knowledge transfer among employees that helps the minimization of the knowledge gain in labor market.	CM_1UC3, CM_1UC4,	CM_2UC3.1, CM_2UC3.2, CM_2UC3.3, CM_2UC4.1, CM_2UC4.2,
56	Energy Poverty	This KPI estimates the reduction of energy-poor households.	CM_1UC3, CM_1UC4, RES_1UC3,	CM_2UC3.1, CM_2UC3.2, CM_2UC3.3, CM_2UC4.1, CM_2UC4.2,
57	New customers connected	This KPI measures the number of new customers of the grid.	CM_1UC3, RES_1UC3,	CM_2UC3.1, CM_2UC3.2, CM_2UC3.3,
		Replication		
58	Use of protocol standards	This KPI estimates the effective use of standards with respect to the declared use.	PF_1UC1,	EMS_2UC1.1, EMS_2UC1.2, MG_2UC1.1, MG_2UC1.3, MG_2UC2.1, PN_2UC1.1, PN_2UC4.1, PF_2UC1.1, RES_2UC3.1, VH_2UC1.1,
59	Use of equipment standards	This KPI estimates the effective use of standards with respect to the declared use.		RES_2UC3.1
60	Interoperability	This KPI tracks the extend in which widespread standard protocols are used to ensure interoperability.		EMS_2UC1.1, EMS_2UC1.2, MG_2UC1.1, MG_2UC1.3, MG_2UC2.1, PN_2UC1.1, PN_2UC1.2, PN_2UC2.1, PN_2UC3.1, PN_2UC4.1,

				PN_2UC4.2, VH_2UC1.1, VH_2UC1.3,
61	EnC replication potential	This KPI estimates the enhancement of EnC replication potential in diverse scenarios, in relation to the activities took place and the developed material for the promotion of this concept, like the number of visits/exchanges and workshops between India and EU partners, etc.	RES_1UC1, RES_1UC2,	RES_2UC1.1, RES_2UC1.2, RES_2UC1.3, RES_2UC1.4, RES_2UC2.1, RES_2UC2.2, RES_2UC2.3, RES_2UC2.4,
62	Open Source	This KPI numbers the open source components will be made available.	RES_1UC3,	RES_2UC3.1
63	Replicable solutions within the country/union	This KPI tracks the lessons and use cases extracted from the four demonstration sites and made available for sharing and training in other islands within the country/union.	CM_1UC4,	CM_2UC4.1, CM_2UC4.2,
64	Replicable solutions in both EU and India/other developed countries / other developing countries	This KPI tracks the lessons and use cases extracted from the four demonstration sites and made available for sharing and training in other islands worldwide, through various channels (like European Utility Week, EDSO, etc).	CM_1UC4,	CM_2UC3.3, CM_2UC4.1, CM_2UC4.2,

7 References

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8 Annexes

Annex 1 Questionnaire for the acquisition of demo sites' information

BASIC DATA ABOUT DEMO SITES

The questions to be answered might not be applicable to all pilot sites. In the case the answer cannot be provided, please insert "not applicable" or "N.A.".

Some questions require a quantitative answer. It is not necessary to give an exact, accurate value - an approximation will be sufficient to assess the conditions at pilot site.

ENERGY DATA OF LOCAL ENERGY SYSTEMS (LES)

- Total yearly consumption: ___ MWh (GWh)
- Total yearly local production: ___ MWh (or GWh)
- Connections of **Local Energy System (LES)** with external grid:

Voltage level	**Voltage (kV)**	**Number**	**Total capacity (MW)**
HV (110 kV and higher)			
MV (lower than 110 kV and higher than 0,4 kV)			
LV (0,4 kV)			

Existing local production units (if applicable, insert details below the table):

Unit type		**Number**	**Total capacity (kWe)**	**Total yearly production (MWh)**	**Is it controllable? Protocol?**	**Available characteristics or info?**
Thermal						
Photovoltaics	Power plants					
	Roof units					
Wind turbines	Large					

	Small					
Cogenerations						
Other						

- Yearly peak load of LES : ___
- Yearly peak local production of LES (maximum generation): ___
- Number of electricity customers (end consumers / producers): HV & MV: ___; LV: ___

- **Planned local production units (if applicable, insert details below the table):**

Unit type		**Number**	**Total capacity (MWe)**	**Total yearly production (MWh)**	**Is it controllable? Protocol?**	**Available characteristics/info?**
Thermal						
Photovoltaics	Power plants					
	Roof units					
Wind turbines	Large					
	Small					
Cogenerations						
Other						

Other Energy Vectors (Existing or planned)

Unit type		**Number**	**Total capacity**	**Is it controllable? communication protocol?**
Heating & Cooling				
Water management				
Biogass/Biomass				
….				

Other				

Other energy related infrastructure (Existing or planned)

- Capacity of Storage installed: ___
- Reactive power compensators (number and total reactive power in kvar): ___
- Number of Electric Vehicles deployed: ___
- Number of charging stations installed: ___
- Controllable loads?: ___
- Flexibility schemes (demand side management, etc.): ___
- Any other energy related information you want to emphasize: ___

Availability of information and data (Existing or planned were applicable)

- Is the network topology information available? ___
- Are there historical production/load data available? If so, how long and what is the granularity? ___
- Available historical meteorological (weather) data? If so, how long and what is the granularity? ___
- Is there active subscription to meteorological data provider? ___
- Available SCADA system? If yes, is it accessible? Please provide details for the communication ___
- Available metering devices? If yes, what are the supported communication protocols? ___.
- Any other ICT infrastructure? If yes, can we get data? ___
- Any other supervisory system for RES or other infrastructure (e.g. desalination)? If yes, can we communicate and get data? ____
- Do you need Non disclosure agreements (NDAs) for any of the data available? ____

Information on the energy market structure (if applicable):

- What is the energy market structure at the demo site (if applicable)? ___

- Are there any incentives available related to energy projects or schemes? ____
- Please briefly describe the tariff scheme if applicable? ____

DATA ABOUT STAKEHOLDERS AND CITIZEN ENGAGEMENT

How many people are in your demo site community? _____

What are the administrative structures around your pilot sites? (various layers of government administration): _____

Estimate the geographical area of your pilot site (km^2): _____

Are there major regulatory barriers? ____

ENERGY ACTORS

List of the Energy stakeholders:

Role	Actor
DSO	
TSO	
Energy Supplier	
Energy Producer	
Electric Mobility Manager	
Storage manager	
Aggregator	
…	

List of Citizens Organisations:

Organisation	No. of Members	Main Activity

0SUES RELATED TO THE LOCAL ENERGY SYSTEM

This chapter is intended to acquire information about potential issues in operation of your local energy system and in organisation / activities of local energy community. The answers shall describe your visions of what you would like to improve in your pilot site in correlation with the project's objectives.

Sections in this chapter serve only as a guidance, giving an initial idea about potential issues in operation of local energy system and in organisation / activities of local energy community. Please add sections to describe additional issues related to your LES and local community you are (or anticipate being) faced with and expect or wish to be treated within the RE-EMPOWERED project.

INCREASED ENERGY EFFICIENCY, RES UTILIZATION AND RELIABILITY

OPTIMAL OPERATION, HIGH FLEXIBILITY AND EFFICIENCY

Relevance for demo site (insert “X”):

Very important	Important	Less important	Not relevant

Description of current situation : ___

Obstacles that might prevent the achievement of the goals:

- Financial: ___
- Technical: ___
- Organisational (including skills of personnel to suppport activities): ___
- Regulatory: ___
- Political Backing: ___
- Poor citizens’ interest and/or acquaintance: ___
- Social counter-movement (as for example: NIMBY (Not In My Backyard)): ___
- Other: ___

Do you expect this issue to be tacled by RE-EMPOWERED project (insert “X”)?:

Mandatory	Nice to have	Not needed

Other remarks regarding treatment of this issue by RE-EMPOWERED: ___

HIGHER RES PENETRATION AND UTILIZATION

This section shall be filled in if there are issues related to development of local production explicitly linked to renewable energy sources (beside the ones described in previous section):

Relevance for demo site (insert “X”):

Very important	Important	Less important	Not relevant

Description of current situation (share of RES in local production and consumption): ___

Obstacles that might prevent the achievement of the goals:

- Financial: ___
- Technical: ___
- Organisational (including skills of personnel to suppport activities): ___
- Regulatory: ___
- Political Backing: ___
- Poor citizens' interest and/or acquaintance: ___
- Social counter-movement (as for example: NIMBY): ___
- Other: ___

Do you expect this issue to be tacled by RE-EMPOWERED project (insert "X")?:

Mandatory	Nice to have	Not needed

Other remarks regarding treatment of this issue by RE-EMPOWERED: ___

RELIABLE AND RESILIENT OPERATION

This section shall be filled in if there are issues related to operation of local grid (congestions, outages, excessive voltage deviations, imbalances, incapability of LES's islanded operation …):

Relevance for demo site (insert "X"):

Very important	Important	Less important	Not relevant

Description of current situation : ___

Goals for the future : ___

Obstacles that might prevent the achievement of the goals:

- Financial: ___
- Technical: ___
- Organisational (including skills of personnel to suppport activities): ___
- Regulatory: ___
- Political Backing: ___
- Poor citizens' interest and/or acquaintance: ___

- Social counter-movement (as for example: NIMBY): ___
- Other: ___

Do you expect this issues to be tackled by RE-EMPOWERED project (insert “X”)?:

Issue	Mandatory	Nice to have	Not needed
Congestions			
Outages			
System black-out			
(Other)			

Other remarks regarding treatment of this issue by RE-EMPOWERED: ___

DIGITIZATION AND ICT DEVELOPMENT

Relevance for demo site (insert “X”):

Very important	Important	Less important	Not relevant

Description of current situation : ___.

Goals for the future : ___

Obstacles that might prevent the achievement of the goals:

- Financial: ___
- Technical: ___
- Organisational (including skills of personnel to suppport activities): ___
- Regulatory: ___
- Political Backing: ___
- Poor citizens’ interest and/or acquaintance: ___
- Social counter-movement (as for example: NIMBY): ___
- Other: ___

Do you expect this issue to be tacled by RE-EMPOWERED project (insert “X”)?:

Mandatory	Nice to have	Not needed

Other remarks regarding treatment of this issue by RE-EMPOWERED: ___

FOSTERING SUSTAINABLE AND ECONOMIC COMMUNITY DEVELOPMENT

NEW COMPETITIVE BUSINESS MODELS AND FINANCING TOOLS

Relevance for demo site (insert “X”):

Very important	Important	Less important	Not relevant

Description of current situation : ___

Goals for the future :

Obstacles that might prevent the achievement of the goals:

- Financial: ___
- Technical: ___
- Organisational (including skills of personnel to suppport activities): ___
- Regulatory: ___
- Political Backing: ___
- Poor citizens’ interest and/or acquaintance: ___
- Social counter-movement (as for example: NIMBY): ___
- Other: ___

Do you expect this issue to be tacled by RE-EMPOWERED project (insert “X”)?:

Mandatory	Nice to have	Not needed

Other remarks regarding treatment of this issue by RE-EMPOWERED: ___

COMMUNITY ENGAGEMENT, TRAINING AND ENERGY COMMUNITY DEVELOPMENT

Relevance for demo site (insert “X”):

Very important	Important	Less important	Not relevant

Description of current situation : ___.

Goals for the future : ___

Obstacles that might prevent the achievement of the goals:

- Financial: ___
- Technical: ___
- Organisational (including skills of personnel to suppport activities): ___
- Regulatory: ___
- Political Backing: ___
- Poor citizens' interest and/or acquaintance: ___
- Social counter-movement (as for example: NIMBY): ___
- Other: ___

Do you expect this issue to be tacled by RE-EMPOWERED project (insert "X")?:

Mandatory	Nice to have	Not needed

Other remarks regarding treatment of this issue by RE-EMPOWERED: ___

IMPROVED ENERGY ACCESS AND ENVIRONMENT QUALITY

Relevance for demo site (insert "X"):

Very important	Important	Less important	Not relevant

Description of current situation : ___

Goals for the future : ___.

Obstacles that might prevent the achievement of the goals:

- Financial: ___
- Technical: ___
- Organisational (including skills of personnel to suppport activities): ___
- Regulatory: ___
- Political Backing: ___
- Poor citizens' interest and/or acquaintance: _____

- Social counter-movement (as for example: NIMBY): ___
- Other: ___

Do you expect this issue to be tacled by RE-EMPOWERED project (insert “X”)?:

Mandatory	Nice to have	Not needed

Other remarks regarding treatment of this issue by RE-EMPOWERED: ___

	EMS_1UC1: Real time monitoring and system data visualization
EMS_2UC1.1	Real time system monitoring and data acquisition and visualization
EMS_2UC1.2	Module manager: intercommunications and data exchange

	EMS_1UC2: Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization
EMS_2UC2.1	Mid-term and short-term RES and load forecasting
EMS_2UC2.2	Forecasting model training
EMS_2UC2.3	Unit Commitment and Economic Dispatch algorithms
EMS_2UC2.4	Multi-energy vector management of operation

Use case ID	EMS_1UC1 -Real time monitoring and system data visualization
High level UCs	HLUC-5, HLUC-6, HLUC-7, HLUC-8
Classification	Primary Use Case
Description	This 1UC addresses the observability of the system, meaning the active monitoring of the assets. It consists of four main data components; The first component is responsible for the real-time acquisition of measurements (Active Power [P], status, hours of operation, etc.) while the second deals with static data, such as generators datasheets, including information such as Nominal Capacity, Ramping Rates, etc. The third component concerns historical data storage, retrieve and visualization, to perform estimation about outages and other contingencies. Finally, cross communication between modules is crucial, to retrieve RES and load forecast, or the Day Ahead Scheduling program.
Scope	DSO needs continuous real-time overview of the status of the system. To achieve that, he will need a tool to plan the day ahead scheduling of the generation and correct any deviations from the forecasted load and RES generation, through a rolling time window.
Requirements	-Data availability
	-Type and structure of data
	-Real-time data collection

	-Data privacy				
	-Interoperable communication protocols				
Related KPIs	24. MAPE (Forecasting accuracy)				
	24. MAPE (Forecasting accuracy)				
	31. Availability of the communication infrastructure				
Actors	DSO, ecoEMS Operator				
Triggering event	-				
RE-EMPOWERED tools involved	ecoEMS				
Pre-condition	Data availability & reliability, Functionalities validated in laboratory environment				
Post-condition	DSO can monitor the status of all the components within the system				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data collection from system	System (SCADA) data are collected in real-time	Active power, real time operating status, hours of operation, updated previous operating status, etc.	SCADA	ecoEMS
2	Data concentration and storage	Concentration of data, pull data from other modules, and storage at MSSQL database	Technical datasheets of assets, CO2 curves, outages, maintenance plan, outages, commissioning, other contingencies, etc.	DSO, ecoEMS Operator	ecoEMS
3	Data visualization	Present an overview of the status of system assets		ecoEMS	DSO
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Communication with SCADA failure	Charts displaying system data cannot be updated	Exception thrown for connection unavailability displayed in web page	ecoEMS	DSO, ecoEMS Operator
2	Missing/fault data	Fault data may be for example negative generation or load	No exception thrown	ecoEMS	DSO, ecoEMS Operator
Realization					
Responsible partner		ICCS			
Contributing partners					

Use case ID	**EMS_2UC1.1 Real time system monitoring and data acquisition and visualization**
High level UCs	EMS_1UC1 -Real time monitoring and system data visualization
Classification	Secondary Use Case
Description	A variety of measurements are necessary for the sufficient data acquisition concerning EMS operation, as well as static technical data for each asset. It is highly important for the secure operation of the system, this information to be reliable transmitted from the SCADA to the database (preferably a MSSQL database), via which the data are used by the Energy Management System. Static data also neat to be reliable and crosschecked and should not be altered if any actual change does not take place. Communication protocols are an important issue due to the necessity to integrate different vendors. The objective of this 2UC is to ensure the effective development and implementation of the on-line data transferring and near real-time monitoring system for the EMS performance overview.
Scope	Validation of effective monitoring and data transferring infrastructure taking into consideration cyber-security of data collection.
Requirements	- Metering devices and sensors to be available on site. - Available communication infrastructure (copper-based, fibre optic, wireless, etc). - Secure and reliable data transferring through the communication channel. - Data collection period should be close to real-time corresponding the application - Spatial Information of related assets (geolocation)
Related KPIs	32. Data reliability 31. Availability of the communication infrastructure 58. Use of protocol standards 33. Data security control

		22. Increased access to own metering data 60. Interoperability			
Actors		SCADA systems, SO , ecoEMS operator			
Triggering event		Periodically or when an event is detected			
RE-EMPOWERED tools involved		ecoEMS			
Pre-condition		- Integration of SCADA systems - Integration of data information model			
Post-condition		Measurements and static data are stored in MSSQL database			
Step by step analysis					
No.	**Event**	**Normal Process**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event Scheduled (on periodic basis)	The available data for the integration of the process are taken from various sources, i.e. SCADA, weather forecasts provider, DSO	- Weather forecast data - Real time demand and generation data, system frequency - Historical data, static data	SCADA systems, DSO, ecoEMS Operator	Load/RES forecasting Module, Data Manager
2	Data correction	Calculations and error data handling takes place, e.g. if negative production is located, it is changed to zero, or all measurements changed into MW/MWh scale, etc. After error correction, data are stored in the MSSQL database	- Weather forecast data - Real time demand and generation data, system frequency - Historical data, static data	Data Manager	MSSQL database
3	Data visualization	Predefined charts are displayed, using all necessary available data	- Real time demand and generation data, system frequency	MSSQL database	ecoEMS
Exception – Incomplete or lack of available data					

No.	Event	Exception handling/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Missing data from SCADA	SCADA systems fails to store and/or transmit real time data to ecoEMS, secondary logging devices should be able to connect and transfer raw data.	Error message	SCADA	ecoEMS Operator, DSO
Exception – Network communication issue with the Data Concentrator					
No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Communication failure	Communication with SCADA or weather forecast provider's API fails due to technical reasons or expired session. Retries continuous until the maximum number of attempts is reached.	Error message	ecoEMS	ecoEMS Operator, DSO
Realization					
Responsible partner	ICCS				
Contributing partners	PROTASIS				

Use case ID	EMS_2UC1.2 Module manager: intercommunications and data exchange
High level UCs	EMS_1UC1 - Real time monitoring and system data visualization
Classification	Secondary Use Case
Description	This SUC addresses the second role of the Orchestrator (the first role is the Data Manager, described in 2UC1.1), which is the Module Manager that takes over the execution of the algorithms in the correct order, so that exceptions will not be thrown. Clarifying this, this manager is consisted by two pillars; primarily the scheduler periodically executes the forecasting modules, every hour for 48 hours horizon with hourly step and every 15 minutes for 4 hours horizon with 15 minutes step. Secondarily, unit commitment and economic dispatch are also scheduled to be executed with the corresponding horizons and steps, after the forecasts are available from the forecasting models. This way, the module manager ensures that the output data from one algorithm and that will be required from another algorithm, are available for module intercommunication and transferred without execution delays.

Scope	ecoEMS depends on serial execution of its algorithms, and Module Manager is responsible for the data availability and transfer through the modules
Requirements	Weather data availability, real time measurements availability, correct configuration
Related KPIs	32. Data reliability 31. Availability of the communication infrastructure 58. Use of protocol standards 33. Data security control 22. Increased access to own metering data 60. Interoperability
Actors	ecoEMS
Triggering event	Periodically, or on demand if user requests it
RE-EMPOWERED tools involved	ecoEMS
Pre-condition	Forecasting models being trained, optimization algorithms necessary input data availability, weather data provider communication
Post-condition	-

Step by step analysis

Step No.	Event	Normal Process	Info. Exchanged	Actor producing info	Actor receiving info
1	Long term forecasts	RES and load LT forecast execution is normally completed, and data are available for further use.	Hourly forecasts	Forecasting module	Unit Commitment module, ecoEMS
2	Short term forecasts	RES and load ST forecast execution is normally completed, and data are available for further use.	15min forecasts	Forecasting module	Economic Dispatch module, ecoEMS
3	Unit commitment	LT forecasts are pulled and used for the unit commitment optimization algorithm	Hourly dispatch orders	Unit Commitment module	System Assets, ecoEMS, DSO

4	Economic dispatch	ST forecasts are pulled and used for the economic dispatch optimization algorithm	15min corrective dispatch orders	Economic Dispatch module	System Assets, ecoEMS, DSO
Exception – Incomplete or lack of available data					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Forecast module failure	In case forecast module is failed, the optimization algorithms will run with not updated previously forecasted timeseries, yet an error message will be thrown to inform the user	Error message	ecoEMS	ecoEMS Operator, DSO
2	Forecast module delayed	In case forecast module is delayed, e.g. weather forecast provider connection problem, the optimization algorithms will run with not updated previously forecasted timeseries, yet an error message will be thrown to inform the user	Error message	ecoEMS	ecoEMS Operator, DSO
Exception – Network communication issue with the Data Concentrator					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
Realization					
Responsible partner	ICCS				
Contributing partners					

Use case ID	**EMS_1UC2 - Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization**
High level UCs	HLUC-1, HLUC-2, HLUC-3, HLUC-4, HLUC-5, HLUC-6, HLUC-7, HLUC-8
Classification	Primary Use Case

Description	This 1UC addresses the heartbeat of the ecoEMS tool, which consists of the algorithms for the forecasts and the optimization algorithm of optimal unit commitment and dispatch. Concerning the RES and load forecasting modules, firstly the forecasting algorithms must be fed with data in order for the training to be completed. Training phase includes the combination of different forecasting models. After the training phase, the models are automatically executed every hour, providing 48hours ahead hourly forecasts. The dispatching optimization consists of two pillars; primarily the hourly output for day ahead the unit commitment, and secondarily the 15minute redispatch correcting the orders based on unit commitment, based on RES, load fluctuations and updated forecasts, or other reasons, e.g., contingencies. It is a multi objective algorithm, providing a single optimal solution, where RES penetration levels and social welfare are maximized, under the secure operation of the electrical system.
Scope	DSO needs to use a tool to plan the day ahead scheduling of the generation, and redispatch on a short-term horizon, according to RES and load fluctuations, or activate the necessary reserves.
Requirements	-Availability of Real-time measurements
	-Availability of RES forecast module and demand estimation
	Static data of system assets (e.g. generators/ power electronics ratings, storage rating) are provided
	Declaration of availability and production declaration for dispatching RES assets
Related KPIs	Reduction in greenhouse gas emissions
	41. Reduced overall cost
	16. RES curtailment reduction (annual)
	8. Peak load reduction
	12. Hours with non-served load or non-observed reserve (h)
	Total non-served load and non-observed reserve (MWh)
	14. Hours with underload of conventional units (h)
	15. Total non-served load (MWh)
	24. MAPE (Forecasting accuracy)
Actors	DSO
Triggering event	-
RE-EMPOWERED tools involved	ecoEMS

Pre-condition	Data availability				
Post-condition	DSO can communicate the dispatch orders to all the components/assets within the system				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Forecast model training	Historical data, managed and fed for training phase.	Forecasting model, calibrated hyperparameters	ecoEMS	ecoEMS
2	RES forecast	Forecast of expected generation	Generation forecast of each RES for 48h ahead horizon, with hourly step	ecoEMS	ecoEMS, ecoEMS Operator
3	Load forecast	Forecast of expected consumption	Load forecast for 48h ahead horizon, with hourly step	ecoEMS	ecoEMS, ecoEMS Operator
4	Module data exchange	Pull event from optimization algorithms, for produced forecasts	Generated/updated forecasts	ecoEMS	ecoEMS
5	Unit commitment	Execution of optimization algorithm and calculation of each asset's hourly commitment	Hourly dispatch order for each asset, Start up/Shut down command for thermal units, production command for thermal units and storage	ecoEMS	System assets, ecoEMS, ecoEMS Operator
6	Economic dispatch	Execution of optimization algorithm and correcting dispatch orders from unit commitment, based on updated forecasts, possible outages, etc.	15min dispatch order for each asset, concerning production level and setpoint	ecoEMS	System assets, ecoEMS, ecoEMS Operator
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Load/Wind/PV forecast curve missing	User must run the forecast module manually	Exception thrown and failed status displayed in web page	ecoEMS	DSO, ecoEMS Operator
2	Generation units' data missing	User must upload the missing data	Exception thrown and failed status displayed in web page	ecoEMS	DSO, ecoEMS Operator
3	Failed communication with SCADA	User must pull the data from SCADA and upload manually	Exception thrown and failed status displayed in web page	ecoEMS	DSO, ecoEMS Operator
Realization					
Responsible partner	ICCS-NTUA				
Contributing partners					

Use case ID	**EMS_2UC2.1 Mid-term and short-term RES and load forecasting**
High level UCs	EMS_1UC2 - Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization
Classification	Secondary Use Case
Description	Estimation of future behaviour of the demand is of paramount importance for the optimal scheduling and unit commitment. This 2UC concerns the ecoEMS functionality of load and RES forecasts. The forecasts will be used in terms of two different horizons: a 24/48h ahead horizon and a 4h ahead horizon. Short and mid term unit commitment and economic dispatch of the assets shall be defined under minimized uncertainty.
Scope	The scope of the UC is to validate the performance of the forecast module in full operation of the ecoEMS tool.
Requirements	- Spatial Information of related assets - Information about seasonal conditions - Daily weather forecast - Historical demand data of at least a year - Real time data and system setpoints
Related KPIs	24. MAPE (forecasting accuracy) 25. MAE (forecasting accuracy) 26. MAD (forecasting accuracy)
Actors	Data Manager, Module Manager, ecoEMS Operator
Triggering event	The function is executed periodically (per 15min or 1 hour or daily)

RE-EMPOWERED tools involved	ecoEMS				
Pre-condition	- Available historical data to be available - Available real time data to be available - module to be adequately trained				
Post-condition	Forecasting is provided to module manager for further elaboration by other modules.				
Step by step analysis					
Step No.	**Event**	**Normal Process**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event Scheduled (on periodic basis)	The available data for the completion of the process are pulled from the various sources, e.g., weather forecast provider	- Weather forecast data - Real time demand and generation data - Historical data.	Data Manager/Module Manager	Load/RES forecasting Module
2	Calculation	The module calculates the short and mid term prognosis.	Mid- and Short-term demand/RES estimation	Load/RES forecasting Module	Load/RES forecasting Module
3	Push event	The results are provided to data manager and module manager	Mid- and Short-term demand/RES estimation	Load/RES forecasting Module	Data Manager/Module Manager
Exception – Incomplete or lack of available data					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Required data are not sufficient.	In case the minimum required data for the calculation of the estimation are not available the module stops the procedure, and an error is produced.	Error message	Load forecasting Module	Data Manager/Module Manager
Exception – Network communication issue with the Data Concentrator					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Network communication error	Connection errors can occur for a variety of reasons. If the predefined response time of a connection is run out the procedure repeat the typical step 1 and the timeout time is increased. Retries continuous until the maximum number of attempts is reached.	Error message	Load forecasting Module	Data Manager/Module Manager
Realization					
Responsible partner		ICCS			
Contributing partners					

Use case ID	**EMS_2UC2.2 Forecasting model training**
High level UCs	EMS_1UC2 - Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization
Classification	Secondary Use Case
Description	Forecast algorithms are produced from a combination of three different forecasting training models; using self-organizing maps(Kohonen maps) and Radial Basis Function neural networks, optimized through a genetic algorithm hyper-parameter tuning, Machine learning Forecasting model and a Recursive Least Squares Forecasting model. The estimated load/RES production curve is a series of discrete points of consecutive predicting values, along with the intervals of XX% of confidence.
Scope	The scope of the SUC is to validate the performance of the forecast training process, which generates the forecasts in the full operation of the ecoEMS tool.
Requirements	- Spatial Information of related assets - Information about seasonal conditions - Daily weather forecast - Historical demand data of at least a year - Real time data
Related KPIs	24. MAPE (forecasting accuracy) 25. MAE (forecasting accuracy) 26. MAD (forecasting accuracy)
Actors	Forecasting module, ecoEMS
Triggering event	The function is executed weekly, updating and calibrating the hyperparameters of the forecast module

RE-EMPOWERED tools involved		ecoEMS			
Pre-condition		- Available historical data to be available - Available real time data to be available			
Post-condition		Forecasting is provided to Data Concentrator for further elaboration by other modules.			
Step by step analysis					
Step No.	**Event**	**Normal Process**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event Scheduled (on periodic basis)	The available data for the training/retraining forecasting module	- Weather forecast data - Real time demand data - Historical data.	Data Manager/Module Manager	Load/RES forecasting Module
2	Calculation	The module calibrates the hyperparameters of the training/retraining phase for the forecasting module	Forecasting hyperparameters	Load/RES forecasting Module	Load/RES forecasting Module
3	Push event	The results are provided to Data Manager/Module Manager	Forecasting hyperparameters	Load/RES forecasting Module	Data Manager/Module Manager
Exception – Incomplete or lack of available data					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Required data are not sufficient.	In case the minimum required data for the retraining of the forecasting modules are not available, the module stops the procedure, and an error is produced.	Error message	Load forecasting Module	Data Manager/Module Manager
Exception – Network communication issue with the Data Concentrator					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Network communication error	Connection errors can occur for a variety of reasons. If the predefined response time of a connection is run out the procedure repeat the typical step 1 and the timeout time is increased. Retries continuous until the maximum number of attempts is reached.	Error message	Load forecasting Module	Data Manager/Module Manager
Realization					
Responsible partner		ICCS			
Contributing partners					

Use case ID	**EMS_2UC2.3 Unit Commitment and Economic Dispatch algorithms**
High level UCs	EMS_1UC2 Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization
Classification	Secondary Use Case
Description	This SUC addresses resources management, e.g. dispatchable loads, storage Units, RES Units, thermal generators, are being committed to primarily satisfy the energy balance constraint, based on the load forecast, aiming to achieve various goals such us the cost minimization, increased RES utilization, etc. To this end, the ecoEMS module should be able to run simulations under hyper-parameter definition, after communicating with other services, such as RES and Load forecast services, and then execute the optimization algorithm to calculate the optimal unit commitment. Those dispatch orders are sent to the various system assets. Economic Dispatch algorithm, is following the Unit Commitment, executed time-closer to the dispatch hour, with larger time granularity, quarter hour time step, producing redispatch orders.
Objectives	Software development of the optimization algorithm for the energy management system
Requirements	1) Installation of adequate hardware components (hardware PC forecast and measurements database, etc.) ensuring availability of measurement and forecasts to the host PC of the optimization algorithms. 2) The optimization algorithm is robust and has been tested in commercial solvers, such as Gurobi. 3) Operation of ecoEMS RES and Load forecast service
Related KPIs	Reduction in greenhouse gas emissions 41. Reduced overall cost 16. RES curtailment reduction (annual)
Actors	DSO, system assets, ecoEMS Operator

Triggering event		Periodically triggered in defined time intervals by the DSO or on demand execution			
RE-EMPOWERED tools involved		ecoEMS			
Pre-condition		1) Definition of timestep for algorithms execution and triggering event. 2) Static data regarding the system assets resources and their constraints are available. 3) Communication between the DSO and the ecoEMS tool is established.			
Post-condition		A set of control signals for system components is available to the DSO.			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data reception	ecoEMS acquires real-time measurements and forecast data	Real time measurements for production, demand, State of Charge of storage devices and generator status and operating time are provided to the DSO. Forecast data are provided by other services.	ecoEMS	DSO, ecoEMS Operator
2	Execution of optimization for Unit Commitment and Economic Dispatch	Execution of optimization algorithm	The ecoEMS tool executes the optimization algorithms and computes the optimal dispatch orders.	ecoEMS	DSO, ecoEMS Operator
3	Formulate control actions	Forwards the control commands to assets	DSO sends the hourly control signals to the assets hardware equipent.	ecoEMS	System assets
Exception #1					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Unavailable data	The ecoEMS tool identifies that either real-time measurements or forecasts data are unavailable, hence the optimization algorithm can not be executed	A message is sent to the ecoEMS Operator that the optimization algorithm can not be executed.	ecoEMS	DSO, ecoEMS Operator
Realization					
Responsible partner		ICCS			
Contributing partners					

Use case ID	EMS_2UC2.4 Multi-energy vector management of operation
High level UCs	EMS_1UC2 Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization
Classification	Secondary Use Case
Description	Power System management of operation should utilize the flexibility of multi energy vectors aiming at most economical operation. This 2UC aims to operate the Power System economically by scheduling different energy vectors while satisfying the wide range of operational, security and availability constraints. The flexibility of different energy vectors like cold storage, boilers for hot water, water pumping, water treatment, electric four-wheelers and electric boats etc. will be tapped and scheduled for the most efficient and economic operation.
Objectives	Scheduling of multi energy vectors for economical operation
Requirements	ecoEMS communication infrastructure is ensured Operation of ecoEMS Forecasting Module Declaration of controllable assets in the power system. Static data of power system assets (e.g. generators ratings, storage rating) are provided. Operational and availability constraints of different energy vectors are required. Periodic pricing signals are required.
Related KPIs	Reduction in greenhouse gas emissions 41. Reduced overall cost 16. RES curtailment reduction (annual)
Actors	DSO, EMS Operator, Data Manager, Module Manager
Triggering event	The function is executed periodically (15min - 1hour)
RE-EMPOWERED tools involved	ecoEMS
Pre-condition	Laboratory evaluation of the multi-objective microgrid functionality Estimation of RES production for a pre-defined horizon are required. Real time measurements of RES production, demand and power exchange with local distribution grid are required. State of charge of storage equipment should are required. Current status and production of thermal units are required. Operational and availability constraints are required Periodic pricing signals are required
Post-condition	Scheduling signals for Power System components are transmitted to system assets. If the scheduling can not be executed due to unavailability of data or inability to control system assets an error message is produced.
Step by step analysis	

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Pull event Scheduled (on periodic basis)	EMS module acquires the necessary data from the Storage Device.	Real time measurements for RES production/demand, State of Charge of storage devices, thermal generator status and production, power exchange with the grid, RES forecast estimation 6. Energy price 7. Flexible loads status	Storage Device	EMS module
2	Calculation	Execution of optimization algorithm.	Start up/Shut down command for thermal units, Production dispatch order for thermal units and storage equipment, Load shedding dispatch order for load controllers	EMS module	EMS module
3	Formulate control actions	EMS module forwards the control commands to the Data Manager/Module Manager.	-	EMS module	Data Manager/Module Manager
Exception - Lack of available data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Required data are not sufficient.	In case the minimum required data for the optimization algorithm are not available the module stops the procedure, and an error is produced.	Error message	EMS module	Logging Device
Exception - Communication Failure with controllable assets					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Storage Device is unavailable	In case the Storage device is unavailable the. EMS module retries continuously until the maximum number of attempts is reached. If the issue is not resolved the procedure is stopped and an error is produced.	Error message	EMS module	Logging Device
Realization					
Responsible partner		ICL			
Contributing partners		ICCS-NTUA			

C. Annex 3 Use Cases definition for ecoMicrogrid

	MG_1UC1: Microgrid monitoring
MG_2UC1.1	Real time microgrid monitoring and data acquisition
MG_2UC1.2	RES production estimation
MG_2UC1.3	Data concentration, storage, and management
	MG_1UC2: Microgrid optimal management of operation
MG_2UC2.1	Effective communication with controllable assets
MG_2UC2.2	Multi objective microgrid management - Optimization of Energy Production, Storage and Purchase
MG_2UC2.3	Multi-energy vector microgrid management of operation

Use case ID	MG_1UC1 - Microgrid Monitoring
High level UCs	HLUC-1, HLUC-3, HLUC-4, HLUC-8
Classification	Primary Use Case
Description	This 1UC addresses the observability of the microgrid, meaning the active monitoring of its assets. It consists of three main components. The first component is responsible for the real-time acquisition of measurements (Voltage [U], Active Power [P], Reactive Power [Q]....) while the second deals with data management, such as aggregation and data storage. The third component utilizes the data from the other components to perform estimation of RES production, both electrical and thermal where it is possible. In addition, a fourth component detects power outages in the microgrid and identifies the location.
Scope	Microgrid operator needs a permanent and continuous real-time overview of the status of the microgrid.
Requirements	-Data availability
	-Type and structure of data
	-Real-time data collection
	-Interoperable communication protocols
	-Data privacy

Related KPIs		24. MAPE (Forecasting accuracy)			
		24. MAPE (Forecasting accuracy)			
		1. Islanding			
		20. Compliance with GDPR			
		31. Availability of the communication infrastructure			
Actors		MGCC, Microgrid Operator, Prosumer, DSO			
Triggering event		-			
RE-EMPOWERED tools involved		ecoMicrogrid			
Pre-condition		Data availability & reliability, Functionalities validated in laboratory environment			
Post-condition		Microgrid operator is able to monitor the status of all the components within the microgrid			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data collection from microgrid	Microgrid data are collected in real-time	P, Q, V, I, ϕ	MGCC	Microgrid operator
2	Data aggregation and storage	Concentration of data and storage for later processing	P, Q, V, I, ϕ	MGCC	Microgrid operator
3	RES forecast	Forecast of expected generation	Generation forecast of each RES	MGCC	Microgrid operator
4	Load forecast	Forecast of expected consumption	Load forecast (electrical & thermal where available)	MGCC	Microgrid operator
5	Data visualization	Present an overview of the status of microgrid assets		MGCC	Microgrid operator

Realization	
Responsible partner	ICCS-NTUA
Contributing partners	PROTASIS

Use case ID	MG_2UC1.1 - Real time microgrid monitoring and data acquisition
High level UCs	MG_1UC1 - Microgrid monitoring
Classification	Secondary Use Case
Description	A variety of metering devices and sensors are necessary for the sufficient data acquisition concerning microgrid's operation. Those captured data and measurements it's highly important to reliably, securely, and effectively be transmitted to an access point (Data Concentrator), via which the data are further elaborated by the microgrid management system. Communication protocols are an important issue due to the necessity to integrate different vendors. The objective of this SUC is to ensure the effective development and implementation of the on-line data transferring and near real-time monitoring system for the microgrid performance assessment and observation.
Scope	Validation of effective monitoring and data transferring infrastructure taking into consideration cyber-security of data collection.
Requirements	- Metering devices and sensors to be available on site. - Available communication infrastructure (copper-based, fiber optic, wireless, etc). - Secure and reliable data transferring through the communication channel. - Data collection period should be close to real-time corresponding the application - Spatial Information of related assets (geolocation)
Related KPIs	32. Data reliability 31. Availability of the communication infrastructure 58. Use of protocol standards 33. Data security control 22. Increased access to own metering data 60. Interoperability
Actors	Metering devices (Electronic Meter, Smart Meter, Sensor, etc), Data Concentrator, Microgrid operator
Triggering event	Periodically or when an event is detected
RE-EMPOWERED tools involved	ecoMicrogrid

Pre-condition		- Integration of metering devices - Communication interfaces should be open and interoperable - Integration of data information model should have been implemented			
Post-condition		Measurements are provided to Data Concentrator			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data acquisition	Monitoring devices/systems produces the data, either on periodical basis or event based.	Measurements of the network parameters (V, I, f, P,Q, T etc.) - data related to the status of the devices.	Network monitoring, protection generation and storage devices.	Communication Data Processor
2	Data processing	Handle the data exchange between devices using different communication protocols	Measurements of the network parameters (V, I, f, P,Q, T etc.) - data related to the status of the devices.	Communication Data Processor	Communication Data Processor
3	Data validation and storage	The module assesses integrity of data and stores it for subsequent use	Measurements of the network parameters (V, I, f, P,Q, T etc.) - data related to the status of the devices.	Communication Data Processor	Data Concentrator
4					
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Communication problem	In case a communication error is detected, the module retries continuously until the maximum number of attempts is reached. If the issue is not resolved the procedure is stopped and an error is produced.	Error message	Communication Data Processor	Logging Device

Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data is inaccurate	Stored data is analyzed for its accuracy. If inaccurate data is detected, a quality flag is produced for further processing.	Measurements of the network parameters (V, I, f, P,Q, T etc.) - data related to the status of the devices.	Communication Data Processor	Logging Device
Realization					
Responsible partner		ICCS			
Contributing partners		PROTASIS			

Use case ID	MG_2UC1.2 - RES production estimation
High level UCs	MG_1UC1 - Microgrid Monitoring
Classification	Secondary Use Case
Description	Estimation of future behavior of production is important for the optimal operation of a microgrid. This 2UC concerns the ecoMicrogrid functionality of RES forecast based on meteorological, historical and real time data. By knowing the RES production for the entire day, the optimization module can account with greater certainty for the required number of unit starts and stops as well as for keeping generation units near the most efficient operating point. Storage units, allow the optimization module to calculate the most cost-beneficial periods to charge and discharge.
Scope	The scope of the UC is to validate the performance of the forecast module in full operation of the ecoMicrogrid tool.
Requirements	- Spatial Information of related assets - Information about seasonal conditions - Daily weather forecast - Real time data (2UC1.1)
Related KPIs	24. MAPE (forecasting accuracy) 25. MAE (forecasting accuracy) 26. MAD (forecasting accuracy)

Actors	Data Concentrator, Microgrid operator, MGCC				
Triggering event	The function is executed periodically (per 15min or 1 hour)				
RE-EMPOWERED tools involved	ecoMicrogrid				
Pre-condition	- Available historical data to be Available at data Concentrator - Available real time data to be Available at data Concentrator - Forecasting Module to be adequately trained - Off-line validation of the module				
Post-condition	Forecasting is provided to Data Concentrator for further elaboration by other modules.				
Step by step analysis					
Step No.	**Event**	**Normal Process**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event Scheduled (on periodic basis)	The available data for the completion of the process are taken from the Storage Device.	- Weather forecast data - Real time production data - Historical data.	Storage Device	Forecasting Module
2	Calculation	The module calculates the prognosis.	RES production estimation	Forecasting Module	Forecasting Module
3	Push event	The results are provided to Data concentrator	RES production estimation	Forecasting Module	Storage Device
Exception – Incomplete or lack of available data					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Required data are not sufficient.	In case the minimum required data for the calculation of the estimation are not available the module stops the procedure, and an error is produced.	Error message	Forecasting Module	Logging Device
Exception – Network communication issue with the Data Concentrator					

Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Network communication error	Connection errors can occur for a variety of reasons. If the predefined response time of a connection is run out the procedure repeat the typical step 1 and the timeout time is increased. Retries continuous until the maximum number of attempts is reached.	Error message	Forecasting Module	Logging Device
Realization					
Responsible partner	ICCS-NTUA				
Contributing partners					

Use case ID	MG_2UC1.3 - Data concentration, storage, and management
High level UCs	MG_1UC1 - Microgrid monitoring
Classification	Secondary Use Case
Description	The implementation of advanced microgrid features, like the extensive use of sensors, protection equipment and metering devices, imply the need of an infrastructure capable of dealing with high velocity and important storage capacity to allow for efficient data management. Ultimately, the data can be used for forecasting, advanced protection functions and optimal management of the assets as well as of keeping track of downtime and power failures. The objective of this SUC is to ensure the increased storage capacity and the efficient management of data volume in the microgrid. Cyber-security of data collection will be also considered.
Scope	Increased storage capacity and efficient management of large data volume.
Requirements	Logging and data concentration devices to be integrated on site. Necessary communication interfaces between Data Concentrator and Storage Device has been previously set.
Related KPIs	32. Data reliability 31. Availability of the communication infrastructure 33. Data security control

		22. Increased access to own metering data 60. Interoperability			
Actors		Data Concentrator, Microgrid operator, Storage Device, ecoPlatform			
Triggering event		Driven by storage or access requests			
RE-EMPOWERED tools involved		ecoMicrogrid, ecoPlatform			
Pre-condition		- Communication interface with Data Concentrator			
Post-condition		- Plethora of data (operational, non-operational, meter usage, event message, metadata) available for the EMS module and the microgrid operator.			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Store data	Store measurements/ data from the Data Concentrator to Storage devices.	Measurements of the network parameters (V, I, f, P,Q, T etc.) - Data related to the status of the devices.	Data Concentrator	Storage Device
Exception #1					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Network communication error	In case a communication error is detected, the module retries continuously until the maximum number of attempts is reached. If the issue is not resolved the procedure is stopped and an error is produced.	Error message	Data Concentrator	Logging Device
Realization					
Responsible partner		ICCS			
Contributing partners		PROTASIS			

Use case ID	MG_1UC2 - Microgrid controllability/optimal management of operation			
High level UCs	HLUC-1, HLUC-2, HLUC-3, HLUC-4, HLUC-8			
Classification	Primary Use Case			
Description	This 1UC addresses the controllability and management of microgrid assets. It consists of different functionalities. The first is responsible for the optimal management of microgrid components using real-time measurements and estimation of future demand and RES production. The second module is performed in a faster time scale and ensures that the microgrid as can respond in active/reactive power setpoints, requested by the DSO, or/and guarantee that ancillary service provision meet existing grid codes requirements at its point of common coupling.			
Scope	Microgrid assets are controlled in a coordinated and optimal manner.			
Requirements	-Availability of Real-time measurements			
	-Availability of RES forecast module and demand estimation			
	-Communication between microgrid components and the MGCC is established			
	Declaration of controllable assets in the microgrid			
	Static data of microgrid assets (e.g. generators/ power electronics ratings, storage rating) are provided			
Related KPIs	Reduction in greenhouse gas emissions			
	41. Reduced overall cost			
	16. RES curtailment reduction (annual)			
	2. Voltage variation			
	8. Peak load reduction			
Actors	MGCC, Microgrid Operator, Prosumer, DSO, Data Concentrator			
Triggering event	-			
RE-EMPOWERED tools involved	ecoMicrogrid			
Pre-condition	1. Laboratory evaluation of control functionalities. 2. Estimation of RES production/Demand for a pre-defined horizon are available			

		3. Real time measurements of RES production, demand and power exchange with local distribution grid are available. 4. Cost of energy purchase, provided by the DSO, is available. 5. State of charge of storage equipment is available. 6. Current status and production of thermal units is available.			
Post-condition		Microgrid equipment is controlled in a coordinated and automated way or the Microgrid operator is notified if issues occur regarding data inavailability or inability to control Microgrid equipment.			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event (Scheduled on periodic basis)	Microgrid real-time measurements, RES forecasts and demand estimation are provided by the data concentrator to the tool.	1. Real time measurements for RES production/demand, 2. State of Charge/Production of storage devices, 3. Thermal generator status and production, 4. Power exchange with the grid 5. RES forecast/ demand estimation. 6. Energy price (provided by the DSO) 7. Flexible loads status	Data Concentrator	ecoMicrogrid
2	Calculation	Execution of microgrid management functionalities and calculation of	1. Start up/Shut down command for thermal units	ecoMicrogrid	MGCC

		control commands for the microgrid equipment that is uploaded to the MGCC	2. Production command for thermal units and storage equipment. 3. Load shedding commands for load controllers		
3	Formulation of control actions	The MGCC formulates the commands to the necessary communication protocols and transmit them to the Microgrid equipment	-	MGCC	MGCC
4	Push Event	MGCC forwards control actions to the Microgrid components and monitors if they are followed.	1. Start up/Shut down command for thermal units 2. Production command for thermal units and storage equipment. 3. Load shedding commands for load controllers	MGCC	Prosumer
Exception #Lack of available data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Required data are not sufficient.	In case the minimum required data for the optimization algorithm are not available the module stops the procedure, and an error is produced.	Error message	ecoMicrogrid	Microgrid Operator
Exception #Communication Failure with controllable assets					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	MGCC cannot interact with a controllable asset.	If the MGCC cannot communicate with a controllable asset or its commands are not realized by the equipment the procedure stops and an error informs the Microgrid operator	Error Message, ID of the asset that does not respond to MGCC commands	ecoMicrogrid	Microgrid Operator

Realization	
Responsible partner	ICCS-NTUA
Contributing partners	

Use case ID	MG_2UC2.1 - Effective communication with controllable assets
High level UCs	MG_1UC2 - Microgrid optimal management of operation
Classification	Secondary Use Case
Description	The objective of this SUC is to ensure the effective communication and conveyance of commands to different controllable assets of a microgrid. The communication scheme, designed according to recommended/used protocols and standards for such applications (Modbus, DNP3, IEC 61850 series of standards), achieves interoperability between vendor-agnostic devices and enables secure and effective dispatch of commands to controllable assets.
Scope	Validation of communication interfaces with controllable assets.
Requirements	- Available communication infrastructure (copper-based, fiber optic, wireless, etc). - Communication protocols each metering device supports to be known, as well as their information model (e.g. GOOSE, Modbus, DNP3, SV, etc). - Reliable and secure (small latency, minimum data loss) for essential and critical data like protection information - Spatial Information of related assets (geolocation)
Related KPIs	32. Data reliability 31. Availability of the communication infrastructure 58. Use of protocol standards 60. Interoperability
Actors	Controllable units, EMS module, Data concentrator, Storage Device
Triggering event	Periodically or when ecoMicrogrid creates a command that needs to be dispatched (event based) or when an event is detected
RE-EMPOWERED tools involved	ecoMicrogrid
Pre-condition	- Validation of the Communication interfaces - Ensure small latency and minimum data loss for essential and critical data like protection information - Controllability of installed assets

Post-condition	- A set of command signals are dispatched to the controllable assets				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data Send	EMS module produce the control commands for the controllable assets and write the data at Storage Device.	1. Start up/Shut down command for thermal units 2. Production command for thermal units and storage equipment. 3. Load shedding commands for load controllers 4. Other controllable assets	EMS module	Storage Device
2	Data Request	Data concentrator reads from the storage device the commands.	1. Start up/Shut down command for thermal units 2. Production command for thermal units and storage equipment. 3. Load shedding commands for load controllers 4. Other controllable assets	Storage Device	Data Concentrator
3	Data Process	Validate the time reference and value of the messages.	1. Start up/Shut down command for thermal units 2. Production command for thermal units and storage equipment. 3. Load shedding commands for load controllers 4. Other controllable assets	Data Concentrator	Data Concentrator

4	Control action dispatch	Data Concentrator propagate the commands to controllable assets.	1. Start up/Shut down command for thermal units 2. Production command for thermal units and storage equipment. 3. Load shedding commands for load controllers 4. Other controllable assets	Data Concentrator	Controllable assets (generating & storage units, protection devices, controllers, etc)
Exception #1					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data Concentrator cannot interact with a controllable asset.	If the Data Concentrator cannot communicate with a controllable asset or its commands are not realized by the equipment the procedure stops and an error is produced.	Error Message, ID of the asset that does not respond to the commands	Data Concentrator	Controllable assets
Exception #2					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	EMS module cannot communicate with the Storage Device	If the predefined response time of a connection is run out the procedure repeat the typical step 1 and the timeout time is increased. Retries continuous until the maximum number of attempts is reached. Events logs are provided to Logging Device	Error Message	EMS module	Logging Device
Exception #2					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Data concetrator cannot communicate with the Storage Device	In case a communication error is detected, the module retries continuously until the maximum number of attempts is reached. If the issue is not resolved the procedure is stopped and an error is produced.	Error Message	Data Concentrator	Logging Device
Responsible partner		ICCS-NTUA			
Contributing partners		PROTASIS			

Use case ID	MG_2UC2.2 Multi objective microgrid management - Optimization of Energy Production, Storage and Purchase
High level UCs	MG_1UC2 Microgrid management of operation
Classification	Secondary Use Case
Description	Microgrid operation should exploit its assets in a way that financial and environmental objectives are met. This 2UC aims to evaluate, in real-time, the microgrid management functionality. Real-time measurements and estimation of future RES production/demand will be considered by a sophisticated algorithm to compute optimal commands for controllable loads, storage Units, RES Units and thermal generators. The functionality will be compared with existing microgrid operation policies to clarify its benefits in term of cost and RES exploitation.
Objectives	Evaluation of the multi-objective microgrid management functionality
Requirements	- ecoMicrogrid communication infrastructure is ensured (2UC1.1, 2UC1.3, 2UC2.1). - Operation of ecoMicrogrid Forecasting Module (2UC1.2). - Declaration of controllable assets in the microgrid. - Static data of microgrid assets (e.g. generators/ power electronics ratings, storage rating) are provided. - Cost of energy purchase, provided by the DSO, is known.
Related KPIs	Reduction in greenhouse gas emissions 41. Reduced overall cost 16. RES curtailment reduction (annual)
Actors	Prosumer, DSO, Microgrid Operator, Data Concentrator, MGCC
Triggering event	The function is executed periodically (15min - 1hour)

RE-EMPOWERED tools involved		ecoMicrogrid			
Pre-condition		- Laboratory evaluation of the multi-objective microgrid functionality - Estimation of RES production for a pre-defined horizon is available - Real time measurements of RES production, demand and power exchange with local distribution grid are available. - State of charge of storage equipment is available. - Current status and production of thermal units is available.			
Post-condition		Control signals for microgrid components are computed and are transmitted to microgrid assets. If the optimization cannot be executed due to unavailability of data or inability to control microgrid assets an error message is produced.			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event Scheduled (on periodic basis)	EMS module acquires the necessary data from the Storage Device.	1. Real time measurements for RES production/demand, 2. State of Charge of storage devices, 3. thermal generator status and production, 4. power exchange with the grid 5. RES forecast/estimation. 6. Energy price 7. Flexible loads status	Storage Device	EMS module
2	Calculation	Execution of optimization algorithm.	1. Start up/Shut down command for thermal units 2. Production command for thermal units and storage equipment. 3. Load shedding commands for load controllers	EMS module	EMS module
3	Formulate control actions	EMS module forwards the control commands to the Data Concentrator.	-	EMS module	Data Concentrator

Exception - Lack of available data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Required data are not sufficient.	In case the minimum required data for the optimization algorithm are not available the module stops the procedure and an error is produced.	Error message	EMS module	Logging Device
Exception - Communication Failure with controllable assets					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Storage Device is unavailable	In case the Storage device is unavailable the. EMS module retries continuously until the maximum number of attempts is reached. If the issue is not resolved the procedure is stopped and an error is produced.	Error message	EMS module	Logging Device
Realization					
Responsible partner	ICCS-NTUA				
Contributing partners					

Use case ID	MG_2UC2.3 Multi-energy vector microgrid management of operation
High level UCs	MG_1UC2 Microgrid management of operation
Classification	Secondary Use Case
Description	Microgrid management of operation should utilize the flexibility of multi energy vectors aiming at most economical operation. This 2UC aims to operate the microgrid economically by scheduling different energy vectors while satisfying the wide range of operational, security and availability constraints. The flexibility of different energy vectors like cold storage, boilers for hot water, water pumping, water treatment, electric four-wheelers and electric boats etc. will be tapped and scheduled for the most efficient and economic operation.

Objectives	Scheduling of multi energy vectors for economical operation				
Requirements	ecoMicrogrid communication infrastructure is ensured (2UC1.1, 2UC1.3, 2UC2.1). Operation of ecoMicrogrid Forecasting Module (2UC1.2). Declaration of controllable assets in the microgrid. Static data of microgrid assets (e.g. generators/ power electronics ratings, storage rating) are provided. Operational and availability constraints of different energy vectors are required. Periodic pricing signals are required.				
Related KPIs	18. Reduction in CO2 41. Reduced overall cost				
Actors	Prosumer, DSO, Microgrid Operator, Data Concentrator, MGCC				
Triggering event	The function is executed periodically (15min - 1hour)				
RE-EMPOWERED tools involved	ecoMicrogrid				
Pre-condition	Laboratory evaluation of the multi-objective microgrid functionality Estimation of RES production for a pre-defined horizon are required. Real time measurements of RES production, demand and power exchange with local distribution grid are required. State of charge of storage equipment should are required. Status and production of thermal units are required. Operational and availability constraints are required Periodic pricing signals are required				
Post-condition	Scheduling signals for microgrid components are transmitted to microgrid assets. If the scheduling cannot be executed due to unavailability of data or inability to control microgrid assets an error message is produced.				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Pull event Scheduled (on periodic basis)	Algorithm acquires the necessary data about energy vectors from the Storage Device.	1. Real time measurements for RES production/demand, 2. State of Charge of storage devices, 3. Thermal generator status and production, 4. power exchange with the grid 5. Flexible loads status 6. Operational and availability of energy vector	Storage Device	EMS module
2	Calculation	Execution of optimization algorithm for scheduling energy vectors.	Schedule slots data of different energy vectors	EMS module	EMS module
3	Formulate schedule slots	EMS module forwards the schedule slots to the Data Concentrator.	-	EMS module	Data Concentrator
Exception - Lack of available data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Required data are not sufficient.	In case the minimum required data for the optimization and scheduling algorithm are not available the module stops the procedure, and an error is produced.	Error message	EMS module	Logging Device
Exception - Communication Failure with controllable assets					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Storage Device is unavailable	In case the Storage device is unavailable the. EMS module retries continuously until the maximum number of attempts is reached. If the issue is not	Error message	EMS module	Logging Device

		resolved the procedure is stopped and an error is produced.			
Realization					
Responsible partner		ICL			
Contributing partners					

PN_2UCs	PN_1UC1: 7-Year Energy Planning
PN_2UC1.1	Data collection and storage
PN_2UC1.2	Electrical models & demand peak models design, RES & Load estimation
PN_2UC1.3	Optimization algorithm for mid to long term horizon (1 to 7 years), for hourly Unit Commitment, maximizing RES penetration and securing normal operation
	PN_1UC2: RES Hosting Capacity
PN_2UC2.1	Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds
PN_2UC2.2	Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment.
	PN_1UC3: Interconnections
PN_2UC3.1	Electrical models, demand peak models & interconnections design, RES & Load estimation
PN_2UC3.2	Hourly Unit Commitment, through optimization algorithm for mid to long term horizon
	PN_1UC4: Multi-energy vectors
PN_2UC4.1	Energy carriers' identification, data collection and quantification of impact on total load (hourly)
PN_2UC4.2	Electrical models & demand peak design, RES & Load estimation, energy carriers' scenarios integration
PN_2UC4.3	Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers

Use case ID	**PN_1UC1 -7-Year Energy Planning**
High level UCs	HLUC-1 , HLUC 4
Classification	Primary Use Case
Description	This 1UC addresses the 7-Year Energy Planning for assessing the deployment plan of new conventional production units, the evolution of a series of indexes such as thermal and RES production, demand, annual RES penetration, maximum instantaneous penetration of Non-Dispatchable RES Units, WPs capacity factor, fossil fuel consumption, hours of not served load, thermal underload hours etc. Depending on a series of parameters that the user must take into consideration, like the mid to long-term evolution of the demand curve, the normalized RES available generation timeseries, the need of reserves. This UC supports DSO to the decision making for system growth or new capacity installations through the critical output.
Scope	Operator needs to simulate different scenarios of system states in order to plan ahead the deployment of new units, or the decommission of thermal units, if RES generation increases and satisfies a significant percentage of the electrical demand, along with the observed reserves.

Requirements	-Data availability for thermal units, unit maintenance plan -RES stations dimensions -Annual load and RES forecast timeseries -System data and constraints (WPs setpoint, base units, fuel prices, etc)
Related KPIs	16. RES curtailment reduction (annual) 40. Energy cost 9. Load peak-to-average 10. Absolute peak hour change 8. Peak load reduction 41. Reduced overall cost 11. Absolute off-peak hour change 12. Hours with non-served load or non-observed reserve (h) 13. Total non-served load and non-observed reserve (MWh) 14. Hours with underload of conventional units (h) 15. Total non-served load (MWh) 16. RES curtailment reduction (annual) 37. WPs capacity factor (%) 17. RES increase in the energy mix (annual) 39. Ancillary services cost
Actors	DSO
Triggering event	-
RE-EMPOWERED tools involved	ecoPlanning

Pre-condition	-Data availability, database connection reliability
Post-condition	- Installation of CSV/XLSX files editor, ZIP files program

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Data aggregation and storage	Concentration of data and storage for later processing	Actual load, generation, technical datasheets of units, etc.	DSO	ecoPlanning
2	RES forecast	LT Forecast of expected generation	Generation forecast of each RES technology	DSO	ecoPlanning
3	Load forecast	LT Forecast of expected consumption	Load forecast timeseries	DSO	ecoPlanning
4	Past System Data	Past system data of peak and annual demand	Annual peak and annual demand	DSO	ecoPlanning
5	Models design and optimization execution	Optimization algorithm is executed for 7 year planning horizon, after designing electrical system and demand/peak model	Hourly Unit Commitment	ecoPlanning	-
6	Data visualization - data export	Present an overview of the status of ES	Brief report with aggregated annual resutls, zip folder with csv files for each year containing hourly results	ecoPlanning	DSO

Exception

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info

1	Load/Wind/PV curve missing	Exception thrown and fail status displayed in web page	User must load the missing curve	ecoPlanning	DSO
2	Past System Data missing	Exception thrown and fail status displayed in web page	User must load the missing data	ecoPlanning	DSO

Realization	
Responsible partner	ICCS-NTUA
Contributing partners	

Use case ID	PN_2UC1.1 - Generation units identification, data collection and storage to MSSQL database
High level UCs	PN_1UC1 - 7-Year Energy Planning
Classification	Secondary Use Case
Description	A list of conventional units and RES stations has to be fulfilled, along with the respecting datasheets; categories of the generation technologies are conventional unit based on type, dispatchable (Hybrid stations, Biomass/Biogas, CSPs) and non dispatchable (WFs, PVs) RES stations. All data, must be collected and stored efficiently in a MSSQL database, so that can be retrieved by all scenarios/models that will be built for the appropriate simulations.
Scope	Effective monitoring of electrical system infrastructure and data transferring capabilities.
Requirements	- Deployment of MSSQL server
Related KPIs	32. Data reliability 31. Availability of the communication infrastructure 58. Use of protocol standards 33. Data security control 22. Increased access to own metering data 60. Interoperability
Actors	DSO, ecoPlanning
Triggering event	Initial registrations and when a fault is detected or a change happens
RE-EMPOWERED tools involved	ecoPlanning
Pre-condition	-List of features of datasheets must be made as a template, MSSQL database scheme has to be provided
Post-condition	-Data must be provided to .NET environment through secure connection
Step by step analysis	

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Collect the data	Receive data from the electrical system assets, at the initial registration, or if any change takes place	CUs data: Station ID, installation and decommission date, fuel consumption curve, fuel type, minimum and maximum active power, rate of load change, CO2 factor, maintenance schedule, etc. RES stations data: installed capacity for WFs and PVs, and remunerations, technical minimum for controllable units, primary offered reserves, maximum daily declarations, storage minimum and maximum capacity, etc.	DSO	Database importer
2	Process the data	Handle the data (extract the useful information, transformation in appropriate measurement units, data types)	CUs data: Station ID, installation and decommission date, fuel consumption curve, fuel type, minimum and maximum active power, rate of load change, CO2 factor, maintenance schedule, etc. RES stations data: installed capacity for WFs and PVs, and remunerations, technical minimum for controllable units, primary offered reserves, maximum daily declarations, storage minimum and maximum capacity, etc.	Database importer	Database importer
3	Validate the data	Assesses the integrity of the data eliminating the erroneous one and requiring the correct data to overwrite the faults.	CUs data: Station ID, installation and decommission date, fuel consumption curve, fuel type, minimum and maximum active power, rate of load change, CO2 factor, maintenance schedule, etc. RES stations data: installed capacity for WFs and PVs, and remunerations, technical minimum for controllable units, primary offered reserves, maximum daily declarations, storage minimum and maximum capacity, etc.	Communication Data Processor	Communication Data Processor
4	Store the data	Store the data to the database tables	CUs data: Station ID, installation and decommission date, fuel consumption curve, fuel type, minimum and maximum active power, rate of load change, CO2 factor, maintenance schedule, etc. RES stations data: installed capacity for WFs and PVs, and remunerations, technical minimum for controllable units, primary offered reserves, maximum daily declarations, storage minimum and maximum capacity, etc.	Database importer	Database MSSQL tables
Exception - Network communication issue					

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Invalid/missing data are received	If invalid or required missing data types exception is thrown and displayed in terminal of importer or GUI		Database importer	Database importer
Realization					
Responsible partner		ICCS			
Contributing partners					

Use case ID	PN_2UC1.2 - Electrical models & demand peak models design, RES & Load estimation
High level UCs	PN_1UC1 - 7-Year Energy Planning
Classification	Secondary Use Case
Description	In this 2UC, firstly a forecast/estimation has to be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC1.2, and any new designed generation units and general system parameters, an Electrical System model is designed. Afterwards, with a selected load curve, and past system data concerning the peak and demand, an estimation is made through a series of statistical processes for the peak and demand of the next 7 years, and the selected load curve is appropriately adjusted, and saved as a Demand/Peak model. Both models are stored in a .json format in the database.
Scope	Design the state of the models that the DSO needs to simulate and have the input parameters stored in the json file.
Requirements	- Connection of .NET with MSSQL, static data stored in the database
Related KPIs	31. Availability of the communication infrastructure 22. Increased access to own metering data 60. Interoperability

Actors		DSO, ecoPlanning, ecoPlanning Operator			
Triggering event		-			
RE-EMPOWERED tools involved		ecoPlanning			
Pre-condition		Estimation of RES production/Demand for a one year horizon are available, RES remuneration of energy purchase, provided by the DSO is available, state of charge of storage is available			
Post-condition		-			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Demand/Peak model design	Demand/peak eastimation with one out of seven processes, e.g. linear extrapolation, etc.	Load factor, Peak increase rate, Demand increase rate	ecoPlanning Operator	ecoPlanning
2	Electrical System model design	RES management	WFs, PVs, Small WTs, Hybrid Stations, CSPs, Biomass-Biogas Stations input	ecoPlanning Operator	ecoPlanning
3	Electrical System model design	Conventional units management	Thermal units technical characteristics, maintenace schedule, merit order	ecoPlanning Operator	ecoPlanning
4	Electrical System model design	General parameters management	Spinning reserves requirements, must-run units, fuel cost data, dynamic constraint parameters, HPS forecast parameters	ecoPlanning Operator	ecoPlanning
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Session timeout	If connectivity is lost, or a large enough amount of time has passed, the session maybe terminated, causing either the model to be autosaved or not to be saved at all	Session timeout and redirection to the dashboard page	ecoPlanning	ecoPlanning Operator
Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	No model name provided	User has to name the model with a unique name and description	Model name	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner		ICCS			

Use case ID	**PN_2UC1.3 - Optimization algorithm for mid to long term horizon (1 to 7 years), for hourly Unit Commitment, maximizing RES penetration and securing normal operation**
High level UCs	PN_1UC1 - 7-Year Energy Planning
Classification	Secondary Use Case
Description	In this UC a simulation is performed for the Energy Planning study, combining the stored static data and the designed models, also stored in a json format in the database. Each year of the simulation has a separate file per category, and a unique column in the aggregated results.
Scope	Evaluation of the Energy Planning optimization algorithm
Requirements	ecoPlanning communication infrastructure is ensured Static data of ES assets (e.g. generators) are provided and stored in the database ES and Demand/Peak models are well defined
Related KPIs	16. RES curtailment reduction (annual) 41. Reduced overall cost 17. RES increase in the energy mix (annual) 37. WPs capacity factor (%)

		16. RES curtailment reduction (annual) 15. Total non-served load (MWh) 40. Energy cost			
Actors		DSO, ecoPlanning, ecoPlanning Operator			
Triggering event		-			
RE-EMPOWERED tools involved		ecoPlanning			
Pre-condition		Ensure all data are available for the optimization algorithm, models are well-designed, connection to internet is strong with adequate bandwidth			
Post-condition		Installation of CSV/XLSX files editor, ZIP files program			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event	ecoPlanning acquires the nessecary data from the MSSQL database and from the designed models	thermal generator static data, RES and load forecast estimation timeseries, .json models information	MSSQL database	ecoPlanning
2	Calculation/Push event	Execution of optimization algorithm	Number of years for Energy Planning algorithm, hourly output in csv files in a zipped file, aggregated report	ecoPlanning	ecoPlanning, ecoPlanning Operator
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Load/Wind/PV curve missing	Exception thrown and fail status displayed in web page	User must load the missing curve	ecoPlanning	ecoPlanning Operator
2	Past System Data missing	Exception thrown and fail status displayed in web page	User must load the missing data	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner		ICCS			

Use case ID	PN_1UC2 -RES 8. DER hosting capacity
High level UCs	HLUC-2, HLUC-4
Classification	Primary Use Case
Description	This 1UC addresses the assessment of the hosting capacity of Renewable Energy Sources in the electric system, in order to define the RES Capacity thresholds and limits of each generation technology, that can be adapted to the system, in a cost effective way. This UC will simulate a list of predetermined scenarios for examining various installed capacity of each RES production technology, providing indexes about the technical and economical sustainability of
Scope	Operator needs to calculate the Capacity margins for each RES technology at the energy mix, to plan ahead the licensing process and of RES investments
Requirements	-Data availability for thermal units, unit maintenance plan
	-RES stations dimensions
	-Annual load and RES forecast timeseries
	-System data and constraints (WPs setpoint, base units, fuel prices, etc)
	-Hosting Capacity thresholds and limits parameters
Related KPIs	16. RES curtailment reduction (annual)
	7. DER hosting capacity
	40. Energy cost
	9. Load peak-to-average
	10. Absolute peak hour change
	8. Peak load reduction
	41. Reduced overall cost
	11. Absolute off-peak hour change
	12. Hours with non-served load or non-observed reserve (h)
	13. Total non-served load and non-observed reserve (MWh)

	14. Hours with underload of conventional units (h)
	15. Total non-served load (MWh)
	16. RES curtailment reduction (annual)
	37. WPs capacity factor (%)
	17. RES increase in the energy mix (annual)
	39. Ancillary services cost
Actors	DSO
Triggering event	-
RE-EMPOWERED tools involved	ecoPlanning
Pre-condition	-Data availability, database connection reliability
Post-condition	- Installation of CSV/XLSX files editor, ZIP files program

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Data aggregation and storage	Concentration of data and storage for later processing	Actual load, generation, technical datasheets of units, etc.	DSO	ecoPlanning
2	RES forecast	LT Forecast of expected generation	Generation forecast of each RES technology	ecoPlanning Operator	ecoPlanning
3	Load forecast	LT Forecast of expected consumption	Load forecast timeseries	ecoPlanning Operator	ecoPlanning
4	Past System Data	Past system data of peak and annual demand	Annual peak and annual demand	DSO	ecoPlanning

5	Hosting Capacity parameters	Input RES intervals to be examined	Initial, final installed MW, and step from initial to final value, for each RES technology	ecoPlanning Operator	ecoPlanning
6	Models design and optimization execution	Optimization algorithm is executed for RES Hosting Capacity, for 1 year, for all technologies	Hourly Unit Commitment	ecoPlanning	-
7	Data visualization - data export	Present an overview of the status of ES	ZIP folder with csv files for each year containing hourly results	ecoPlanning	ecoPlanning Operator
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Load/Wind/PV curve missing	Exception thrown and fail status displayed in web page	User must load the missing curve	ecoPlanning	ecoPlanning Operator
2	Past System Data missing	Exception thrown and fail status displayed in web page	User must load the missing data	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner	ICCS-NTUA				

Use case ID	**PN_2UC2.1 - Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds**
High level UCs	PN_1UC2 - RES Hosting Capacity
Classification	Secondary Use Case
Description	In this 2UC, firstly a forecast/estimation has to be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC2.1, and any new designed generation units and general system parameters, an Electrical System model is designed. Afterwards, with a selected load curve, and past system data concerning the peak and demand, an estimation is made through a series of statistical processes for the peak and demand of the next 7 years, and the selected load curve is appropriately adjusted, and saved as a Demand/Peak model. Both models are stored in a .json format in the database.

Scope	Design the state of the models that the DSO needs to simulate, and have the input parameters stored in the json file.
Requirements	- Connection of .NET with MSSQL, static data stored in the database
Related KPIs	31. Availability of the communication infrastructure 22. Increased access to own metering data 60. Interoperability
Actors	DSO, ecoPlanning, ecoPlanning Operator
Triggering event	-
RE-EMPOWERED tools involved	ecoPlanning
Pre-condition	Estimation of RES production/Demand for a one year horizon are available, RES remunaration of energy purchase, provided by the DSO is available, state of charge of storage is available
Post-condition	-

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Demand/Peak model design	Demand/peak eastimation with one out of seven processes, e.g. linear extrapolation, etc.	Load factor, Peak increase rate, Demand increase rate	ecoPlanning Operator	ecoPlanning
2	Electrical System model design	RES management	WFs, PVs, Small WTs, Hybrid Stations, CSPs, Biomass-Biogas Stations input	ecoPlanning Operator	ecoPlanning
3	Electrical System model design	Conventional units management	Thermal units technical characteristics, maintenace schedule, merit order	ecoPlanning Operator	ecoPlanning
4	Electrical System model design	General parameters management	Spinning reserves requirements, must-run units, fuel cost data, dynamic constraint parameters, HPS forecast parameters	ecoPlanning Operator	ecoPlanning

5	RES Hosting Capacity parameters	Map the alternative scenarios of different RES technology installed capacity	Steps in MW for installed capacity per technology	ecoPlanning Operator	ecoPlanning
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Session timeout	If connectivity is lost, or a large enough amount of time has passed, the session maybe terminated, causing either the model to be autosaved or not to be saved at all	Session timeout and redirection to the dashboard page	ecoPlanning	ecoPlanning Operator
Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	No model name provided	User has to name the model with a unique name and description	Model name	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner		ICCS			

Use case ID	**PN_2UC2.2 -Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment.**
High level UCs	PN_1UC2 - RES Hosting Capacity
Classification	Secondary Use Case
Description	In this UC series of annual simulations are performed for the RES Hosting Capacity study, combining the stored static data and the designed models, also stored in a json format in the database. Through the output post process, Operator will be able to locate the overall optimal RES energy mix, concerning both technical and economic aspects of each project.
Scope	Evaluation of the RES Hosting Capacity optimization algorithm

Requirements	ecoPlanning communication infrastructure is ensured Static data of ES assets (e.g. generators) are provided and stored in the database ES and Demand/Peak models are well defined, capacity parameters defined
Related KPIs	16. RES curtailment reduction (annual) 41. Reduced overall cost 17. RES increase in the energy mix (annual) 37. WPs capacity factor (%) 16. RES curtailment reduction (annual) 15. Total non-served load (MWh) 40. Energy cost 7. DER hosting capacity
Actors	DSO, ecoPlanning, ecoPlanning Operator
Triggering event	-
RE-EMPOWERED tools involved	ecoPlanning
Pre-condition	Ensure all data are available for the optimization algorithm, models are well-designed, connection to internet is strong with adequate bandwidth
Post-condition	Installation of CSV/XLSX files editor, ZIP files program

Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event	ecoPlanning acquires the nessecary data from the MSSQL database and from the designed models	thermal generator static data, RES and load forecast estimation timeseries, .json models information	MSSQL database	ecoPlanning
2	Calculation/Push event	Execution of optimization algorithm	RES installed capacity parameters, hourly output in csv files in a zipped file, aggregated report	ecoPlanning	ecoPlanning, ecoPlanning Operator
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
Exception - Invalid data					

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Load/Wind/PV curve missing	Exception thrown and fail status displayed in web page	User must load the missing curve	ecoPlanning	ecoPlanning Operator
2	Past System Data missing	Exception thrown and fail status displayed in web page	User must load the missing data	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner		ICCS			

Use case ID	**PN_1UC3 -Interconnections**
High level UCs	HLUC-3, HLUC-4
Classification	Primary Use Case
Description	This 1UC addresses the Interconnection Assessment by performing steady state (DC power flow) simulations of the electric system to evaluate the interconnection advantages. The UC reports the operation of the production units and several results pertaining to the energy production in terms of quantity, fuel consumption and cost, CO2 emissions, etc. The optimization can be executed for maximum 7 years, defining which year the interconnections takes place, and calculating the energy flows in and out hourly
Scope	Operator needs to explore the sustainability of a possible interconnection with the mainland system or other non-interconnected isolated/island power system
Requirements	-Data availability for thermal units, unit maintenance plan
	-RES stations dimensions
	-Annual load and RES forecast timeseries
	-System data and constraints (WPs setpoint, base units, fuel prices, etc)
	-Interconnection lines parameters
Related KPIs	16. RES curtailment reduction (annual)
	40. Energy cost
	9. Load peak-to-average

	10. Absolute peak hour change
	8. Peak load reduction
	41. Reduced overall cost
	11. Absolute off-peak hour change
	12. Hours with non-served load or non-observed reserve (h)
	13. Total non-served load and non-observed reserve (MWh)
	14. Hours with underload of conventional units (h)
	15. Total non-served load (MWh)
	16. RES curtailment reduction (annual)
	37. WPs capacity factor (%)
	17. RES increase in the energy mix (annual)
	39. Ancillary services cost
Actors	DSO
Triggering event	-
RE-EMPOWERED tools involved	ecoPlanning
Pre-condition	-Data availability, database connection reliability
Post-condition	- Installation of CSV/XLSX files editor, ZIP files program

Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data aggregation and storage	Concentration of data and storage for later processing	Actual load, generation, technical datasheets of units, etc.	DSO	ecoPlanning
2	RES forecast	LT Forecast of expected generation	Generation forecast of each RES technology	DSO	ecoPlanning
3	Load forecast	LT Forecast of expected consumption	Load forecast timeseries	DSO	ecoPlanning

4	Past System Data	Past system data of peak and annual demand	Annual peak and annual demand	DSO	ecoPlanning
5	Interconnections parameters	Input of interconnection lines to be examined	Length, capacity, impedance, merit order	DSO	ecoPlanning
6	Models design and optimization execution	Optimization algorithm is executed for up to 7 year planning horizon, calculating the flows in and out.	Hourly Unit Commitment	ecoPlanning	-
7	Data visualization - data export	Present an overview of the status of ES	ZIP folder with csv files for each year containing hourly results	ecoPlanning	DSO
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Load/Wind/PV curve missing	Exception thrown and fail status displayed in web page	User must load the missing curve	ecoPlanning	DSO
2	Past System Data missing	Exception thrown and fail status displayed in web page	User must load the missing data	ecoPlanning	DSO
Realization					
Responsible partner		ICCS-NTUA			
Contributing partners					

Use case ID	**PN_2UC3.1 - Electrical models, demand peak models & interconnections design, RES & Load estimation**
High level UCs	PN_1UC3 - Interconnections
Classification	Secondary Use Case
Description	In this 2UC, firstly a forecast/estimation has to be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC3.1, and any new designed generation units and general system parameters, an Electrical System model is designed. Afterwards, with a selected load curve, and past system data concerning the peak and demand, an estimation is made through a series of statistical processes for the peak and demand of the next 7 years, and the selected load curve is appropriately adjusted, and saved as a Demand/Peak model. Both models are stored in a .json format in the database. In addition, the interconnection(s) characteristics have to be given by the Operator, as well as choose the desirable Electrical Systems to interconnect, either between them, or with the mainland system.

Scope	Design the state of the models that the DSO needs to simulate, and have the input parameters stored in the json file.				
Requirements	- Connection of .NET with MSSQL, static data stored in the database				
Related KPIs	31. Availability of the communication infrastructure 22. Increased access to own metering data 60. Interoperability				
Actors	DSO, ecoPlanning, ecoPlanning Operator				
Triggering event	-				
RE-EMPOWERED tools involved	ecoPlanning				
Pre-condition	Estimation of RES production/Demand for a one year horizon are available, RES remunaration of energy purchase, provided by the DSO is available, state of charge of storage is available, existing or expected interconnection lines characteristics				
Post-condition	-				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Demand/Peak model design	Demand/peak eastimation with one out of seven processes, e.g. linear extrapolation, etc.	Load factor, Peak increase rate, Demand increase rate	ecoPlanning Operator	ecoPlanning
2	Electrical System model design	RES management	WFs, PVs, Small WTs, Hybrid Stations, CSPs, Biomass-Biogas Stations input	ecoPlanning Operator	ecoPlanning
3	Electrical System model design	Conventional units management	Thermal units technical characteristics, maintenace schedule, merit order	ecoPlanning Operator	ecoPlanning
4	Electrical System model design	General parameters management	Spinning reserves requirements, must-run units, fuel cost data, dynamic constraint parameters, HPS forecast parameters	ecoPlanning Operator	ecoPlanning

5	Interconnection(s) parameters	Design the interconnection(s) line(s)	Nodes to mainland system, departure and arrival nodes, deployment year, line impedance, merit order, length, capacity,	ecoPlanning Operator	ecoPlanning
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Session timeout	If connectivity is lost, or a large enough amount of time has passed, the session maybe terminated, causing either the model to be autosaved or not to be saved at all	Session timeout and redirection to the dashboard page	ecoPlanning	ecoPlanning Operator
Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	No model name provided	User has to name the model with a unique name and description	Model name	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner		ICCS			

Use case ID	**PN_2UC3.2 - Hourly Unit Commitment, through optimization algorithm for mid to long term horizon**
High level UCs	PN_1UC3 - Interconnections
Classification	Secondary Use Case
Description	In this UC a simulation is performed for the Optimization study, combining the stored static data and the designed models, also stored in a json format in the database. Each year of the simulation has a separate file per category and per interconnection. Unit Commitment algorithm takes into account the interconnection deployment, to enable the maximization of the overall (interconnected power systems) social welfare.
Scope	Evaluation of the Interconnections optimization algorithm
Requirements	ecoPlanning communication infrastructure is ensured Static data of ES assets (e.g. generators) are provided and stored in the database

	ES and Demand/Peak models are well defined, interconnections information is available, overall system design is available				
Related KPIs	16. RES curtailment reduction (annual) 41. Reduced overall cost 17. RES increase in the energy mix (annual) 37. WPs capacity factor (%) 16. RES curtailment reduction (annual) 15. Total non-served load (MWh) 40. Energy cost				
Actors	DSO, ecoPlanning, ecoPlanning Operator				
Triggering event	-				
RE-EMPOWERED tools involved	ecoPlanning				
Pre-condition	Ensure all data are available for the optimization algorithm, models are well-designed, connection to internet is strong with adequate bandwidth				
Post-condition	Installation of CSV/XLSX files editor, ZIP files program				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event	ecoPlanning acquires the nessecary data from the MSSQL database and from the designed models	thermal generator static data, RES and load forecast estimation timeseries, .json models information	MSSQL database	ecoPlanning
2	Calculation/Push event	Execution of optimization algorithm	Number of years for Interconnections Unit Commitment algorithm, hourly output in csv files in a zipped file, each interconnections has a separate file, concerning the departure and arrival node.	ecoPlanning	DSO, ecoPlanning Operator
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Load/Wind/PV curve missing	Exception thrown and fail status displayed in web page	User must load the missing curve	ecoPlanning	ecoPlanning Operator
2	Past System Data missing	Exception thrown and fail status displayed in web page	User must load the missing data	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner		ICCS			

Use case ID	**PN_2UC4.1 - Energy carriers identification, data collection and quantification of impact on total load (hourly)**
High level UCs	PN_1UC4 - Multienergy vectors
Classification	Secondary Use Case
Description	A list of all energy carriers has to be fulfilled, with the primary energy input, the final energy outcome, and the best suitable conversion to energy demand (MWh) measurement units; energy carriers that have to be necessarily listed are conventional units, RES stations, demand side management, electric vehicles charging profiles, cooling, water pumping, and any other process depending on the needs of each island, e.g. desalination. The list needs to include all features reported at the respecting datasheets. All data, have to be collected and stored efficiently in a MSSQL database, so that can be retrieved by all scenarios/models that will be built for the appropriate simulations.
Scope	Effective monitoring of electrical system infrastructure and data transferring capabilities.
Requirements	- Deployment of MSSQL server
Related KPIs	32. Data reliability 31. Availability of the communication infrastructure 58. Use of protocol standards 33. Data security control 22. Increased access to own metering data 60. Interoperability
Actors	DSO, ecoPlanning, ecoPlanning Operator
Triggering event	Initial registrations and when a fault is detected or a change happens

RE-EMPOWERED tools involved	ecoPlanning				
Pre-condition	-List of features of datasheets has to be made as a template, MSSQL database scheme has to be provided				
Post-condition	-Data have to be provided to .NET environment through secure connection				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Collect the data	Receive data from the electrical system assets, and other undergone processes that have impact on the total/net load, at the initial registration, or if any change takes place	Energy Carriers: Identification of processes, energy used, energy offered, any auxiliary loads, CUs data: Station ID, installation and decommission date, fuel consumption curve, fuel type, minimum and maximum active power, rate of load change, CO2 factor, maintenance schedule, etc. RES stations data: installed capacity for WFs and PVs, and remunerations, technical minimum for controllable units, primary offered reserves, maximum daily declarations, storage minimum and maximum capacity, etc.	DSO	Database importer
2	Process the data	Handle the data (extract the useful information, transformation in appropriate measurement units, data types)	Same as above	Database importer	Database importer
3	Validate the data	Assesses the integrity of the data eliminating the erroneous one and requiring the correct data to overwrite the faults.	Same as above	Communication Data Processor	Communication Data Processor
4	Store the data	Store the data to the database tables	Same as above	Database importer	Database MSSQL tables
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Invalid/missing data are received	If invalid or required missing data types exception is thrown and displayed in terminal of importer or GUI		Database importer	Database importer
Realization					
Responsible partner	ICCS				

Use case ID	**PN_2UC4.2 - Electrical models & demand peak design, RES & Load estimation, energy carriers scenarios integration**
High level UCs	PN_1UC4 - Multienergy vectors
Classification	Secondary Use Case
Description	In this 2UC, firstly a forecast/estimation has to be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC4.1, and any new designed generation units and general system parameters, an Electrical System model is designed. The impact of energy carriers (DSM, cooling, etc) is being quantified in MWh and incorporated in the electrical system load. Afterwards, with the adjusted load curve, past system data concerning the peak and demand, an estimation can be made through a series of statistical processes for the peak and demand of the next 7 years, and saved as a Demand/Peak model, or with the direct use of the adjusted system load timeseries. Both models are stored in a .json format in the database.
Scope	Design the state of the models that the DSO needs to simulate, and have the input parameters stored in the json file.
Requirements	- Connection of .NET with MSSQL, static data stored in the database
Related KPIs	31. Availability of the communication infrastructure 22. Increased access to own metering data 60. Interoperability
Actors	DSO, ecoPlanning, ecoPlanning Operator
Triggering event	-
RE-EMPOWERED tools involved	ecoPlanning
Pre-condition	Estimation of RES production/Demand for a one year horizon are available, RES remunaration of energy purchase, provided by the DSO is available, state of charge of storage is available

Post-condition		-			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Energy carriers incorporation	Adjust the load curve	Equivalent electrical MWh of energy used/generated by other carriers, e.g. BTU.	ecoPlanning Operator	ecoPlanning
2	Demand/Peak model design	Demand/peak eastimation with one out of seven processes, e.g. linear extrapolation, etc.	Load factor, Peak increase rate, Demand increase rate	ecoPlanning Operator	ecoPlanning
3	Electrical System model design	RES management	WFs, PVs, Small WTs, Hybrid Stations, CSPs, Biomass-Biogas Stations input	ecoPlanning Operator	ecoPlanning
4	Electrical System model design	Conventional units management	Thermal units technical characteristics, maintenace schedule, merit order	ecoPlanning Operator	ecoPlanning
5	Electrical System model design	General parameters management	Spinning reserves requirements, must-run units, fuel cost data, dynamic constraint parameters, HPS forecast parameters	ecoPlanning Operator	ecoPlanning
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Session timeout	If connectivity is lost, or a large enough amount of time has passed, the session maybe terminated, causing either the model to be autosaved or not to be saved at all	Session timeout and redirection to the dashboard page	ecoPlanning	ecoPlanning Operator
Exception - Invalid data					

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	No model name provided	User has to name the model with a unique name and description	Model name	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner		ICCS			

Use case ID	**PN_2UC4.3 - Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers**
High level UCs	PN_1UC4 - Multienergy vectors
Classification	Secondary Use Case
Description	In this UC simulations can be performed for all the studies of the previous UCs, combining the stored static data and the designed models and the adjusted load curves that information of the energy vectors.
Scope	Evaluation of the multi vector overall energy optimization algorithm
Requirements	ecoPlanning communication infrastructure is ensured Static data of ES assets (e.g. generators) are provided and stored in the database ES and Demand/Peak models are well defined, energy carriers electrical demand/generation equivalent is available
Related KPIs	16. RES curtailment reduction (annual) 41. Reduced overall cost 17. RES increase in the energy mix (annual) 37. WPs capacity factor (%) 16. RES curtailment reduction (annual) 15. Total non-served load (MWh) 40. Energy cost
Actors	DSO, ecoPlanning, ecoPlanning Operator
Triggering event	-
RE-EMPOWERED tools involved	ecoPlanning
Pre-condition	Ensure all data are available for the optimization algorithm, models are well-designed, connection to internet is strong with adequate bandwidth

Post-condition	Installation of CSV/XLSX files editor, ZIP files program				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Pull event	ecoPlanning acquires the necessary data from the MSSQL database and from the designed models	thermal generator static data, RES and adjusted load forecast estimation timeseries, .json models information	MSSQL database	ecoPlanning
2	Calculation/Push event	Execution of optimization algorithm	Number of years for Energy Planning algorithm, hourly output in csv files in a zipped file, aggregated report	ecoPlanning	ecoPlanning, ecoPlanning Operator
Exception - Network communication issue					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
Exception - Invalid data					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Load/Wind/PV curve missing	Exception thrown and fail status displayed in web page	User must load the missing curve	ecoPlanning	ecoPlanning Operator
2	Past System Data missing	Exception thrown and fail status displayed in web page	User must load the missing data	ecoPlanning	ecoPlanning Operator
Realization					
Responsible partner	ICCS				

E. Annex 5 Use Cases definition for ecoDR

2UCs	DR_1UC1: Increased energy monitoring at demand side
DR_2UC1.1	Real time monitoring of energy consumption
DR_2UC1.2	Dynamic pricing-based energy cost computation
	DR_1UC2: Integration Interfaces for Load Management
DR_2UC2.1	Scheduling of loads
DR_2UC2.2	Programmable Load shedding controller

Use case ID	DR_1UC2 - Increased energy monitoring at demand side
High level UCs	HLUC-2, HLUC-4, HLUC-7, HLUC-9
Classification	Primary Use Case
Description	This 1UC forms the base for visibility of consumed electrical energy by the users/community. This UC will include interface of ecoDR tool to ecoPlatform to receive Real time pricing/dynamic pricing data. Using this Real time pricing/dynamic pricing data and measured value for electrical energy consumed, ecoDR will compute cost of consumed electrical energy. The computed cost of consumed electrical energy along with measured values of consumed electrical energy will be transmitted to ecoPlaform for its storage in database and subsequent use by ecoCommunity tool. Also the total consumed electrical energy value from the first use of energy monitoring unit will be stored in local non volatile memory.
Scope	Real time monitoring of consumed electrical energy to increase energy awareness of community .
Requirements	-Real time price/ Dynamic price Data availability
	-Real-time data collection
	-Interface with ecoPlatform to receive and transmit data
Related KPIs	23. Automatic metering of consumers
	29. (Buildings) Final consumption
	40. Energy cost
	28. Energy savings
Actors	System operators, consumers
Triggering event	Periodically

RE-EMPOWERED tools involved	ecoDR, ecoPlatform				
Pre-condition	Real time price Data availability & reliability, Functionalities validated in laboratory environment				
Post-condition	The computed value of cost of electrical energy along with measured values of consumed electrical energy will be transmitted to ecoPlatform for its storage in database and total consumed electrical energy value from the first use of energy monitoring unit will stored in local non volatile memory				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Receive Real time price data	Successfully receive the pricing data	Cost of active energy per unit and time duration	ecoPlatform	ecoDR
2	Transmit consumed energy, cost data	Successfully transmit the energy and cost data	Consumed energy and cost	ecoDR	ecoPlatform
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
	Temporary connection lost with eco Tools	keep a log of data in local memory		ecoDR (smart meter)	
	Permanent connection lost with eco Tools	Use static value of energy cost saved in non volatile memory of smart meter during its setup		ecoDR (smart meter)	
Realization					
Responsible partner	CMERI				
Contributing partners	ICL,DTU				

Use case ID	**DR_2UC2.1 - Real time monitoring of energy consumption**
High level UCs	
Classification	Secondary Use Case
Description	Real-time usage data allows to optimize distribution and empowers consumers to make smarter usage decisions. EcoDR will provide access to real-time data to boost new service and functionalities, providing energy consumption data and other electrical parameters like active power, power factor etc.. This 2UC deals with the effective development and implementation of the near real-time data acquisition process.

Scope	The scope of the UC is to validate the effective and robust metering functionality of ecoDR				
Requirements	-Advanced embedded processor for firmware implementation				
	-Power electronic components and items				
Related KPIs	23. Automatic metering of consumers				
	40. Energy cost				
Actors	System operator, consumers				
Triggering event	Periodically				
RE-EMPOWERED tools involved	ecoDR, ecoCommunity, ecoPlatform				
Pre-condition	- Integration of devices to the field				
Post-condition	The transmitted value of electrical energy along with other electrical energy parameters to ecoPlatform will be stored in database for further utilization by the other ecoTools.				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Reading meter data	The metrological part of ecoDR metering from its sensors.	Demand and Energy data (P,Q, PF, E, I etc.)	ecoDR	ecoDR
2	Meter sending the consumption data	Meter at scheduled frequency sends the data to ecoPlatform.	Demand and Energy data (P,Q, PF, E, I etc.)	ecoDR	ecoPlatform, ecoMicrogrid
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	ecoDR cannot communicate with the ecoPlatform	keep a log of data in local memory for a predefined time period (e.g. 10 mins)	N/A	ecoDR	ecoDR
Realization					
Responsible partner	CMERI				
Contributing partners	ICL,DTU				

Use case ID	DR_2UC2.2 - Dynamic pricing based energy cost computation
High level UCs	DR_1UC1 - Increased energy monitoring at demand side
Classification	Secondary Use Case
Description	Better alignment of the cost of electricity supply with demand, using dynamic pricing tariffs, can potentially yield multiple benefits. Real Time Pricing allows end users to make better choices - benefitting both energy provider and end users. This UC describes the process of real time pricing of energy cost based on received dynamic pricing data.
Scope	The scope of this UC is to verify the real time pricing functionality of ecoDR based on the dynamic prices provided.
Requirements	- communication networks up and running - Interface with ecoPlatform to receive value for max permissible load and dynamic pricing data
Related KPIs	23. Automatic metering of consumers
	29. (Buildings) Final consumption
	40. Energy cost
	28. Energy savings
Actors	System operators, consumers
Triggering event	Periodically
RE-EMPOWERED tools involved	ecoDR, ecoPlatform, ecoCommunity
Pre-condition	Real time price Data availability & reliability
Post-condition	The transmitted value of cost of electrical energy to ecoPlatform will be stored in database and total consumed electrical energy value from the first use of energy monitoring unit will stored in local non volatile memory.

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Reading meter data	The metrological part of ecoDR meter from its sensors.	Demand and Energy data (KW, KWr, PF, KWH, AMP etc.)	ecoDR	ecoDR
2	Billing calculation	Based on the dynamic price data received the price of energy is calculated.	-	ecoDR	ecoDR

3	Sending the billing data	At scheduled frequency sends the billing data to ecoPlatform and ecoCommunity	Meter number, reading date and time, KW, KVA, KWH, KVAH, PF.	ecoDR	ecoPlatform, ecoCommunity
Exception #1					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Temporary connection lost with ecoPlatform	The data stored in local memory for a predefined time period (i.e. 10min)	Error Message	ecoDR	ecoDR
2	Connectivity resumed after the lost	Compute the consumed energy cost based on the log data saved. Then, transmit the energy and cost data to the ecoPlatform	Meter number, reading date and time, KW, KVA, KWH, KVAH, PF.	smart meter	ecoPlatform, ecoCommunity
Exception #2					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Dynamic price list is not available	Use static value of energy cost saved in non volatile memory of smart meter during its setup	feedback/message ack for using static rates	ecoDR	ecoPlatform
Realization					
Responsible partner		CMERI			
Contributing partners		ICL,DTU			

Use case ID	**DR_1UC2 - Integration Interfaces for Load Management**
High level UCs	HLUC-2, HLUC-4, HLUC-7
Classification	Primary Use Case
Description	This 1UC deals with the development of advanced energy meter infrastructure with programmable load limiter to regulate the output load connected via meter to maximum permissible load to be powered through meter output . It also deals with management of critical and non critical load based on scheduling information received via eco platform tool.

Scope	Development of hardware and implementation of advanced metering functionalities such as programmable load control, dynamic pricing and scheduling of loads to increase consumer satisfaction and cost efficiency
Requirements	-suitable hardware to control critical/non critical/other class of loads
	-Real-time data collection
	-Interface with ecoPlatform to receive value for max permissible load
Related KPIs	5. SAIDI
	28. Energy savings
	54. User satisfaction contributing to aggregated flexibility
Actors	System operators, consumers
Triggering event	Periodically
RE-EMPOWERED tools involved	ecoDR, ecoPlatform
Pre-condition	ecoPlatform tool send max permissible load value and schedule for critical/ noncritical load management, Functionalities validated in laboratory environment
Post-condition	The action of disconnecting the output power by meter will be communicated to ecoPlatform for transmission of the state of meter to the users via ecoCommunity tool. Present status for critical and noncritical output is transmitted to ecoPlatform for its reflection to user on ecoCommunity

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Receive data for max permissible loads	successfully receive the scheduling data	schedule/ table for each class of load	ecoPlatform	smart meter
2	Receive data for scheduling of loads	successfully receive the scheduling data	schedule/ table for each class of load	ecoPlatform	smart meter

Realization

Responsible partner	CMERI
Contributing partners	ICL,DTU

Use case ID	DR_2UC2.1 - Scheduling of loads
High level UCs	DR_1UC1 - Integration Interfaces for Load Management
Classification	Secondary Use Case
Description	This UC deals with the scheduling of non critical and flexible loads. The proposed scheme attempts to coordinate the available flexibility so as to increase the operational effectiveness of the network. The ecoDR receives the information regarding the load schedule and is responsible to implement it. This UC will also deal with the design of supporting hardware and software to implement the scheduler shared by ecoCommunty tool. This UC will also ensure manual override.
Scope	Scheduling of non-critical and flexible loads to increase consumer satisfaction and cost efficiency
Requirements	- Suitable hardware to control of non critical and flexible loads - Interface with ecoCommunty/ecoPlatform to receive and transmit load schedule data
Related KPIs	5. SAIDI
	54. User satisfaction contributing to aggregated flexibility
	28. Energy savings
Actors	System operators, consumers
Triggering event	Periodically
RE-EMPOWERED tools involved	ecoDR, ecoPlatform, ecoCommunty
Pre-condition	- Schedule for flexible and non critical loads to be available - Functionalities validated in laboratory environment
Post-condition	Present status for critical and non critical output is transmitted to ecoCommunty/ecoPlatform for its reflection to users.

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Receive data for scheduling of loads	Successfully receive the scheduling data	Schedule/ table for each class of load	ecoCommunty/ecoPlatform	smart meter
2	Timer interrupt/scheduling points	Turn on/off specific class of loads as per the schedule	-	ecoDR	ecoDR
3	Receive data for manual override on schedule	Successfully receive the manual scheduling data	schedule/ table for manual override for each class of load	ecoCommunty/ecoPlatform	smart meter

Realization	
Responsible partner	CMERI
Contributing partners	ICL,DTU

Use case ID	**DR_2UC2.2 - Programmable Load shedding controller**
High level UCs	DR_1UC2 Integration Interfaces for Load Management
Classification	Secondary Use Case
Description	This UC deals with control to regulate the output load connected via meter to max permissible load to be powered through meter output . It does this by comparing the sampled value of power consumed by load via output terminal of meter with the received value of max permissible load. if measured value of the load is greater then max permissible load then the meter will disconnect the output electrical power for fixed duration of time. After the fixed duration of time is over, meter will resume the output electrical power and again compare the output power and max permissible power and repeat the same actions as detailed before. On receiving the command for new value for max permissible load meter will store the new value in its non volatile memory and compare the measured value of output power and max permissible load and take actions based on result as already detailed.
Scope	Recieve the max threshold value of permissible load and regulate it at the meter output.
Requirements	Technical requirements: communication networks up and running
	Interface with ecoPlatform to receive max permissible load
Related KPIs	5. SAIDI
	54. User satisfaction contributing to aggregated flexibility
	28. Energy savings
Actors	Consumers, system operators
Triggering event	Periodically
RE-EMPOWERED tools involved	ecoDR, ecoPlatform
Pre-condition	ecoPlatform tool send max permissible load value
Post-condition	The action of disconnecting the output power by meter will be communicated to ecoPlatform for transmission of the state of meter to the users via ecoCommunity tool.

Step by step analysis

Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Receive data for max permissible loads	successfully receive the scheduling data	schedule/ table for each class of load	ecoPlatform	ecoDR
2	Timer interrupt	turn on/off output power for loads for a fixed duration like 5 minutes	-	ecoDR	-
Realization					
Responsible partner		CMERI			
Contributing partners		ICL, DTU			

F. Annex 6 Use Cases definition for ecoPlatform

2UCs	PF_1UC1: Microgrid data acquisition
PF_2UC1.1	Data acquisition and monitoring
PF_2UC1.2	Data cleansing to ensure consistency and visualization
	PF_1UC2: Platform as a service for dependent tools integration
PF_2UC2.1	Facilitate data exchange between dependent tools
PF_2UC2.2	Facilitate access to controllable assets for dependent tools
	PF_1UC3: Data storage and cloud server
PF_2UC3.1	Data cloud storage
PF_2UC3.2	Facilitate archived data access for dependent tools using API

Use case ID	PF_1UC1-Microgrid data acquisition
High level UCs	
Classification	Primary Use Case
Description	This use case addresses the data acquisition in the microgrid. This use case consists of two main components. 1. Communication should be in place to connect sensors and acquire data that are used by the other tools. 2. Data cleansing
Scope	Provide the operator the state of the microgrid to assist in the decision making
Requirements	Scalability
	Data interoperability
	Reliable sensors and communication networks
	- use of specific communication protocol
	- data privacy
Related KPIs	32. Data reliability
	31. Availability of the communication infrastructure
	58. Use of protocol standards

Actors	MGCC, Microgrid Operator, Prosumer, DSO				
Triggering event	Self running, automatic based on predefined time resolution and sequence				
RE-EMPOWERED tools involved	ecoPlatform				
Pre-condition	Sensors and communication network availability, Data selection for monitoring, Data availability				
Post-condition	The microgrid operator can observe the state of the microgrid in real-time				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data acquisition from sensors, databases of other tools	Acquire the data in real-time and direct to cloud storage	Power, energy, temperature, irradiance,	MGCC, Gateways, Sensors, Database of other tools	EcoPlatform Hub
2	Monitoring	A light weight dashboard for data monitoring		ecoPlatform Hub	Microgrid operator
Realization					
Responsible partner	DTU				
Contributing partners	NTUA, ICL, IITK, IISc				

Use case ID	**PF_2UC1.1-Connect to sensors and acquire data through designated communication network and protocols**
High level UCs	Microgrid data acquisition
Classification	Secondary Use Case
Description	This use case concerns ecoPlatforms' functionality of acquiring data from various developed solutions. Communication interoperability from the data derived from ecoMicrogrid, intelligent electronic devices, and smart meters will be ensured based on the conclusions of Task 5.1. In addition, sensed weather data, including the solar irradiance, could also be integrated using MQTT over LoRaWAN.
Scope	Make platform interoperable for the integration of all developed solutions
Requirements	ensure interoperability between tools developed, Real time data, privacy preservation
Related KPIs	58. Use of protocol standards 32. Data reliability
Actors	Data Concentrator, Operator, MGCC, RE-EMPOWERED tools such as ecoMonitor, ecoDR, ecoCommunity, ecoMicrogrid
Triggering event	Periodically

RE-EMPOWERED tools involved	ecoPlatform, ecoMonitor				
Pre-condition	sensor networks and meters to reach desired observability-The meters and sensors deployed should be open and accessible- Internet access- Data concentrator, databases and gateways have authentication functionality				
Post-condition	Sensed data available in ecoPlatform hub				
Step by step analysis					
Step No.	**Event**	**Process**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Establish Device Identity Registry	Storing information about the devices and databases to be permitted to connect	-	Sensors, gateways, and databases	EcoPlatform hub
2	Authentication	The devices and databases need to be authenticated to ensure security	-		
3	Data transfer	The sensed data and events are transmitted to the cloud storage		Sensors, gateways, and databases	EcoPlatform hub
Exception – Incomplete or lack of available data					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
	Incomplete data	Notifies the operator		EcoPlatform hub	Operator, logging devices
Exception – Network communication issues					
Step No.	**Event**	**Exception handling/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Network communication fails	Notifies the operator and wait for the reestablishment of communication network		EcoPlatform hub	Operator, logging devices
Realization					
Responsible partner	DTU				
Contributing partners	NTUA, ICL, IITK, IISc				

Use case ID	**PF_2UC1.2-Data cleansing to ensure consistency and human machine interface**
High level UCs	Microgrid data acquisition

Classification	Secondary Use Case
Description	As an interface platform that interacts and collects data from various components, a data filtration functionality is necessary for ecoPlatform. The data filtration function will filter out the outliers and fill in missing data due to uncertainties in the sensors or communication channels and prevent penetration of corrupted data into the applications enhancing the reliability and efficiency of the system. A human-machine interface that facilitates the operators to choose the functions to run will also be implemented
Objectives	Ensure data consistency and develop interface for operator
Requirements	1) Robust human machine interface for the operator of the multi-energy system. 2) Ensure consistent datasets 3) Cybersecurity in data acquisition and supervisory control (?)
Related KPIs	32. Data reliability
Actors	Prosumer, DSO, Microgrid Operator, other tools
Triggering event	Periodical
RE-EMPOWERED tools involved	ecoPlatform
Pre-condition	1) Microgrid data is available 2) Correlation between the different tools are established 3) Communication layer between the system components and other tools are established.
Post-condition	A consistent data set of system state and parameters are available. An overview of the system operation will be provided and alarms will be highlighted.

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Raw data cleansing	the raw data from the sensors and meters of the microgrid is checked for any inconsistencies and filtered and cleansed if needed	All sensed and measured data of the microgrid	ecoPlatform hub	Data Storage, human interface dashboard
2	Human machine interface	Data, and events display in a lightweight interface dashboard		ecoPlatform hub	human interface dashboard
Exception #1					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Incomplete data	Notifies the operator		ecoPlatform hub	Operator, Data Storage, human interface dashboard
Realization					
Responsible partner		DTU			
Contributing partners		NTUA, ICL, IITK, IISc			

Use case ID	**PF_1UC2-Platform as a service for dependent tools integration**				
High level UCs					
Classification	Primary Use Case				
Description	One of the major functionalities of the ecoPlatform is to serve as a Platform as a Service (PaaS) that can integrate all the solutions in one software structure. In this way, it can assist the operation of the other tools for data exchange and cooperation.				
Scope	To ensure a reliable interface between the tools				
Requirements	Interoperability between the tools, reliable communication channels				
Related KPIs	31. Availability of the communication infrastructure				
Actors	Microgrid operator, DSO, Prosumer				
Triggering event	Periodically, Based on request				
RE-EMPOWERED tools involved	ecoPlatform				
Pre-condition	Data acquisition system and communication interface between the tools are established				
Post-condition	API access to dependent tools for data exchange and cooperation				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Establish communication between the tools	A reliable communication channel between the tools are established	-	Dependent tools, sensors, MGCC, Gateways	Ecoplatform

2	Connection security	The interfaces will be authenticated and authorized by Ecoplatform Hub to ensure security	-	Dependent tools, sensors, MGCC, Gateways	Ecoplatform
3	Facilitate data transfer and control action	The data is transferred based on the request of a dependent tool	sensed values, microgrid states, control actions		
Exception #1					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Wrong or uncertain measurements	Suspension	Signals	N/A	N/A
Exception #2					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
Realization					
Responsible partner	DTU				
Contributing partners	ICCS				

Use case ID	**PF_2UC2.1-Facilitate data exchange between dependent tools**
High level UCs	**PF_1UC2-Platform as a service for dependent tools integration**
Classification	Secondary Use Case
Description	ecoPlatform will serve as a platform for data transfer between the dependent tools. The provision of data transfer in near-real-time with low latency and slower archived data will be available. The transfer access will be authenticated and authorized by the ecoPlatform
Scope	To ensure a reliable data transfer between the tools
Requirements	Interoperability between the tools, reliable communication channels, Dependent tools capable of data transfer with cloud, Access to the internet

Related KPIs	31. Availability of the communication infrastructure
Actors	Microgrid operator, DSO, Prosumer
Triggering event	Periodically, Based on request from the tools
RE-EMPOWERED tools involved	ecoPlatform
Pre-condition	Data acquisition system and communication interface between the tools are established
Post-condition	API access to dependent tools for data exchange

Step by step analysis

Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Connection security	The interfaces will be authenticated and authorized by EcoPlatform Hub to ensure security	-	Dependent tools, sensors, MGCC, Gateways	EcoPlatform
2	Data handling and transfer	The incoming data is to be handled and transferred without delay as and when required and also stored in a short-term backup for disaster recovery	sensed values, microgrid states,	RE-EMPOWERED tools	RE-EMPOWERED dependent tools

Exception #1

Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Wrong or uncertain measurements	Suspension of the data transfer with flagging error signal, also notifies the operator. Retries the connection attempts	Error Signals with ID	RE-EMPOWERED tools, sensors, meters	RE-EMPOWERED dependent tools, Ecoplatform, Operator
2	Challenges with software interface for data transfer	API for data transfer between the tools might become sensitive to an external request. The connection request is retried periodically and the tool requesting the data is notified with an error signal.	Error Signals with ID	RE-EMPOWERED tools, sensors, meters	RE-EMPOWERED dependent tools, Ecoplatform, Operator

Exception #2

Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
2	Network communication issues	Several of the demo sites are located at remote places, and possibilities of network	ERROR signal with ID	RE-EMPOWERED tools, sensors, meters	RE-EMPOWERED dependent tools, Ecoplatform, Operator

		outage is high. Notifies the operator and periodically retries to connect.			
Realization					
Responsible partner	DTU				
Contributing partners					

Use case ID	**PF_2UC2.2-Facilitate access to controllable assets for dependent tools**				
High level UCs	**PF_1UC2-Platform as a service for dependent tools integration**				
Classification	Secondary Use Case				
Description	There are several controllable assets in the planned demos. The Eco platform can serve as an intermediary for software-based tools to convey commands to controllable assets, either directly integrated into the Eco platform or indirectly via other tools developed in the project. In the response, the ecoPlatform also notifies the status of the controllable assets back to the entity sending the commands.				
Scope	To ensure interoperable between the tools				
Requirements	Communication between the tools are available and open, Communication drivers for the controllabel assets are known, low latency between the endpoints				
Related KPIs	31. Availability of the communication infrastructure				
Actors	Microgrid operator, Controllable assets				
Triggering event	Based on request from the tools or operator				
RE-EMPOWERED tools involved	ecoPlatform, ecoMicrogrid				
Pre-condition	communication interface between the tools are established				
Post-condition	API access to dependent tools for transferring commands to controllable assets				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Control command transfer	Transfer the commands for controllable assets either directly or to tools that supervises the controllable assets	Command signals	Dependent tools, ecoPlatform	Controllable assets

Exception #1					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Overriding the commands due to conflicts	Depending on the state of the microgrid multiple commands from different tools could create a conflict. The	Commands	RE-EMPOWERED tools, sensors, meters, MGCC	Controllable assets
Exception #2					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
2	Network communication issues	Several of the demo sites are located at remote places, and possibilities of network outage is high. Notifies the operator and periodically retries to connect.	ERROR signal with ID	RE-EMPOWERED tools controllable assets	RE-EMPOWERED dependent tools, ecoPlatform, Operator
Realization					
Responsible partner	DTU				
Contributing partners	ICCS				

Use case ID	**PF_1UC3- Data storage and cloud server**
High level UCs	
Classification	Primary Use Case
Description	ecoPlatform will also serve as a data storage hub for dependent tools. ecoPlatform will facilitate short-term storage for data and command stream requiring low latency. Also, it is possible to archive the data to be used by other tools or for research. Both Data from the cloud server should be able to be queried by other tools
Scope	To provide cloud storage solution and API to the applications
Requirements	Interoperability between the data points, server, and data query
Related KPIs	31. Availability of the communication infrastructure 32. Data reliability
Actors	Microgrid operator, DSO,
Triggering event	Periodically, upon request
RE-EMPOWERED tools involved	ecoPlatform
Pre-condition	Communication interface between the tools and the cloud server are established

Post-condition	API availability for accessing the data				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Data storage setup	Setting up the data storage solution in the cloud	-		
2	Storing the data	The data will be stored in cloud	Sensed data, state of microgrid	MGCC, sensors, Tools	ecoPlatform
3	API access for data	Data access via API with authentication will be available for tools	Sensed data, state of microgrid	ecoPlatform	MGCC, sensors, Tools
Realization					
Responsible partner	DTU				
Contributing partners	NTUA, ICL, IITKGP, IISc				

Use case ID	**PF_2UC3.1- Route the microgrid data and data from dependent tools to cloud database**
High level UCs	PF_1UC3- Data storage and cloud server
Classification	Secondary Use Case
Description	The data stream, microgrid states, and commands necessary for real-time processing need to be routed to storage optimized for fast access. Such storage can also be accessed for disaster recovery. However, longer-term data that are not time-critical will be routed to cost-effective storage, which is comparatively slow to access.
Scope	To provide cloud storage solution with low latency in access and data archiving
Requirements	Communication channels between the tools already established
Related KPIs	32. Data reliability
Actors	Microgrid operator, DSO,
Triggering event	Periodically, upon request
RE-EMPOWERED tools involved	ecoPlatform
Pre-condition	Communication interface between the tools and the cloud server are established
Post-condition	API availability for accessing the data
Step by step analysis	

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
2	Routing the data to storages	The data will be stored in cloud. The relevant data for fast access will be stored separately from long term larger data sets which needs to be archived	Sensed data, state of microgrid	MGCC, sensors, Tools	ecoPlatform
Realization					
Responsible partner		DTU			
Contributing partners		NTUA, ICL, IITK, IISc			

Use case ID	**PF_2UC3.2- Facilitate archived data access for dependent tools using API**
High level UCs	1UC3- Data storage and cloud server
Classification	Secondary Use Case
Description	API's will be provided for accessing the data archived by ecoPlatform. Archived long term data could be utilized in improving the effectiveness of forecasting
Scope	To provide access to cloud storage
Requirements	Communication channels between the tools already established
Related KPIs	32. Data reliability
Actors	Microgrid operator, DSO,
Triggering event	Upon request
RE-EMPOWERED tools involved	ecoPlatform
Pre-condition	Communication interface between the tools and the cloud server are established
Post-condition	API availability for accessing the data
Realization	
Responsible partner	DTU
Contributing partners	NTUA, ICL, IITKGP, IISc

G. Annex 7 Use Cases definition for ecoMonitor

	MON_1UC1: Drinking water quality surveillance
MON_2UC1.1	Acquisition and monitoring of water quality
MON_2UC1.2	Data processing and evaluation

<table>
<tr><th colspan="2">Use case ID</th><th colspan="4">MON_1UC1 - Monitoring drinking water quality parameters</th></tr>
<tr><td colspan="2">High level UCs</td><td colspan="4">HLUC-7</td></tr>
<tr><td colspan="2">Classification</td><td colspan="4">Primary Use Case</td></tr>
<tr><td colspan="2">Description</td><td colspan="4">Monitoring drinking water is critical for securing health gains for the rural communities which have less access both to safe water and to water quality information. Monitoring water safety includes two main components: The first component is responsible for the acquisition of Water quality parameters based on the desired water parameters of concern (temperature, dissolved oxygen, pH, conductivity, ORP, etc.). The second aspect involves processing and evaluation of the collected data. Monitoring data must be available for both decision makers and end users. This 1UC describes the community level solar powered monitor and analysis tool for water quality surveillance.</td></tr>
<tr><td colspan="2">Scope</td><td colspan="4">Purified water, water quality parameters</td></tr>
<tr><td colspan="2" rowspan="2">Requirements</td><td colspan="4">-Energy access for operation of water purification plant</td></tr>
<tr><td colspan="4">-Water sample collection for monitoring of water quality parameters</td></tr>
<tr><td colspan="2">Related KPIs</td><td colspan="4">54. User satisfaction contributing to aggregated flexibility</td></tr>
<tr><td colspan="2">Actors</td><td colspan="4">Consumers</td></tr>
<tr><td colspan="2">Triggering event</td><td colspan="4">Periodically</td></tr>
<tr><td colspan="2">RE-EMPOWERED tools involved</td><td colspan="4">ecoMonitor</td></tr>
<tr><td colspan="2">Pre-condition</td><td colspan="4">Successfully collection of water samples at periodic interval</td></tr>
<tr><td colspan="2">Post-condition</td><td colspan="4">Necessary corrective action such as backwashing or replacement of filet after analysis of water quality parameters</td></tr>
<tr><td colspan="6">Step by step analysis</td></tr>
<tr><td>Step No.</td><td>Event</td><td>Process/activity</td><td>Info. Exchanged</td><td>Actor producing info</td><td>Actor receiving info</td></tr>
</table>

1	Water samples collection	successfully collection of water samples at periodic interval	Water quality parameters	ecoMonitor	ecoMonitor
2	Water quality analysis	Analysis of water quality parameters at laboratory environment	-	ecoMonitor	-
Realization					
Responsible partner		CMERI			
Contributing partners					

Use case ID		**MON_2UC1.1 - Acquisition and monitoring of water quality**			
High level UCs		MON_1UC1 - Drinking water quality surveillance			
Classification		Secondary Use Case			
Description		This 2UC deals with the collection of water samples from the field at regular interval.			
Scope		Purified drinking water			
Requirements		-Energy access for operation of water purification plant			
Related KPIs		54. User satisfaction contributing to aggregated flexibility			
Actors		Local communities, Residents			
Triggering event		-			
RE-EMPOWERED tools involved		ecoMonitor			
Pre-condition					
Post-condition		Collection of water samples at regular interval for water quality parameter analysis			
Step by step analysis					
No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Collecting Samples	At regular base samples are collected from the field. All samples are accompanied by an appropriate collection form and are handling according to the standards.	Water samples	ecoMonitor	ecoMonitor
2	Storage of samples	Samples are temporarily stored for the further analysis.	Water samples	ecoMonitor	ecoMonitor
Realization					
Responsible partner		CMERI			

<table>
<tr><th colspan="2">Use case ID</th><th colspan="4">MON_2UC1.2 - Data processing and evaluation</th></tr>
<tr><td colspan="2">High level UCs</td><td colspan="4">MON_1UC1 - Drinking water quality surveillance</td></tr>
<tr><td colspan="2">Classification</td><td colspan="4">Secondary Use Case</td></tr>
<tr><td colspan="2">Description</td><td colspan="4">This UC deals with the analysis of water quality parameters in laboratory environment.</td></tr>
<tr><td colspan="2">Scope</td><td colspan="4">Water quality parameter analysis</td></tr>
<tr><td colspan="2">Requirements</td><td colspan="4">Water quality analysis set up such as TDS testers for measurement of total concentration of dissolved substances, pH meters to monitor its chemical properties (acidic/alkaline), digital thermometers for temperature measurement, conductivity meter for salinity measurement etc</td></tr>
<tr><td colspan="2">Related KPIs</td><td colspan="4">54. User satisfaction contributing to aggregated flexibility</td></tr>
<tr><td colspan="2">Actors</td><td colspan="4">Residents, system operator, Local community</td></tr>
<tr><td colspan="2">Triggering event</td><td colspan="4">Periodically</td></tr>
<tr><td colspan="2">RE-EMPOWERED tools involved</td><td colspan="4">ecoMonitor</td></tr>
<tr><td colspan="2">Pre-condition</td><td colspan="4">Successfully collection of water samples at periodic interval</td></tr>
<tr><td colspan="2">Post-condition</td><td colspan="4">Necessary corrective action such as backwashing or replacement of filter after analysis of water quality parameters</td></tr>
<tr><td colspan="6">Step by step analysis</td></tr>
<tr><td>Step No.</td><td>Event</td><td>Process/activity</td><td>Info. Exchanged</td><td>Actor producing info</td><td>Actor receiving info</td></tr>
<tr><td>1</td><td>Water quality analysis</td><td>Analysis of water quality parameters at laboratory environment</td><td>-</td><td>ecoMonitor</td><td>Relevant stakeholders</td></tr>
<tr><td colspan="6">Realization</td></tr>
<tr><td colspan="2">Responsible partner</td><td colspan="4">CMERI</td></tr>
</table>

H. Annex 8 Use Cases definition for ecoCommunity

2UCs	CM_1UC1: Dynamic pricing of electricity
CM_2UC1.1	Displaying the dynamic pricing based on shape of energy profile
CM_2UC1.2	Billing and payments
CM_2UC1.3	Data security and privacy
	CM_1UC2: Scheduling and Coordination
CM_2UC2.1	Facilitating(display) of the scheduling and shifting of non-critical and flexible loads
CM_2UC2.2	Coordination of communal/shared loads
	CM_1UC3: Outreach forum
CM_2UC3.1	Feedback and suggestions from users about the tools
CM_2UC3.2	Reporting of problems
CM_2UC3.3	Forum to share experiences
	CM_1UC4: Guidance and Training
CM_2UC4.1	Training material (troubleshooting)
CM_2UC4.2	Easy-to-use multimedia material and step-by-step guides (walkthroughs)

Use case ID	**CM_1UC1: Dynamic pricing of electricity**
High level Ucs	HLUC-2
Classification	Primary Use Case
Description	This 1UC1 addresses the dynamic pricing of electricity. Varying price signals with colour coding and time slots will be displayed to the consumers in this platform. This increases the flexibility potential of consumers. Dynamic pricing structure incentivises the consumers to modify their behaviour and time-shift their energy usage. This will provoke high consumer engagement. This platform also displays the billing information to consumers and allows them to pay the bills online. Security and privacy of the sensitive consumers data will be ensured. The data models of dynamic pricing will be based on the international standard IEC-62746-10-1.
Scope	Pricing, billing and payments
Requirements	-Metering Data availability
	-Forecasting of generation and load data

	-Type and structure of data
	-Real-time data collection
	-Load profile
	-Data privacy
Related KPIs	23. Automatic metering of consumers
	32. Data reliability
	29. (Buildings) Final consumption
	8. Peak load reduction
	33. Data security control
	9. Load peak-to-average
	40. Energy cost
	28. Energy savings
Actors	Consumers, Aggregators, System operators
Triggering event	Periodically
RE-EMPOWERED tools involved	ecoCommunity
Pre-condition	Metering data availability & reliability, Dynamic pricing information, Functionalities validated in laboratory environment
Post-condition	

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Dynamic Pricing	Getting varying pricing signals and displaying to consumers	Pricing signals	TBD	Consumers
2	Customer Billing	Billing information will be displayed to the consumers	Billing signal	TBD	Consumers
3	Payments gateway	An option of paying bills online will be provided			

Realization

Responsible partner	ICL
Contributing partners	DTU, IISc, CSIR-CMERI

Use case ID	**CM_2UC1.1: Displaying the dynamic pricing based on shape of energy profile**
High level UCs	HLUC-2

Classification	Secondary Use Case				
Description	The 2UC1.1 is about displaying the dynamic pricing of electricity based on shape of energy profile. The information about the shape of energy profile will be obtained from the DSM mechanism implemented in Task 3.2. Varying price signals with colour coding and time slots will be displayed to the consumers through this platform. This increases the flexibility potential of consumers.				
Scope	Dynamic pricing display				
Requirements	-Load profile availability				
	Dynamic pricing information				
	-Type and structure of data				
	-Real-time data collection				
	- Forecast Load profile				
	-Data privacy				
Related KPIs	32. Data reliability				
	8. Peak load reduction				
	9. Load peak-to-average				
Actors	Consumers, Aggregators, System operators				
Triggering event	Periodically				
RE-EMPOWERED tools involved	ecoCommunity				
Pre-condition	Dynamic pricing information				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Dynamic Pricing	Getting varying pricing signals and displaying to consumers	Pricing signals	ecoDR	Consumers
Realization					
Responsible partner	ICL				
Contributing partners	DTU, IISc, CSIR-CMERI				

Use case ID	CM_2UC1.2: Billing and payments				
High level Ucs	HLUC-2				
Classification	Secondary Use Case				
Description	This 2UC1.2 addresses the billing and payments. The electricity consumption based on the dynamic pricing will be calculated and the billing information will be displayed to the consumers. A secured payment gateway will be present which allows the customers to pay the bills seamlessly.				
Scope	Billing, payments				
Requirements	-Metering Data availability				
	-Tariff information				
	-Type and structure of data				
	-Real-time data collection				
	-Data privacy				
Related KPIs	23. Automatic metering of consumers				
	32. Data reliability				
	29. (Buildings) Final consumption				
	40. Energy cost				
	28. Energy savings				
Actors	Consumers, Aggregators, System operators				
Triggering event	Periodically				
RE-EMPOWERED tools involved	ecoCommunity				
Pre-condition	Metering data availability & reliability				
Post-condition					
Step by step analysis					
Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info

1	Customer Billing	Billing information will be displayed to the consumers	Billing signal	TBD	Consumers
2	Payments gateway	An option of paying bills online will be provided	Payments	Consumers	Operator
Realization					
Responsible partner	ICL				
Contributing partners	DTU, IISc, CSIR-CMERI				

Use case ID	**CM_2UC1.3: Data security and privacy**
High level Ucs	HLUC-2
Classification	Secondary Use Case
Description	This 1UC1 addresses the data security and privacy. This is important because the personal and sensitive information of the customers is involved. In this platform both security and privacy of the consumers data will be ensured. The data models of dynamic pricing will be built based to the international standard IEC-62746-10-1.
Scope	Security and privacy
Requirements	-Metering Data availability
	-Type and structure of data
	-Real-time data collection
	-Load profile
	-Data privacy
Related KPIs	32. Data reliability
	33. Data security control
Actors	Consumers, Aggregators, System operators
Triggering event	As and when required
RE-EMPOWERED tools involved	ecoCommunity
Pre-condition	Data security and privacy schemes from DMS

Step by step analysis					
Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Security and Privacy	Load profile and consumption information	Load data	Customer	ecoDR/ecoMicrogrid
Realization					
Responsible partner	ICL				
Contributing partners	DTU, IISc, CSIR-CMERI				

Use case ID	CM_1UC2: Scheduling and Coordination
High level UCs	HLUC-2, HLUC-5
Classification	Primary Use Case
Description	This 1UC2 addresses the scheduling and coordination of loads. Here, the information about availability time slots for different non-critical loads will be displayed. This increases the consumers' flexibility in scheduling the loads. This tool will facilitate(display) scheduling and coordination of communal energy usage information among its members, such as irrigation pumping, to address challenges in sharing communal resources. Coordination helps in optimal operation and reduced variable operating costs for the energy system.
Scope	Scheduling of non-critical loads and communal coordination of loads.
Requirements	-Data Forecasting
	-Type and structure of data
	-Interoperable communication protocols
	-Data privacy
Related KPIs	24. MAPE (Forecasting accuracy)
	32. Data reliability
	30. Self-consumption ratio
Actors	Consumers, Microgrid operator
Triggering event	Based on requirement

RE-EMPOWERED tools involved	ecoCommunity				
Pre-condition	Forecasted Data availability & reliability, Information about different types of load at each demo site for communal sharing				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Display on/off available time slots for non-critical loads	Planning the scheduling activity	Non critical load availability	TBD	Microgrid operator
2	Type of load and time slot information for communal sharing	Coordination of the different communal loads	Booking information displaying type of load, availability, and time slot	TBD	Microgrid operator
Realization					
Responsible partner	ICL				
Contributing partners	CSIR-CMERI, DTU, ICCS-NTUA				

Use case ID	**CM_2UC2.1: Facilitating(display) of the scheduling and shifting of non-critical and flexible loads**
High level UCs	HLUC-2, HLUC-5
Classification	Secondary Use Case
Description	This 2UC2.1 addresses the scheduling of loads. There will be different types of loads in the system like critical, non-critical and flexible loads. The information about availability time slots for different non-critical and flexible loads will be displayed. This increases the consumers' flexibility in scheduling the loads.
Scope	Scheduling of non-critical and flexible loads
Requirements	-Load Forecasting
	-Type and structure of data
	-Interoperable communication protocols
	-Data privacy
Related KPIs	24. MAPE (Forecasting accuracy)

	32. Data reliability				
	30. Self-consumption ratio				
Actors	Consumers, Microgrid operator				
Triggering event	Based on requirement				
RE-EMPOWERED tools involved	ecoCommunity				
Pre-condition	Forecasted Data availability & reliability				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Display on/off available time slots for non-critical loads	Planning the scheduling activity	Non critical load availability	ecoCommunity	Microgrid operator
Realization					
Responsible partner	ICL				
Contributing partners	CSIR-CMERI, DTU, ICCS-NTUA				

Use case ID	**CM_2UC2.2: Coordination of communal/shared loads**
High level UCs	HLUC-2, HLUC-5
Classification	Secondary Use Case
Description	This 2UC2.2 addresses the coordination of communal loads. The communal loads like irrigation pumps will be shared among the communal members - a booking fixed time slot based matrix tool will be developed to realize this functionality. This tool will facilitate(display) coordination of communal energy usage information among the members. This address challenges in sharing communal resources. Coordination helps in optimal operation and reduced variable operating costs for the energy system.
Scope	Communal coordination of loads.
Requirements	-Load Forecasting
	-Type and structure of data

	-Interoperable communication protocols				
	-Data privacy				
Related KPIs	24. MAPE (Forecasting accuracy)				
	32. Data reliability				
	30. Self-consumption ratio				
Actors	Consumers, Microgrid operator				
Triggering event	Based on requirement				
RE-EMPOWERED tools involved	ecoCommunity				
Pre-condition	Information about different types of load at each demo site for communal sharing				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Type of load and time slot information for communal sharing	Coordination of the different communal loads	Booking information displaying type of load, availability and time slot	ecoCommunity	Microgrid operator
Realization					
Responsible partner	ICL				
Contributing partners	CSIR-CMERI, DTU, ICCS-NTUA				

Use case ID	**CM_1UC3: Outreach forum**
High level UCs	HLUC-6
Classification	Primary Use Case
Description	The 1UC3 is related to building a forum where users can share experience, which will increase the communal engagement. Also, consumers can report issues, register suggestions for improvements and interact with each other with respect to the energy system as a community. Consumers will have the provision to report the problems like repair works and to call for immediate response. This use case helps in modifying the tools according to customer needs and further development of the tools.
Scope	Suggestions, report issues and share feedback
Requirements	Data storage
	Data handling and processing

Related KPIs		50. Participant recruitment			
		51. Active participation			
		54. User satisfaction contributing to aggregated flexibility			
		52. Customer acceptance			
Actors		Consumers			
Triggering event		Based on requirement			
RE-EMPOWERED tools involved		ecoCommunity			
Pre-condition		Data storage, data handling and processing			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Low priority notifications	Portal for feedback, suggestions and reporting issues	Feedback, suggestions and issues	Consumers	Microgrid operator
2	High priority notifications	Reporting of repairs, calling for immediate response.	Repair alerts	Consumers	Microgrid operator
3	Forum	Sharing experiences for communal engagement	Experiences	Consumers	Microgrid operator
Realization					
Responsible partner		ICL			
Contributing partners		BV			

Use case ID	**CM_2UC3.1: Feedback and suggestions from users about the tools**
High level UCs	HLUC-6
Classification	Secondary Use Case
Description	The 2UC3.1 is about collecting feedback and suggestions from the customers about the tool. Here the customers can provide feedback, register suggestions for improvements.
Scope	Suggestion and feedback
Requirements	Data storage
	Data handling and processing
Related KPIs	50. Participant recruitment
	51. Active participation
	54. User satisfaction contributing to aggregated flexibility
	52. Customer acceptance

Actors	Consumers				
Triggering event	Based on requirement				
RE-EMPOWERED tools involved	ecoCommunity				
Pre-condition	Data storage, data handling and processing				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Low priority notifications	Portal for feedback, suggestions and reporting issues	Feedback, suggestions and issues	Consumers	Microgrid operator
Realization					
Responsible partner	ICL				
Contributing partners	BV				

Use case ID	**CM_2UC3.2: Reporting of problems**
High level UCs	HLUC-6
Classification	Secondary Use Case
Description	The 2UC3.2 is related with development of an interface to report problems. Here, consumers can report issues about the tool, also they will have the provision to report the problems like repair works and to call for immediate response.
Scope	Report issues
Requirements	Data storage
	Data handling and processing
Related KPIs	50. Participant recruitment
	51. Active participation
	54. User satisfaction contributing to aggregated flexibility
	52. Customer acceptance
Actors	Consumers
Triggering event	Based on requirement
RE-EMPOWERED tools involved	ecoCommunity
Pre-condition	Data storage, data handling and processing
Step by step analysis	

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	High priority notifications	Reporting of repairs, calling for immediate response.	Repair alerts	Consumers	Microgrid operator
Realization					
Responsible partner		ICL			
Contributing partners		BV			

Use case ID	**CM_2UC3.3: Forum to share experiences**
High level UCs	HLUC-6
Classification	Secondary Use Case
Description	The 2UC3.3 is related to building a forum where users can share experience about the energy system, which will increase the communal engagement.
Scope	Forum to share experiences
Requirements	Data storage
	Data handling and processing
Related KPIs	50. Participant recruitment
	51. Active participation
	54. User satisfaction contributing to aggregated flexibility
	52. Customer acceptance
Actors	Consumers
Triggering event	Based on requirement
RE-EMPOWERED tools involved	ecoCommunity
Pre-condition	Data storage, data handling and processing
Step by step analysis	

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Forum	Sharing experiences for communal engagement	Experiences	Consumers	Microgrid operator
Realization					

Responsible partner	ICL
Contributing partners	BV

Use case ID	**CM_1UC4: Guidance and Training**
High level UCs	HLUC-6
Classification	Primary Use Case
Description	The 1UC4 is related to guidance and training platform development. This platform will have guidance and training material on how to use various equipment. The service manuals will help the local technicians to learn about different equipment easily. Different multimedia material and step-by-step guides will be provided to help the consumers in using the tool easily.
Scope	Guidance and training
Requirements	Training and step by step guide materials from each tool leader
	Data storage
	Data handling and processing
Related KPIs	50. Participant recruitment
	51. Active participation
	54. User satisfaction contributing to aggregated flexibility
	53. EnC participation/adoption
Actors	Consumers, Microgrid operator
Triggering event	Based on requirement
RE-EMPOWERED tools involved	ecoCommunity
Pre-condition	Training materials from each tool leader, Data storage, Data handling and processing

Step by step analysis

Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Guidance and training material	Service manuals of various equipments for helping the local technicians.	Operating manuals	Microgrid operator	Consumers (local technicians)

2	Walkthrough information guides	Developing interactive interface containing multimedia material and step-by-step guides, about how to use the appropriate customer targeted tools like ecoCommunity.	Multimedia material	Microgrid operator	Consumers
Realization					
Responsible partner	ICL				
Contributing partners	IITD, CSIR-CMERI, BV, IIT-KGP				

Use case ID	**CM_2UC4.1: Training material (troubleshooting)**
High level UCs	HLUC-6
Classification	Secondary Use Case
Description	The 2UC4.1 is related to storing of training material. This platform will have training material on how to use various equipment. Various service manuals will be made available so as to help the local technicians to learn about different equipment easily.
Scope	Training material
Requirements	Training materials from each tool leader
	Data storage
	Data handling and processing
Related KPIs	50. Participant recruitment
	51. Active participation
	54. User satisfaction contributing to aggregated flexibility
	53. EnC participation/adoption
Actors	Consumers, Microgrid operator
Triggering event	Based on requirement
RE-EMPOWERED tools involved	ecoCommunity
Pre-condition	Training materials from each tool leader, Data storage, Data handling and processing
Step by step analysis	

Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Guidance and training material	Service manuals of various equipment for helping the local technicians.	Operating manuals	Microgrid operator	Consumers(local technicians)
Realization					
Responsible partner	ICL				
Contributing partners	IITD, CSIR-CMERI, BV, IIT-KGP				

Use case ID	**CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)**				
High level UCs	HLUC-6				
Classification	Secondary Use Case				
Description	The 2UC4.2 is related to storing of multimedia material and step-by-step guides. In this platform, different multimedia material and step-by-step guides will be provided to help the consumers in using the relevant tools, viz ecoCommunity, easily.				
Scope	Guidance and training				
Requirements	Step by step guides from each tool leader				
	Data storage				
	Data handling and processing				
Related KPIs	50. Participant recruitment				
	51. Active participation				
	54. User satisfaction contributing to aggregated flexibility				
	53. EnC participation/adoption				
Actors	Consumers, Microgrid operator				
Triggering event	Based on requirement				
RE-EMPOWERED tools involved	ecoCommunity				
Pre-condition	Multimedia and step-by-step materials from each tool leader, Data storage, Data handling and processing				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**

1	Walkthrough information guides	Developing interactive interface containing multimedia material and step-by-step guides, about how to use the appropriate customer targeted tools like ecoCommunity.	Multimedia material	Microgrid operator	Consumers
Realization					
Responsible partner		ICL			
Contributing partners		IITD, CSIR-CMERI, BV, IIT-KGP			

I. Annex 9 Use Cases definition for ecoResillience

2UCs	RES_1UC1: Optimal passive resilient support structure for solar photovoltaic system
RES_2UC1.1	Optimal selection of parameters
RES_2UC1.2	Computational fluid dynamics (CFD) and structural analysis (CSA) of support structures
RES_2UC1.3	Experimental validation of the designed structure through wind tunnel testing
RES_2UC1.4	Design of resilient foundation for solar photovoltaic system
	RES_1UC2: Improved resilient tower and passive mechanism for wind turbine blades
RES_2UC2.1	Preliminary design of a tower truss structure and its optimization
RES_2UC2.2	Design of a resilient mechanism to reduce wind loads on blades and its optimization
RES_2UC2.3	Laboratory and field testing of the mechanism
RES_2UC2.4	Resilient foundation for wind turbine tower structure
	RES_1UC3: WT Local Manufacturing and Testing
RES_2UC3.1	Testing of Small Wind Turbines using Standards

Use case ID	RES_1UC1: Optimal passive resilient support structure for solar photovoltaic system
High level UCs	HLUC-1, HLUC-3, HLUC-6, HLUC-8, HLUC-9
Classification	Primary Use Case
Description	This 1UC1 addresses the optimal design procedure for the development of self-adaptive passive solar photovoltaic systems to minimize the wind loads during severe cyclonic conditions. A mechanism will be developed to bring the incident angle of the solar panels to near zero to minimize the drag and lift forces. This subsequently reduces the overall load on the support structures and foundation.
Scope	Development of resilient structure for photovoltaic system
Requirements	-Preliminary conceptual design
	- Cyclone data and selection of critical wind speed
	-Optimization of structures through numerical simulations
	-Experimental validation
	-Materials for concave and convex structures
	-Materials to make resilient support structures
Related KPIs	38. Wind-resilient infrastructure
	61. EnC replication potential
	21. Safety

		55. Skill/Knowledge acquirement 19. Increase of environmental awareness			
Actors		Critical wind velocity			
Triggering event		-Adverse environmental condition			
RE-EMPOWERED tools involved		ecoResilience			
Pre-condition		Cyclone data, Functionalities validated in laboratory environment			
Post-condition		Reliable operation at the designed solar incidence angle at the specified location			
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Preliminary design	Aerodynamic data of different structures, cyclone data, Calculation of loads and moments during positive and negative wind velocities	loads and moments, size of add on structures	Literature, hand books	TBD
2	Optimal selection of parameters	Selection of critical wind velocity, and optimization of slit size and size of addon structures through iterative procedure	Wind velocity, loads and moments, deflection	Analytical calculations	TBD
3	CFD and CSA of support struture of photovoltaic system	CFD simulations at different wind velocities, CSA to choose appropriate size of support structure dimensions	loads and moments, deflection, stress distribution	Numerical simulations	TBD
4	Experimental validation of designed structures	Wind tunnel testing of scale down models and rope testing to validate the CFD results	loads and moments, deflection of solar panels	Laboratory and field testing	TBD
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Normal operating condition	solar panel remains at position	wind velocity	Ambient condition	TBD
Realization					
Responsible partner		CSIR-CMERI			

Use case ID	**RES_2UC1.1 - Optimal selection of parameters**
High level UCs	HLUC-1, HLUC-3, HLUC-6, HLUC-8, HLUC-9

Classification	Secondary Use Case				
Description	This 2UC1.1 addresses the preliminary design of wind adaptive support structure for solar photovoltaic system based on the selected wind velocity and optimization of the geometrical parameters based on the available aerodynamic data.				
Scope	Optimization of the geometrical parameters				
Requirements	- Aerodynamic data of different bluff bodies				
	- Computer aided design (CAD) software and the design of the support structure				
	-Aerodynamic forces and moments formulae				
	-Computational code for optimization of analytical design				
	-Materials for support structures				
Related KPIs	72.Reliable operation at cyclonic conditions				
	61. EnC replication potential				
	21. Safety				
	55. Skill/Knowledge acquirement				
Actors	Aerodynamic data				
Triggering event	-Designed wind velocity				
RE-EMPOWERED tools involved	ecoResilience				
Pre-condition	Cyclone data, Functionalities validated in laboratory environment				
Post-condition	Reliable operation at the designed solar incidence angle at the specified location				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	
1	Design of CAD model of the structure for the PV system	preparation of model for photovoltaic system with slit and roller support	movement of the base structure	wind velocity	
2	Integration of preliminary add-on concave and convex structures at the top and bottom surface	Calculation of loads and moments about the roller support	moments about the roller support	concave and convex structure	
3	Optimization of the sizes of concave and convex structures through a computer program	Iterative procedure to have clockwise and anti clockwise movement of photovoltaic frame during positive and negative wind velocities	size of concave and convex structures	concave and convex structure	

Realization	
Responsible partner	CSIR-CMERI

Use case ID	**RES_2UC1.2 - Computational fluid dynamics (CFD) and structural analysis (CSA) of support structures**
High level UCs	HLUC-3,HLUC-8, HLUC-9
Classification	Secondary Use Case
Description	This 1UC1.2 addresses the optimization of the adaptive support structure through CFD and CSA perfromed using ANSYS Fluent. These simulations help in finalizing the size of addon structures based on the loads, moments, deformation and stress distribution.
Scope	Analysis of the add-on structures
Requirements	- CAD model of the passive resilient photovoltaic support system
	-Computational mesh and solver, and post processing tool
	-Aerodynamic force coefficients and moments about the support
	-Static structural analysis of support structure
Related KPIs	72.Reliable operation at the designed wind velocity
	61. EnC replication potential
	21. Safety
	55. Skill/Knowledge acquirement
Actors	Aerodynamic data
Triggering event	-Designed wind velocity
RE-EMPOWERED tools involved	ecoResilience
Pre-condition	Cyclone data, Functionalities validated in laboratory environment
Post-condition	Reliable operation at the designed solar incidence angle at the specified location

Step by step analysis

Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Preparation of CAD model of the support structure	Selection of details of components of the support structure, preparation of two dimensional sketch and preparation of three dimensional model from components	Details of components	CAD software	Ansys commertial software
2	Meshing of CAD model and setting of solver	Importing of CAD model to Ansys software, meshing through ICEM CFD software,	detailed computational data of	ANSYS Fluent	CFD Post

		incorporating boundary condition, selection of solver and schemes	flow field variables and convergence plots		
3	Post processing of CFD data	Calculation of forces and moments, and flow field	Forces and moments data	CFD Post	Ansys static structural tool
4	static structural Analysis	Apply hydrostatic loads distribution and self loads on support structure	Stress distribution and deformation of structure	Ansys static structural tool	ANSYS Fluent
5	Fluid structure analysis	Repeat step 1 to 4 to optimize the size of the addon structures	Forces and moments data, Stress distribution and deformation of structure	Ansys static structural tool	ANSYS Fluent
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Normal operating condition	solar panel remains at position	wind velocity	Ambient condition	
Realization					
Responsible partner		CSIR-CMERI			

Use case ID	**RES_2UC1.3 - Experimental validation of the designed structure through wind tunnel testing**
High level UCs	HLUC-3
Classification	Secondary Use Case
Description	This 1UC1.3 addresses the scale down model testing of the designed resilient support structure in the wind tunnel. A scale down model of the optimized support structure will be prepared initially based on the blockage ratio of wind tunnel. Next, the functionality of the resilient structure at both on and off-design wind velocities are examined through force and moments measurement through 6 component F/T transducer.
Scope	Validation of add-on structures at on and off design conditions
Requirements	- A scale down model of the support structure
	-wind tunnel with a force and torque transducer
	-Mounting accessories and micro manometer with pitot static tube
	-DAQ system with LABVIEW data acquisition software
Related KPIs	72.Reliable operation at both on and off design wind velocity

	61. EnC replication potential				
	21. Safety				
	55. Skill/Knowledge acquirement				
Actors	Pitching moment				
Triggering event	-Designed wind velocity				
RE-EMPOWERED tools involved	ecoResilience				
Pre-condition	Functionalities validated in laboratory environment				
Post-condition	Reliable operation at the designed solar incidence angle at the specified location				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Calculation of ratio of scale down model	Calculation of front area of optimized support structure to determine blockage ratio. Determine scale down ratio from blockage ratio	Frontal area	CAD software	
2	Preparation and mounting of scale down model	Fabrication of support structure model with perspex sheet and roller bearing. Mounting of model over the transducer.	Size of the model	Analytical calculation	
3	Wind tunnel testing	Fix the required test section through VFD drive. Measure the wind velocity using pitot static tube. Connect the F/T transducer to DAQ system and acquire the data	Deflection of solar photovoltaic panels, forces and moments data	F/ T transducer	
4	Validation of data	Analysis the forces and moment data from experiments and compare with numerical results	Forces and moments data		
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Normal operating condition	solar panel remains at position	wind velocity	Ambient condition	
Realization					
Responsible partner	CSIR-CMERI				

Use case ID	**RES_2UC1.4 - Design of resilient foundation for solar photovoltaic system**

High level UCs	HLUC-3				
Classification	Secondary Use Case				
Description	This 2UC3.1 addresses the design of foundation for solar photovoltaic system support structure. First, soil load bearing capacity data is collected from the government officials. Next, the total loads acting on the support structure is examined. The depth and width of the foundation is determined from the above loads and moments. Finally, the designed foundation strength is determined through rope test at the simulated soil environment before implementing at the actual demo site.				
Scope	Validation of add-on structures at on and off design conditions				
Requirements	- Soil load bearing data				
	-Structural and wind loads and moments				
	-Foundation drawing				
	-Raw material for concrete				
Related KPIs	72.Reliable operation at both on and off design wind velocity				
	61. EnC replication potential				
	21. Safety				
	55. Skill/Knowledge acquirement				
Actors	Normal wind condition and cyclone				
Triggering event					
RE-EMPOWERED tools involved	ecoResilience				
Pre-condition	stable foundation, Functionalities validated in laboratory environment				
Post-condition	stable foundation				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Collection of soil testting data from local government offical	contacting the appropriate local government official for soil testing data and topographical conditions	parameters of soil	soil test	foundation design
2	Foundation design	calculation of loads and moments based on IS code, design the foundation structure			
Realization					
Responsible partner	CSIR-CMERI				

Use case ID	RES_1UC2 -Design of a resilient tower and a passive mechanism for the wind turbine blades
High level UCs	HLUC-3, HLUC-6
Classification	Primary Use Case
Description	This 1UC2 addresses the detailed survey of methods used to reduce wind loads on tower truss and wind turbine blades during cyclones and the design of tower truss and a mechanism to reduce loads on wind turbine blades at adverse environmental conditions. CFD simulation of flow past the wind turbine blades will be performed at different angle of attacks and free stream velocities. Stress distribution on the tower truss and the wind turbine blades will be examined through CSA from hydrostatic pressure obtained from simulations to optimize the support structures.
Scope	Design of resilient tower truss and a mechanism for wind turbine blades to reduce wind load
Requirements	- Conceptual tower design from literature
	-Optimization of tower through CFD and CSA simulations.
	-Design of a mechanism to vary the angle of attack of wind turbine blades during cyclone condition
	-Testing and validation of designed mechanism in the laboratory with scale-down model
	-Bill of materials for tower and mechanism design
Related KPIs	72.Reliable operation at both on and off design wind velocity
	61. EnC replication potential
	21. Safety
	55. Skill/Knowledge acquirement
Actors	Cyclone data
Triggering event	- Cyclone
RE-EMPOWERED tools involved	ecoResilience
Pre-condition	Wind turbine will be idle
Post-condition	Wind turbine will be returned to horizontal axis position for optimal power generation

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	Preliminary tower design	Literature review, design of tower, stress distribution on the tower at different wind velocities.	stress distribution, deflection	handbooks, Numerical simulation	2UC2.1
2	Design of mechanism for wind turbine blades	CAD model development, CFD simulations and computational structural analysis of blades at different angle of attack and velocities	Loads, moments, stress and deformation	CAD model and Numerical simulations	2UC2.2

3	Validation of the mechanism	Laboratory validation and field testing of the designed mechanism	loads, and deflection	Field testing	2UC3.2
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Normal operating condition	wind turbine remains at position to generate power	wind velocity	Ambient condition	2UC3.2
Realization					
Responsible partner		CSIR-CMERI			

Use case ID	**RES_2UC2.1 - Preliminary design of a tower truss structure and its optimization**
High level UCs	HLUC-3
Classification	Secondary Use Case
Description	This 2UC2.1 addresses the design of the tower truss to support the wind turbine. First, existing methods used in tower design will be reviewed and it will be followed by theoretical design of the tower based on wind turbine total weight (dead load) and loads acting on the wind turbine (live load). The size and different parameters of the tower is optimized through CSA tool in ANSYS commercial software
Scope	Validation of add-on structures at on and off design conditions
Requirements	- Literature review
	-Preliminary design of tower
	-Optimization of the tower parameters
	- Raw materials for tower fabrication
Related KPIs	72.Reliable operation at both on and off design wind velocity
	61. EnC replication potential
	21. Safety
	55. Skill/Knowledge acquirement
Actors	Normal wind condition and cyclone
Triggering event	-Cyclone
RE-EMPOWERED tools involved	ecoResilience
Pre-condition	stable tower

Post-condition	stable tower				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Review of methods used for tower design	Review of tower structures, types of support structure, advantage and disadvantage of different towers	Merits and demerits of different tower	Literature, handbooks	
2	Preliminary design of tower	Collection of wind turbine data from wind turbine developer / supplier. Calculation of expected wind load. Design of tower.	weight of the system, blade diameter and cross sectional area, blade material	Wind turbine supplier	
3	Optimization of the tower truss	CSA analysis of the preliminary design using ANSYS software. Optimization of the tower through CSA using loads and moments	Deformation, stress distribution, etc.	Numerical simulations	
Realization					
Responsible partner	CSIR-CMERI				

Use case ID	**RES_2UC2.2 - Design of a resilient mechanism to reduce wind loads on blades and its optimization**
High level UCs	HLUC-3
Classification	Secondary Use Case
Description	This 2UC2.2 addresses the design of a mechanism to reduce loads on wind turbine blades during severe cyclone. The wind loads acting on the blades will be calculated for different wind velocities and angle of attacks using numerical simulations (CFD). These loads and moments are transferred to blades and static structural analysis is performed using ANSYS software.
Scope	Design of mechanism for off design conditions
Requirements	- Design of mechanism for wind turbine blades
	-Optimization of mechanism through simulations
	-Raw materials for fabrication of mechanism
Related KPIs	72.Reliable operation at both on and off design wind velocity
	61. EnC replication potential
	21. Safety
	55. Skill/Knowledge acquirement

Actors	Manual operation				
Triggering event	Cyclone				
RE-EMPOWERED tools involved	ecoResilience				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Design of a mechanism	Preliminary design of a mechanism to reduce loads on wind turbine blade	deflection, loads	wind turbine	
2	Optimization of mechanism	CFD simulations and static structural design analysis of blades at different operating wind velocities and angle of attack. Calculation of loads and moments	stress distribution, deflection	wind turbine, wind velocity	
Exception					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Normal operating condition	solar panel remains at position	wind velocity	Ambient condition	
Realization					
Responsible partner	CSIR-CMERI				

Use case ID	**RES_2UC2.3 - Laboratory and field testing of the mechanism**
High level UCs	HLUC-3
Classification	Secondary Use Case
Description	This 2U2.3 addresses the laboratory testing of the function of the mechanism. First, the working of the mechanism will be tested after fabrication. Next, the designed mechanism will be integrated with the wind turbine system with model tower. Functionality of the mechanism will be tested in the laboratory for multiple operations.
Scope	Testing of mechanism during off design conditions
Requirements	- Components of the mechanism
	-Wind turbine and the tower structure
	-Sample foundation for tower
	-Field testing at CMERI
Related KPIs	72.Reliable operation at both on and off design wind velocity
	61. EnC replication potential

	21. Safety				
	55. Skill/Knowledge acquirement				
Actors	Manual operation				
Triggering event	cyclone				
RE-EMPOWERED tools involved	ecoResilience				
Pre-condition	Cyclone, Functionalities validated in laboratory environment				
Post-condition	Solar panels will return to actual solar incidence angle at the specified location				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Testing of designed mechanism	Fabrication of designed mechanism components, assembling the components, integration of mechanism with the wind turbine, testing at CMERI	Functionality of resilient structures	laboratory testings	
Realization					
Responsible partner	CSIR-CMERI				

Use case ID	**2UC2.4 - Design of foundation for wind turbine tower structure**
High level UCs	HLUC-3
Classification	Secondary Use Case
Description	This 2UC3.1 addresses the design of foundation for the tower truss and wind turbine system. As mentioned in the earlier use case, the soil load bearing capacity data of the installation site is collected from the government officals. Next, the total loads (structural and wind) and moments acting on the support structure is examined. The depth and width of the foundation is determined from the above loads and moments. Finally, the designed foundation strength is determined through rope test at the simulated soil environment before implementing at the actual demo site.
Scope	Validation of add-on structures at on and off design conditions
Requirements	- Soil load bearing data
	-Structural and wind loads and moments
	-Foundation drawing
	-Raw material for concrete
Related KPIs	72.Reliable operation at both on and off design wind velocity
	61. EnC replication potential

	21. Safety				
	55. Skill/Knowledge acquirement				
Actors	Normal wind condition and cyclone				
Triggering event					
RE-EMPOWERED tools involved	ecoResilience				
Pre-condition	stable foundation, Functionalities validated in laboratory environment				
Post-condition	stable foundation				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Collection of soil testing data from local government official	contacting the appropriate local government official for soil testing data and topographical conditions	parameters of soil	soil test	foundation design
2	Foundation design	calculation of loads and moments based on IS code, design the foundation structure			
Realization					
Responsible partner	CSIR-CMERI				

Use case ID	**RES_1UC3 – SWT Local Manufacturing and Testing**
High level UCs	
Classification	Primary Use Case
Description	This 1UC addresses the local manufacturing of residential small wind turbines (SWT). Local manufacturing will allow increased resilience of the wind energy conversion systems, by using the available material and human resources of the region, as part of a sustainable process that strengthens local economies, creates income sources, and facilitates knowledge sharing, while also increasing the resilience of the system. Additionally, already existing designs for locally manufactured small wind turbines will be upscaled for higher rated power and validated using the IEC 61400-12-1 standard as a guide, in the small wind experimental facilities of ICCS-NTUA and will be demonstrated in the Kythnos and Ghoramara demo sites.
Scope	Small wind turbines need a resilient maintenance process that needs to be facilitated by a local network
Requirements	- Local material supply chains
	- Knowledge transfer and local manufacturing skills
	- Testing using small wind turbine standards
	- Data acquisition and monitoring

	- Data management				
Related KPIs	51. Active participation				
	54. User satisfaction contributing to aggregated flexibility				
	52. Customer acceptance				
	62. Open source				
	55. Skill/Knowledge acquirement				
Actors	Local manufacturing and maintenance network, SWT test site operator, SWT desing lab				
Triggering event	-				
RE-EMPOWERED tools involved	ecoResilience				
Pre-condition	Small wind turbine design validated at test site				
Post-condition	Small wind turbine can operate reliably and be maintained locally				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	SWT design	High rated power residential SWT is designed	3D CAD	SWT design lab	SWT test site operator
2	SWT testing	Operation data are collected	Power curve	SWT test site operator	SWT design lab
3	Material supply chains	Material supply data are collected	List of material supply aspects	Local manufacturing and maintenance network	SWT design lab
4	Manufacturing infrastructure and skills	Manufacturing data are collected	List of manufacturing aspects	Local manufacturing and maintenance network	SWT design lab
Realization					
Responsible partner	ICCS-NTUA				

Use case ID	**RES_2UC3.1 – Testing of Small Wind Turbines using Standards**
High level UCs	RES_1UC3 - SWT Local Manufacturing and Testing

Classification	Secondary Use Case
Description	This 2UC addresses the testing of locally manufactured small wind turbines, that have been upscaled for higher rated power, with the use of the IEC 61400-12-1 standard as a guide, in the facilities of ICCS-NTUA.
Scope	Small wind turbines need consistent testing before deployment.
Requirements	- Data acquisition and monitoring
	- Data management
	- Testing using IEC standards
	- Designer input and feedback
Related KPIs	59. Use of equipment standards
	58. Use of protocol standards
	62. Open source
	21. Safety
Actors	SWT test site operator, SWT desing lab
Triggering event	-
RE-EMPOWERED tools involved	ecoResilience
Pre-condition	Small wind turbine design
Post-condition	Small wind turbine can operate reliably and safely

Step by step analysis

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	SWT desing	High rated power residential SWT is designed	3D CAD	SWT desing lab	SWT test site operator
2	SWT testing	Operation data are collected	Power curve	SWT test site operator	SWT desing lab

Realization

Responsible partner	ICCS-NTUA

G. Annex 9 Use Cases definition for ecoConverter

K. Annex 9 Use Cases definition for ecoVehicle

2UCs	VH_1UC1: Tailor-made Electric Vehicle (EV) charging facility
VH_2UC1.1	Effective control strategies for dc-bus voltage regulation
VH_2UC1.2	State of charge and temperature estimation
VH_2UC1.3	Temperature regulated charging strategies
	VH_1UC2: Selection and customization of eRickshaw
VH_2UC2.1	Sizing and Selection of the power train components
VH_2UC2.2	Customization of the vehicle to the demo site requirements
	VH_1UC3: Onboard energy management for e-Boat
VH_2UC3.1	PV Integration with e-Boat
VH_2UC3.2	Optimal Energy management algorithms

Use case ID	**VH_1UC1 - Improved EV Charging Facility**
High level UCs	HLUC-1, HLUC-3, HLUC-4, HLUC-8
Classification	Primary Use Case
Description	This 1UC refers to the development and deployment of EV charging facilities in the Ghoramara Island and Keonjhar,designed for improved performance, tailored for each of the demo sites. The first component of this UC is to address issues, such as DC-link voltage regulation, through effective control strategies. The second component deals with the estimation of SOC and other performance parameters of the batteries, to select the appropriate charging patterns. The third component addresses temperature regulation to ensure improved battery life, which is affected by the charging at higher rate.
Scope	Facilitate the utilisation of green source of energy for EV charging.
Requirements	-Avalability of ac-supply from the PV fed micro-grid
	-Real-time data collection
	-energy vector forecasting

Related KPIs	24. MAPE (Forecasting accuracy)				
	24. MAPE (Forecasting accuracy)				
Actors	Microgrid Operator, Charing station operator, Prosumer, DSO				
Triggering event	-				
RE-EMPOWERED tools involved	ecoVehicle				
Pre-condition	Data availability & reliability, Functionalities validated in laboratory environment				
Post-condition	Microgrid operator is able to monitor the status of all the components within the microgrid				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Collection of input output specifications of charger and charging station	Overall specification of the capability of proposed micro-grid is to be discussed in terms of bus power and voltage and requirement of load (EV Charging)	Power, voltage level and maximum current delivery capability of the bus feeding charging station.	TBD	Microgrid operator
2	Charging station layout	Layouting is to be carried out with the specification of the each of the energy conversion level considering efficiency of energy conversion	Bus voltage, current and regulation of circuit variables	TBD	Microgrid operator
3	Design and fabrication of power electronics converter	Each of the identified component of the charging station and the charger are to be sized and fabricated after component selection.	Design procedure	TBD	Collaborators
4	Control algorithm to ensure desired charging profile and temperature regulation	Control interface is to be developed and control algorithm is to be implemented	control algorithms	TBD	collaborators
Realization					
Responsible partner	VNIT				
Contributing partners	VNIT				

Use case ID	**VH_2UC1.1 - Effective control strategies for dc-bus voltage regulation**
High level UCs	VH_2UC1 - Electric Vehicle charging facility

Classification	Secondary Use Case				
Description	The charger and the charging station to be deployed, must support charging at faster rate. This type of operation affects the bus voltage and indirectly the grid. Therefore, it is important to address the bus voltage regulation. Sudden connection and the disconnection of the load which is a constant current type because of CC charging, results in the large fluctuation at the dc-bus. Particularly for the case of temperature regulated charging, current profile is pulse in nature and results in more severe bus voltage fluctuation. Different control strategies are to be implemented.				
Scope	Effective regulation of dc-bus voltage				
Related KPIs	32. Data reliability 31. Availability of the communication infrastructure 58. Use of protocol standards 33. Data security control 22. Increased access to own metering data 60. Interoperability				
Actors	1. MGCC				
Triggering event	1. Periodically; 2. Charging profile				
RE-EMPOWERED tools involved	ecoVehicle				
Pre-condition					
Post-condition	- Measurements are provided to Data Concentrator				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Controller interface	monitoring of bus-voltage, input current to boost converter stage, and charging profile	bus voltages and current	voltage and current sensors	Microcontroller through interface circuitry
2	Control action	Control algorithm to act as per the charging current profile and the bus voltage state	control action to the charger	PFC rectifier and charger	battery pack to be charged
Realization					
Responsible partner	VNIT				
Contributing partners	VNIT				

Use case ID	**VH_2UC1.2: State of charge and temperature estimation**

High level UCs	VH_2UC1 - Electric Vehicle charging facility				
Classification	Secondary Use Case				
Description	The state of charge (SOC) of the battery plays an important role in the selection of the charging profile. Therefore, a charger must perform SOC estimation. This is to be carried out through the most basic approach of coulomb counting. Charging at faster rate results in the increase of battery temperature which requires to be regulated, to improve the battery life. For this purpose, electrothermal model of the battery pack is to be used as a temperature estimator. Both SOC and the temperature estimation requires information of charging/discharging current information.				
Scope	The scope of the UC is to develop and use the SOC and temperature estimator for the proper operation of the charger and the charging station.				
Requirements	- battery current and voltage information				
Related KPIs	- Load forecasting				
Actors	Microgrid operator, MGCC				
Triggering event	-estimated battery temperature and SOC				
RE-EMPOWERED tools involved	ecoVehicle				
Pre-condition	-battery parameter information, proper function of current and voltage sensors				
Step by step analysis					
Step No.	**Event**	**Normal Process**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	SOC estimation	battery current/voltage is to be sensed and coulomb counting method is to be used	SOC	SOC estimator	interface controller
2	Temperature estimator	electrothermal model of the battery is to be used as an estimator through the information of battery current/voltage	battery temperature	temperature estimator	interface controller
Realization					
Responsible partner	VNIT				
Contributing partners	VNIT				

Use case ID	**VH_2UC1.3 - Temperature regulated charging strategies**
High level UCs	VH_2UC1 - Electric Vehicle Charging Facility
Classification	Secondary Use Case

Description	Operating temperature of the battery during the charging/discharging is always a concern with respect to the life of the battery and is the limiting factor on the charging rate of the battery. Temperature regulation during the charging process can be achieved through the temperature estimator and according switching between conventional cc/cv or pulse charging profile.
Scope	Temperature regulated charging strategies supports in improving the life of the battery
Requirements	-Main requirement of the this use case is the temperature estimator and the proper sizing of the the charger.
Related KPIs	60. Interoperability
Actors	-Temperature estimator; SOC estimator; - interface controller, charger
Triggering event	1. Periodically
RE-EMPOWERED tools involved	ecoVehicle
Pre-condition	-Temperature estimator and SOC estimator
Post-condition	
Exception – Communication problem	
Exception – Data is inaccurate	
Realization	
Responsible partner	VNIT
Contributing partners	VNIT

Use case ID	VH_1UC2: Selection and customization of eRickshaw
High level UCs	HLUC-2, HLUC-3, HLUC-5, HLUC-6, HLUC-7
Classification	Primary Use Case
Description	This UC deals with the custom design and deployment of electric three wheelers, for commutation and transportation of goods and passengers. Customization and sizing of power train components will be performed to meet different gradability and loading conditions. Customization of vehicles with foldable seating arrangement will be carried out, to accommodate passengers with full capacity or with partial loads.
Scope	Facilitate the utilisation of green source of energy for eco-friendly transportation
Requirements	- Availability of vehicle payload capacity, gradability of road, air drag information etc
	- Availability of data of electric three wheeler components (e.g. motor and controller ratings, storage battery capacity etc)

		-Availability of solar powered battery charging station
Related KPIs		18. Reduction in CO2
		19. Increase of environmental awareness
Actors		System operator, charging station operator, Local community
Step by step analysis		
No.	**Event**	**Process/activity**
1	Payload calculation	Based on number of passengers and other parameters such as payload, aerodynamic drag, gradability of road etc, total payload will be calculated
2	Structure design of electric three-wheeler	This process involves structural design of electric three wheelers with foldable seating arrangement so as to carry passengers with partial loads
3	Selection and sizing of powertrain components	Powertrain components such as motor, controller etc are selected based on payload calculation. Battery sizing will be done based on runtime of the vehicle.
Exception #Lack of available data		
Exception #Communication Failure with controllable assets		
Realization		
Responsible partner		CSIR-CMERI
Contributing partners		IIT KGP

Use case ID	**VH_2UC2.1: Sizing and Selection of the power train components**
Classification	Secondary Use Case
Description	This secondary UC deals with the proper selection and sizing of the power train components to meet different gradability and loading conditions at demo sites.
Scope	Proper selection of components to promote eco-friendly transportation
Requirements	- Availability of road conditions and parameters such as gradability, aerodynamic drag, payload, speed requirements etc
Related KPIs	18. Reduction in CO2 19. Increase of environmental awareness
Actors	System operator

Triggering event						
RE-EMPOWERED tools involved		ecoVehicle				
Step by step analysis						
Step No.	**Event**	**Process/activity**				
1	Selection and sizing of powertrain components	Powertrain components such as motor, controller etc are selected based on payload calculation. Sizing of battery depends on runtime of the vehicle.				
Realization						
Responsible partner		CSIR-CMERI				
Contributing partners		IIT KGP				

Use case ID		**VH_2UC2.2: Customization of the vehicle to the demo site requirements**				
High level UCs		VH_1UC2: Selection and customization of eRickshaw				
Classification		Secondary Use Case				
Description		This US deals with customization in electric three wheelers with foldable seating arrangement such as to accommodate only passengers with full capacity or passengers with partial loads.				
Scope		Structural modification for eco-friendly transportation of goods and passengers				
Requirements		- Availability of road conditions and parameters such as gradability, aerodynamic drag, payload, speed requirements etc				
Related KPIs		18. Reduction in CO2 19. Increase of environmental awareness				
Actors		System operator				
RE-EMPOWERED tools involved		ecoVehicle				
Step by step analysis						
Step No.	**Event**	**Process/activity**				
1	Payload calculation	Calculation of payload based on different parameters such as mass of passenger/ goods, aerodynamic drag, gradability of road etc				
2	Structure design of electric three wheeler	Structural design of elelctric three wheelers with foldable seating arrangement so as to carry passengers with partial loads				
Exception #Lack of available data						

Exception #Communication Failure with controllable assets	
Realization	
Responsible partner	CSIR-CMERI
Contributing partners	IIT KGP

Use case ID	**VH_2UC3: Onboard energy management for e-Boat**			
High level UCs	HLUC-2, HLUC-3, HLUC-5, HLUC-6, HLUC-7			
Classification	Primary Use Case			
Description	This UC considers design, development and deployment of solar powered battery operated electric boat at Ghoramara demo site. Considering harsh environmental conditions and high stream conditions in the river Ganges, the motor and power train will be customized accordingly. The overall design and construction of the boat will be such as to optimal use and management of renewable energy through harnessing maximum solar energy from onboard roof mounted solar panel and improvement propulsive efficiency.			
Scope	facilitate eco-friendly water transportation through maximum utilization of renewable energy			
Requirements	-Availability of solar energy			
	-Availability of solar powered shore battery charging station			
	-Availability of onboard energy storage system e.g. battery			
	- Availability of data of e-boat components (e.g. motor and power electroncs ratings, solar panel capacity, storage battery capacity, charger ratings etc) are provided.			
Related KPIs	18. Reduction in CO2			
	42. CAPEX ratio			
	43. OPEX ratio			
	19. Increase of environmental awareness			
Actors	System operator, charging station operator, consumers			
Triggering event	-			
RE-EMPOWERED tools involved	ecoVehicle			
Pre-condition	1. Estimation of RES production in the area is available 2. State of charge of storage equipment is available. 3. Current status of RES production is available.			
Post-condition				
Step by step analysis				

Step No.	Event	Process/activity	Info. Exchanged	Actor producing info	Actor receiving info
1	e-boat design	This process involves design and sizing of e-boat powertrain components such as motor, controller, charger etc to overcome the high stream velocity at river Ganges.	-	-	-
2	Improvement of propulsive efficiency	Improvement of propulsive efficiency through minimization of drag resistance by suitable design of hull structure.	-	-	-
3	Management of energy	This process involves optimal management of onboard solar energy, battery energy and RES energy from shore charging station. The objective is to maximum utilization of onboard solar energy, and less utilization of power from shore charging station.	1. Real time measurements for solar energy production 2. State of Charge of onboard battery, 3. Availability of power at shore charging station	e-Boat operator, Charging station operator	e-boat operator
Exception #Lack of available data					
Realization					
Responsible partner	CSIR-CMERI				
Contributing partners	VNIT, IITBBS				

Use case ID	**VH_2UC3.1: PV Integration with e-Boat**
High level UCs	VH_1UC3: Onboard energy management for e-Boat
Classification	Secondary Use Case
Description	This UC deals with the integration of solar energy with the propulsion system of battery-operated electric boat. Special focus will be given to maintain stability of the system while integrating roof top PV system.
Scope	Operation of e-boat through harnessing maximum renewable energy from onboard solar panel
Requirements	- Availability of solar energy
	-Availability of onboard energy storage system e.g. battery

	- Availability of e-boat components ratings (e.g. motor and power electronics ratings, solar panel capacity, storage battery capacity, charger ratings etc)				
Related KPIs	18. Reduction in CO2				
	19. Increase of environmental awareness				
Actors	System operator				
RE-EMPOWERED tools involved	ecoVehicle				
Pre-condition	1. Estimation of RES production in the area is available				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Energy estimation	Based on runtime of e-boat, energy estimation (PV energy, battery energy) is done.			
2	Components sizing	Powertrain components sizing and selection based on availability of PV energy, battery energy and load profile with an aim to maximum utilization of solar PV energy			
3	Integration of PV energy vector	This process involves integration of rooftop onboard solar panel with onboard battery with BMS, and associated charging system			
Exception #Lack of available data					
Exception #Communication Failure with controllable assets					
Realization					
Responsible partner	CSIR-CMERI				
Contributing partners	VNIT				

Use case ID	**VH_2UC3.2: Optimal Energy management algorithms**
High level UCs	VH_1UC3: Onboard energy management for e-Boat
Classification	Secondary Use Case

Description	Under this UC an optimal energy management to efficiently use the various energy mix such as PV and battery will be developed. Integration of this energy vector requires a robust control of power electronic converter to control the power injection due to the dynamic behaviour of the system. Algorithms to deal with nonlinear systems will be developed.				
Scope	1) To develop an optimal energy management system considering the non-linear behaviour of the energy vectors.				
Requirements	- Availability of solar energy				
	-Availability of onboard energy storage system e.g. battery				
Related KPIs	2. Voltage variation				
	27. Energy losses				
Actors	Energy management algorithms				
Triggering event	Energy availability of source and requirement of load				
RE-EMPOWERED tools involved	ecoVehicle				
Step by step analysis					
Step No.	**Event**	**Process/activity**	**Info. Exchanged**	**Actor producing info**	**Actor receiving info**
1	Load characteristics	Monitoring of load current, bus voltage	Bus voltage and current	Voltage and current sensors	Controller
2	Source characteristics	Battery SOC, Output voltage and current of PV panel	Battery SOC, voltage and current	Voltage and current sensors	Controller
3	Energy management algorithms	Decision of current sharing between onboard battery and solar panel	Optimization function	Controller	Power Converters
4	Control action	Operation of the MPPT controller	Driving signals to power converters	Controller	Power Converters
Exception #Lack of available data					
Exception #Communication Failure with controllable assets					
Realization					
Responsible partner	CMERI				
Contributing partners	IITBBS, VNIT				