RE-EMPOWERED

Renewable Energy EMPOWERing European & InDian Communities

Deliverable D7.5 / D7.2d: Report demonstration round 2 (Final Demo)

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*Type	*Dissemination Level
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)
DATA data sets, microdata, etc	

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Executive Summary

The overarching goal of RE-EMPOWERED is to foster efficient, de-carbonized and RES-intensive multi-energy local energy systems and provide local communities with tools for economic and social development. To achieve these goals, the project has delivered a suite of “ecoTools,” namely ecoEMS, ecoMicrogrid, ecoPlanning, ecoDR, ecoPlatform, ecoConverter, ecoMonitor, ecoCommunity, ecoVehicle and ecoResilience, deployed at four demo sites across the EU and India, and thereby demonstrated their value in energy systems at different scales and levels of maturity. Two demonstration runs have been performed at each demo site, one for testing and one operational demonstration. This deliverable reports on the activities of the second round of demonstration which involves the final demonstration testing of ecoTools, laying the foundation for the project assessment.

The demonstration activities were carried out at the four demo sites according to the plan set in D7.1 [1] considering the defined Use Cases (UCs) with some adjustments. Tables summarizing the UCs at each demo site are included, providing information about the UCs that have been tested fully in the 1st demonstration round, those that have been more thoroughly tested at the 2nd demonstration round and those that have been tested only on the 2nd round. Furthermore, a detailed description is provided for each UC per ecoTool and demo site. This includes the methodology followed, the outcome obtained from each activity, and visualized results. The primary goal is to collect essential data, validate, and assess the designed use cases for each tool, ensuring a comprehensive evaluation of its functionality. In certain cases, necessary adaptations were implemented in the 2nd round, following insights reported during the initial testing demonstration round (D7.4 [2]).

Keywords:

Demonstration, Final Testing, Use Cases, Smart Grids, Energy islands, Local Energy Systems, Bornholm, Kythnos, Ghoramara, Keonjhar, ecoEMS, ecoMicrogrid, ecoPlanning, ecoDR, ecoMonitor, ecoPlatform, ecoCommunity, ecoResilience, ecoConverter, ecoVehicle

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Acronyms

Acronym	Description
AC	Alternating Current
AFPMG	Axial Flux Permanent Magnet Generator
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
APK	Android Application Package
AQI	Air Quality Index
BESS	Battery Energy Storage System
BLDC	Brush Less Direct Current
CAD	Computer Aided Design
CFD	Computational Fluid Dynamics
CHP	Combined Heat and Power
CO	Carbon Monoxide
CO2	Carbon Dioxide
CSV	Comma-Separated Values
DA	Day-ahead
DC	Direct Current
DG	Diesel Generator
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
ECMWF	European Centre for Medium-Range Weather Forecasts
EMS	Energy Management System
EU	European Union
EV	Electric Vehicle
FAQ	Frequently Asked Questions
GFS	Global Forecast System
HC	Hosting Capacity
HMI	Human Machine Interface
HTTP	Hypertext Transfer Protocol
HVAC	Heating Ventilation and Air Conditioning
IoT	Internet of Things
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
LMSWT	Locally Manufactured Small Wind Turbine
MG	MicroGrid

MPPT	Maximum Power Point Tracking
MQTT	Message Queuing Telemetry Transport
NCEP	National Centers for Environmental Prediction
NII	Non-Interconnected Island
NIS	Non-Interconnected Island Systems
NO2	Nitrogen Dioxide
NWP	Numerical Weather Prediction
OPC	Open Platform Communications
P&O	Perturb and Observe
P2X	Power to X
PC	Personal Computer
PCC	Plain Cement Concrete
PM2.5/ PM10	Particulate Matter of 2,5/10 microns
PPC	Partial Power Converter
PV	Photovoltaic
RE	Renewable Energy
RES	Renewable Energy Source
RH	Relative Humidity
RT	Real Time
SCADA-HMI	Supervisory Control and Data Acquisition – Human Machine Interface
SOC	State of Charge
SQL	Structured Query Language
TCP	Transmission Control Protocol
UC	Use Case
WP	Work Package
WT	Wind Turbine

1 Introduction

1.1 Purpose and scope of the document

The RE-EMPOWERED project has delivered a suite of “ecoTools”, tailored to the specific needs of the pilot cases, and deployed them at four demo sites in EU and India. Currently the project is demonstrating their value in energy systems at different scales and levels of maturity. Building on the previously defined Use-Cases (UCs) in D2.1 [3] and D7.1 [1], two demonstration rounds were planned at the four demo sites. This deliverable reports the second and final round of demonstration activities per demo and ecoTool. The successful testing is substantiated by test results for the completed activities defined by the use-cases. For some UCs this round is the first time they are demonstrated while for others, the second round gave us the chance to implement needed refinements and make the tests deeper and broader. Some UCs have been fully tested in the first demonstration round and are not repeated in this deliverable. Therefore, the reader is referred to D7.4 [2] and D7.5 to obtain a full picture of the demonstration activities. It should be noted that the UCs of D7.1 [1] and D2.1 [3] were refined when needed. Following the completion of the first demonstration round, necessary adaptations to the ecoTools have been identified (reported in D7.4 [2]) and implemented in the 2nd demonstration round.

During the demonstration activities, data from the operation of the Local Energy Systems were collected and are evaluated as part of the assessment phase in WP8.

1.2 Structure of the document

Chapter 2 provides an overview of the demonstration activities that took place at the four demo sites, considering the defined UCs through check list tables of the UCs per demo site with reference on their progress history.

Chapter 3 provides a detailed description of all the 2nd round demonstration activities performed based on the UCs for each tool on each demo site, reported in Chapter 2. The steps followed for the demonstration activities are presented along with the obtained results supported with visualizations in most cases.

Chapter 4 concludes the document.

2 Demonstration activities overview

This Chapter contains a comprehensive overview in the form of tables for the status and timeline of each secondary Use Case (UC) in the demo sites. The secondary UCs are used in the analysis as they are more detailed and specific than the primary UCs, leading to more efficient testing and presentation. The tables provide distinction between UCs that are first demonstrated during the 2nd round ("Y" in status), the ones that were tested in both rounds ("Updated" in status) and those that were fully demonstrated in the 1st round ("Fully demonstrated in 1st round " in status).

2.1 Bornholm

Use Cases Inventory - Pilot Site Demonstration: Bornholm Island	UC priority	Status	Timeline
ecoEMS			
EMS_1UC1: Real time monitoring and system data visualization			
EMS_2UC1.1: Real time system monitoring and data acquisition and visualization	Medium	Fully demonstrated in 1st round	
EMS_2UC1.2: Module manager: intercommunications and data exchange	High	Fully demonstrated in 1st round	
EMS_1UC2: Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization			
EMS_ 2UC2.1: Mid-term and short-term RES and load forecasting. Training of the Forecasting model	High	Fully demonstrated in 1st round	
EMS_ 2UC2.2: Unit Commitment and Economic Dispatch algorithms	High	Updated	Dec 24
EMS_ 2UC2.3: Multi-energy vector management of operation	High	Fully demonstrated in 1st round	
ecoDR			
DR_1UC1: Increased energy monitoring at demand side			
DR_2UC1.1: Real time monitoring of energy consumption	Medium	Updated	Dec 2024
DR_1UC2: Integration Interfaces for Load Management			
DR_2UC2.1: Scheduling of loads	Low	Partially completed	Dec 2024
ecoPlatform			
PT_1UC1: Microgrid data acquisition			

PT_2UC1.1: Connect to sensors and acquire data through designated communication network and protocols	High	Fully demonstrated in 1st round	
PT_2UC1.2: Data cleansing to ensure consistency and human machine interface	Medium	Fully demonstrated in 1st round	
PT_1UC2: Platform as a service for dependent tools integration			
PT_2UC2.1: Facilitate data exchange between dependent tools	High	Fully demonstrated in 1st round	
PT_2UC2.2: Facilitate access to controllable assets for dependent tools	Medium	Updated	Dec 2024
PT_1UC3: Data storage and cloud server			
PT_2UC3.1: Route the microgrid data and data from dependent tools to cloud database	Medium	Updated	Dec 24
PT_2UC3.2: Facilitate archived data access for dependent tools using API	High	Fully demonstrated in 1st round	
ecoMonitor			
MN_1UC1: Ambient air quality surveillance			
MN_2UC1.1: Acquisition and transmission of air quality parameters data	Low	Updated	Dec 24
MN_2UC1.2: Data processing and evaluation	Low	Y	Dec 24
ecoCommunity			
CM_1UC3: Outreach forum			
CM_2UC3.1: Feedback and suggestions from users about the tools	Medium	Y	Dec 24
CM_2UC3.2: Reporting of problem	High	Y	Dec 24
CM_2UC3.3: Forum to share experiences	High	Y	Dec 24
CM_1UC4: Guidance and Training			
CM_2UC4.1: Training material (troubleshooting)	Medium	Y	Dec 24
CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)	High	Y	Dec 24
CM_1UC5: Consumption Monitoring			
CM_2UC5.1: Monitoring of heating system at load centers	High	Y	Dec 24

Table 1 Use cases status and timeline for Bornholm demo site

2.2 Kythnos

2.2.1 Kythnos Power System

A checklist of the successfully achieved Use Cases (UCs) demonstrated in Kythnos Power System is presented below.

Use Cases Inventory - Pilot Site Demonstration: Kythnos Power System	UC priority	Status	Duration
ecoEMS			
EMS_1UC1: Real time monitoring and system data visualization			
EMS_2UC1.1: Real time system monitoring and data acquisition and visualization	Medium	Fully demonstrated in 1st round	
EMS_2UC1.2: Module manager: intercommunications and data exchange	High	Fully demonstrated in 1st round	
EMS_1UC2: Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization			
EMS_ 2UC2.1: Mid-term and short-term RES and load forecasting	Low	Updated	Dec 24
EMS_ 2UC2.3: Unit Commitment and Economic Dispatch algorithms	High	Updated	Dec 24
ecoPlanning			
PN_1UC1: 7-Year Energy Planning			
PN_2UC1.1: Data collection and storage	Medium	Fully demonstrated in 1st round	
PN_2UC1.2: Electrical models & demand peak models design, RES & Load estimation	High	Fully demonstrated in 1st round	
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	Updated	Dec 24
PN_1UC2: RES Hosting Capacity			
PN_2UC2.1: Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds	High	Fully demonstrated in 1st round	
PN_2UC2.2: Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment	High	Updated	Dec 24
PN_1UC3: Interconnections			
PN_2UC3.1: Electrical models, demand peak models & interconnections design, RES & Load estimation	High	Y	Dec 24

PN_2UC3.2: Hourly Unit Commitment, through optimization algorithm for mid to long term horizon	High	Y	Dec 24
PN_1UC4: Multi-energy vectors			
PN_2UC4.1: Energy carriers' identification, data collection and quantification of impact on total load (hourly)	Low	Fully demonstrated in 1st round	
PN_2UC4.2: Electrical models & demand peak design, RES & Load estimation, energy carriers' scenarios integration	High	Fully demonstrated in 1st round	
PN_2UC4.3: Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers	High	Updated	Dec 24
ecoMonitor			
MN_1UC1: Ambient air quality surveillance			
MN_2UC1.1: Acquisition and transmission of air quality parameters data	High	Partially completed	Dec 24
MN_2UC1.2: Data processing and evaluation	Medium	Y	Dec 2024

Table 2 Use cases status and timeline for Kythnos power system demo site

2.2.2 Gaidouromandra Microgrid

A checklist of the successfully achieved Use Cases (UCs) demonstrated in Gaidouromandra microgrid is presented below.

Use Cases Inventory - Pilot Site Demonstration: Gaidroumandra Microgrid	**UC priority**	**Status**	**Duration**
ecoMicrogrid			
MG_1UC1: Microgrid monitoring			
MG_2UC1.1: Real time microgrid monitoring and data acquisition	High	Fully demonstrated in 1st round	
MG_2UC1.2: RES production estimation	Low	Y	Nov - Dec 24
MG_2UC1.3: Data concentration, storage, and management	High	Fully demonstrated in 1st round	
MG_1UC2: Microgrid optimal management of operation			
MG_2UC2.1: Effective communication with controllable assets	High	Fully demonstrated in 1st round	
MG_2UC2.3: Multi-energy vector microgrid management of operation	High	Y	Nov - Dec 24
ecoDR			
DR_1UC1: Increased energy monitoring at demand side			

DR_2UC1.1: Real time monitoring of energy consumption	Medium	Updated	Dec 24
ecoPlatform			
PT_1UC2: Platform as a service for dependent tools integration			
PT_2UC2.1: Facilitate data exchange between dependent tools	High	Fully demonstrated in 1st round	
PT_1UC3: Data storage and cloud server			
PT_2UC3.1: Route the microgrid data and data from dependent tools to cloud database	Medium	Fully demonstrated in 1st round	
PT_2UC3.2: Facilitate archived data access for dependent tools using API	Low	Updated	Dec 24
ecoCommunity			
CM_1UC1: Dynamic pricing of electricity			
CM_2UC1.1: Displaying the dynamic pricing based on shape of energy profile	High	Fully demonstrated in 1st round	
CM_2UC1.3: Data security and privacy	Medium	Fully demonstrated in 1st round	
CM_1UC2: Scheduling and Coordination			
CM_2UC2.1: Facilitating (display) of the scheduling and shifting of non-critical and flexible loads	High	Fully demonstrated in 1st round	
CM_1UC3: Outreach forum			
CM_2UC3.1: Feedback and suggestions from users about the tools	Medium	Y	Dec 24
CM_2UC3.2: Reporting of problem	High	Y	Dec 24
CM_2UC3.3: Forum to share experiences	High	Y	Dec 24
CM_1UC4: Guidance and Training			
CM_2UC4.1: Training material (troubleshooting)	Medium	Y	Dec 24
CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)	High	Updated	Dec 24
CM_1UC5: Display of Energy Consumption			
CM_2UC5.1: Monitoring of electricity consumption of energy consumers	High	Fully demonstrated in 1st round	
ecoResilience			
RS_1UC3: WT Local Manufacturing and Testing			
RS _2UC3.2: Testing of Small Wind Turbines using Standards	High	Updated	Nov-Dec 24

Table 3 Use cases status and timeline for Gaidouromandra demo site

2.3 Ghoramara

A checklist of the successfully achieved Use Cases (UCs) demonstrated in Ghoramara microgrid is presented below.

Use Cases Inventory - Pilot Site Demonstration: Gaidroumandra Microgrid	UC priority	Status	Timeline
ecoMicrogrid			
MG_1UC1: Microgrid monitoring			
MG_2UC1.1: Real time microgrid monitoring and data acquisition	High	Fully demonstrated in 1st round	
MG_2UC1.3: Data concentration, storage, and management	Medium	In progress by the Indian partners	
ecoDR			
DR_1UC1: Increased energy monitoring at demand side			
DR_2UC1.1: Real time monitoring of energy consumption	Medium	Fully demonstrated in 1st round	
DR_1UC2: Integration Interfaces for Load Management			
DR_2UC2.1: Scheduling of loads	High	Fully demonstrated in 1st round	
DR_2UC2.2: Programmable Load shedding controller	High	Fully demonstrated in 1st round	
ecoMonitor			
MN_1UC1: Ambient air quality surveillance			
MN_2UC1.1: Acquisition and transmission of air quality parameters data	Medium	Fully demonstrated in 1st round	
ecoPlatform			
PT_1UC2: Platform as a service for dependent tools integration			
PT_2UC2.1: Facilitate data exchange between dependent tools	High	Fully demonstrated in 1st round	
PT_1UC3: Data storage and cloud server			
PT_2UC3.1: Route the microgrid data and data from dependent tools to cloud database	Medium	Fully demonstrated in 1st round	
PT_2UC3.2: Facilitate archived data access for dependent tools using API	Low	Fully demonstrated in 1st round	
ecoCommunity			
CM_1UC1: Dynamic pricing of electricity			
CM_2UC1.1: Displaying the dynamic pricing based on shape of energy profile	High	In progress by the Indian partners	

CM_2UC1.2: Billing and payments	Medium	In progress by the Indian partners	
CM_1UC2: Scheduling and Coordination			
CM_2UC2.1: Facilitating(display) of the scheduling and shifting of non-critical and flexible loads	Medium	In progress by the Indian partners	
CM_2UC2.2: Coordination of communal/ shared loads	Medium	In progress by the Indian partners	
CM_1UC3: Outreach forum			
CM_2UC3.1: Feedback and suggestions from users about the tools	Medium	Y	Dec 2024
CM_2UC3.2: Reporting of problem	High	Y	Dec 2024
CM_2UC3.3: Forum to share experiences	High	Y	Dec 2024
CM_1UC4: Guidance and Training			
CM_2UC4.1: Training material (troubleshooting)	Medium	In progress by the Indian partners	
CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)	High	Y	Dec 2024
CM_1UC5: Display of Energy Consumption			
CM_2UC5.1: Monitoring of electricity consumption of energy consumers	High	In progress by the Indian partners	
ecoResilience			
RS_1UC1: Resilient support structure for solar photovoltaic system with passive addon components			
RS_2UC1.1: Optimal selection of parameters	High	Fully demonstrated in 1st round	
RS_2UC1.2: Computational fluid dynamics and structural analysis of support structures	Low	Fully demonstrated in 1st round	
RS_2UC1.3: Experimental validation of the designed structure through wind tunnel testing	High	Fully demonstrated in 1st round	
RS_2UC1.4: Design of resilient foundation for solar photovoltaic system	Low	Fully demonstrated in 1st round	
RS_1UC2: Improved resilient tower and passive mechanism for wind turbine blades			
RS_2UC2.1: Preliminary design of a tower truss structure and its optimization	Low	Fully demonstrated in 1st round	
RS_2UC2.2: Design of a resilient mechanism to reduce wind loads on blades and its optimization	Low	Fully demonstrated in 1st round	

RS_2UC2.3: Laboratory and field testing of the mechanism	High	Fully demonstrated in 1st round	
RS_2UC2.4: Resilient foundation for wind turbine tower structure	Low	Fully demonstrated in 1st round	
RS_1UC3: Design, Development and Installation of small wind turbine from locally available materials			
RS_2UC3.1: Small Wind Turbine Manufacturing and installation	High	Y	Dec 2024
RS _2UC3.2 Testing of Small Wind Turbines using Standards	Low	Partially completed. In progress by the Indian partners	
ecoConverter			
C_1UC1: Development and control of power electronic converters			
C_2UC1.1: Development and control of power electronic converters	High	Fully demonstrated in 1st round	
C_2UC1.2: Testing and on-filed demonstration of the power electronic converters satisfying various standards	High	Partially completed. In progress by the Indian partners	
ecoVehicle			
VH_1UC2: Selection and customization of rickshaw			
VH_2UC2.2: Customization of the vehicle to the demo site requirements	High	Fully demonstrated in 1st round	
VH_1UC3: Onboard energy management for e-Boat			
VH_2UC3.1: PV Integration with e-Boat	High	Fully demonstrated in 1st round	

Table 4 Use cases status and timeline for Ghoramara island demo site

2.4 Keonjhar

A checklist of the successfully achieved Use Cases (UCs) demonstrated in Keonjhar microgrid is presented below.

Use Cases Inventory - Pilot Site Demonstration: Gaidroumandra Microgrid	UC priority	Status	Timeline
ecoMicrogrid			
MG_1UC1: Microgrid monitoring			
MG_2UC1.1: Real time microgrid monitoring and data acquisition	High	Fully demonstrated in 1st round	
MG_2UC1.2: RES production estimation	Low	Y	Dec 24

MG_2UC1.3: Data concentration, storage, and management	High	Fully demonstrated in 1st round	
MG_1UC2: Microgrid optimal management of operation			
MG_2UC2.2: Multi objective microgrid management - Optimization of Energy Production, Storage and Purchase	High	Y	Dec 24
ecoPlanning			
PN_1UC1: 7-Year Energy Planning			
PN_2UC1.1: Data collection and storage	Low	Fully demonstrated in 1st round	
PN_2UC1.2: Electrical models & demand peak models design, RES & Load estimation	High	Fully demonstrated in 1st round	
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	Updated	Dec 24
PN_1UC2: RES Hosting Capacity			
PN_2UC2.1: Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds	High	Fully demonstrated in 1st round	
PN_2UC2.2: Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment	High	Updated	Dec 24
PN_1UC3: Interconnections			
PN_2UC3.1: Electrical models, demand peak models & interconnections design, RES & Load estimation	High	Y	Dec 24
PN_2UC3.2: Hourly Unit Commitment, through optimization algorithm for mid to long term horizon	High	Y	Dec 24
PN_1UC4: Multi-energy vectors			
PN_2UC4.1: Energy carriers' identification, data collection and quantification of impact on total load (hourly)	Low	Fully demonstrated in 1st round	
PN_2UC4.2: Electrical models & demand peak design, RES & Load estimation, energy carriers' scenarios integration	High	Fully demonstrated in 1st round	
PN_2UC4.3: Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers	High	Updated	Dec 24
ecoDR			
DR_1UC1: Increased energy monitoring at demand side			

DR_2UC1.1: Real time monitoring of energy consumption	Medium	In progress by the Indian partners	
DR_1UC2: Integration Interfaces for Load Management			
DR_2UC2.1: Scheduling of loads	High	In progress by the Indian partners	
DR_2UC2.2: Programmable Load shedding controller	High	In progress by the Indian partners	
ecoPlatform			
PT_1UC2: Platform as a service for dependent tools integration			
PT_2UC2.1: Facilitate data exchange between dependent tools	High	Fully demonstrated in 1st round	
PT_1UC3: Data storage and cloud server			
PT_2UC3.1: Route the microgrid data and data from dependent tools to cloud database	Medium	Fully demonstrated in 1st round	
PT_2UC3.2: Facilitate archived data access for dependent tools using API	Low	Fully demonstrated in 1st round	
ecoCommunity			
CM_1UC1: Dynamic pricing of electricity			
CM_2UC1.2: Billing and payments	Medium	Updated	Dec 24
CM_1UC2: Scheduling and Coordination			
CM_2UC2.1: Facilitating(display) of the scheduling and shifting of non-critical and flexible loads	Medium	Updated	Dec 24
CM_1UC3: Outreach forum			
CM_2UC3.1: Feedback and suggestions from users about the tools	Medium	Y	Dec 24
CM_2UC3.2: Reporting of problem	High	Updated	Dec 24
CM_2UC3.3: Forum to share experiences	Medium	Updated	Dec 24
CM_1UC4: Guidance and Training			
CM_2UC4.1: Training material (troubleshooting)	Medium	Y	Dec 24
CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)	High	Updated	Dec 24
ecoVehicle			
VH_1UC2: Selection and customization of rickshaw			
VH_2UC2.2: Customization of the vehicle to the demo site requirements	High	Fully demonstrated in 1st round	

Table 5 Use cases status and timeline for Keonjhar demo site

3 Demonstration round 2 activities at demo sites

3.1 Bornholm Island

In the 1st demonstration round for Bornholm site, several use cases have been fully tested (EMS_2UC1.1, EMS_2UC1.2, EMS_ 2UC2.1, EMS_ 2UC2.3, PT_2UC1.1, PT_2UC1.2, PT_2UC2.1, PT_2UC3.2).

Some use cases were further tested in round 2 (EMS_ 2UC2.2, DR_2UC1.1, PT_2UC2.2, PT_2UC3.1, MN_2UC1.1), and some use cases were tested in round 2 for the 1st time (MN_2UC1.2, CM_2UC3.1, CM_2UC3.2, CM_2UC3.3, CM_2UC4.1, CM_2UC4.2, CM_2UC5.1).

3.1.1 ecoEMS

EMS_2UC1.1: Real time system monitoring and data acquisition and visualization

This use case was fully demonstrated in D7.4

EMS_ 2UC1.2: Module manager: intercommunications and data exchange

This use case was fully demonstrated in D7.4

EMS_ 2UC2.1: Mid-term and short-term RES and load forecasting. Training of the Forecasting model

This use case was fully demonstrated in D7.4

EMS_ 2UC2.2: Unit Commitment and Economic Dispatch algorithms

The final use case of the ecoEMS focuses on automating and optimizing energy dispatch decisions. The key objectives include: (a) daily simulation preparation using forecasts, community engagement, and data from Neogrid devices, (b) running pre-Day Ahead Scheduling, issuing orders, and visualizing results, and (c) executing Day Ahead Scheduling on an hourly basis with a 24-hour horizon to optimize dispatch and enhance flexibility. ecoEMS operates autonomously, fetching data from ecoPlatform at specified intervals and running simulations to generate and publish dispatch orders for various resources (imports/exports, CHP, renewable energy sources, and Neogrid temperature controls). In case of delays, ecoEMS defaults to the most recent available data. The system continuously updates forecasts, flexible demand slots, and Neogrid data, adjusting the energy dispatch to maximize efficiency and community engagement.

Since demonstration round 1, in this demonstration round the fixed temperature adjustment of 5 degrees Celsius that was provided to all Neogrid devices has been optimized. In Figure 1 we can see the temperature adjustments that are tailored to each device, according to each water return temperature.

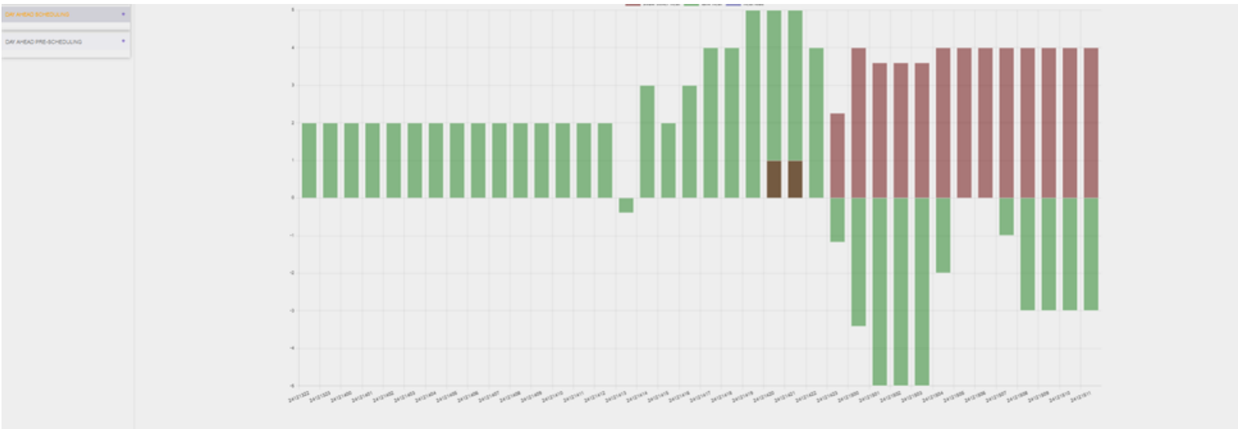


Figure 1 ecoEMS displaying the suggested temperature adjustment to a Neogrid device

Temperature adjustments are made available in ecoPlatform for further processing. From ecoPlatform values are directly snatched by the demonstration site manager using the Neogrid platform. In the platform the corresponding data streams are associated with the correct location.

#	Name	Topic	Unit	Last Data					
⌄	ecoplatform-demo-publisher	reempowered-ecoplatform.dk	8883	🔒	P001-qPRLe6fjDKY8v2dlzKddjHdCosZ	-hidden-	✓	Yes	BEOF	Conversions Scan Disable

#	Name	Topic	Location	Last Data	
1	BV/consumer_consumption	BV/consumer_consumption	Grevens Dal 17, 3760, Gudhjem	2 hours ago	Subscribe
2	BV/heat_plant	BV/heat_plant	-	Never	Subscribe
3	ecocommunity/ec_summary	ecocommunity/ec_summary	Anker Engelunds Vej 1, 2800, Kongens Lyngby	6 days ago	Subscribe
4	ecoems/22891_temperature	ecoems/22891_temperature	Bokulvej 2, 3760, Gudhjem	2 hours ago	Unsubscribe
5	ecoems/22893_temperature	ecoems/22893_temperature	Gartnervænget 1, 3760, Gudhjem	2 hours ago	Unsubscribe
6	ecoems/22895_temperature	ecoems/22895_temperature	Grevens Dal 17, 3760, Gudhjem	2 hours ago	Unsubscribe
7	ecoems/22897_temperature	ecoems/22897_temperature	Grevens Dal 19, 3760, Gudhjem	2 hours ago	Unsubscribe

Figure 2 Neogrid Platform is subscribed to data streams from ecoPlatform using MQTT

EMS_ 2UC2.3: Multi-energy vector management of operation

This use case was fully demonstrated in D7.4

3.1.2 ecoDR

DR_2UC1.1: Real time monitoring of energy consumption

As explained in the first-round reporting, the real-time data transfer from the router to the ecoPlatform was not fully functional. This issue has been resolved by implementing an additional script that collects data from the router interface and sends them to the ecoPlatform. The 16 different measurements are now mapped to their corresponding data streams under the ecoDR dataset.

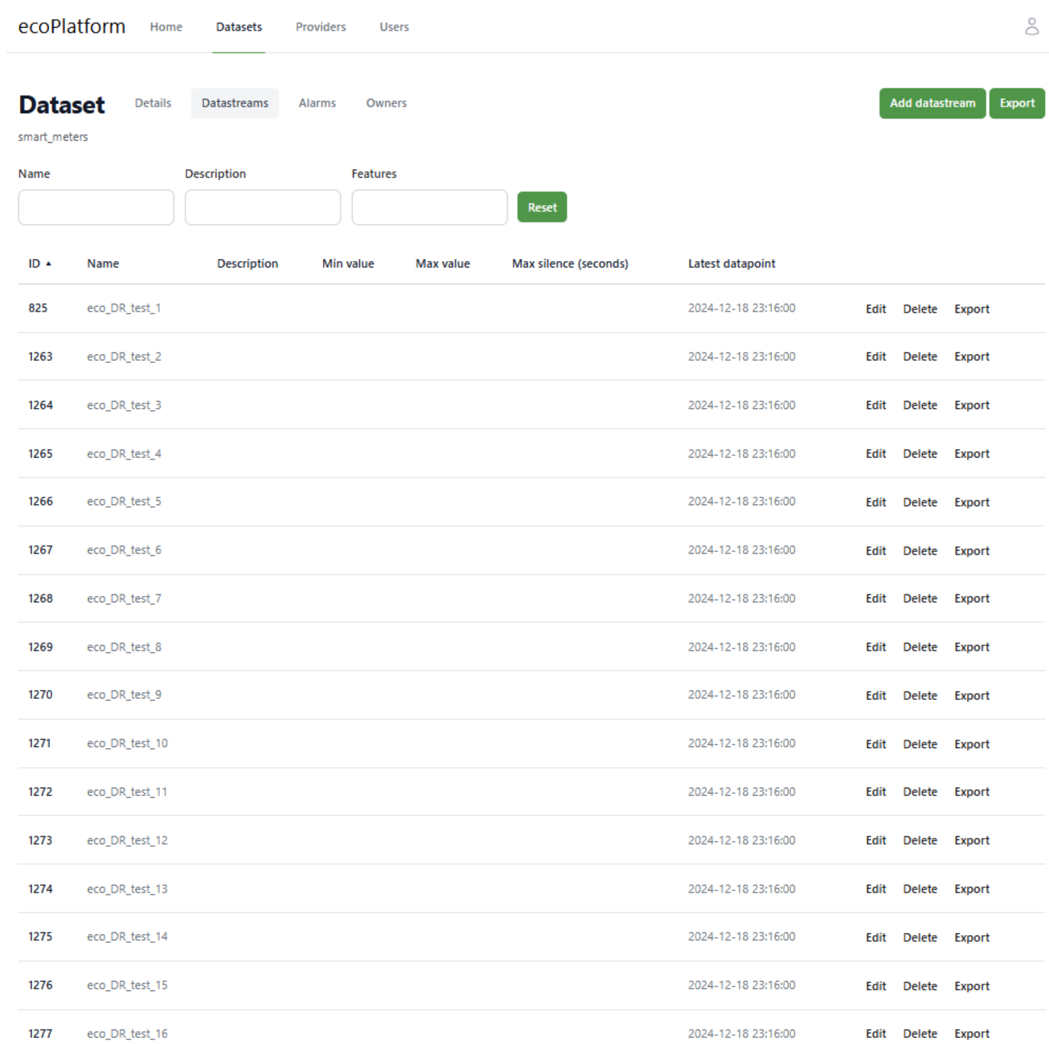


Figure 3 Overview of the 16 measurements mapped to the ecoDR dataset.

To provide an illustration of some of the 16 different measurements, examples are shown in Figure 4 and Figure 5 below.

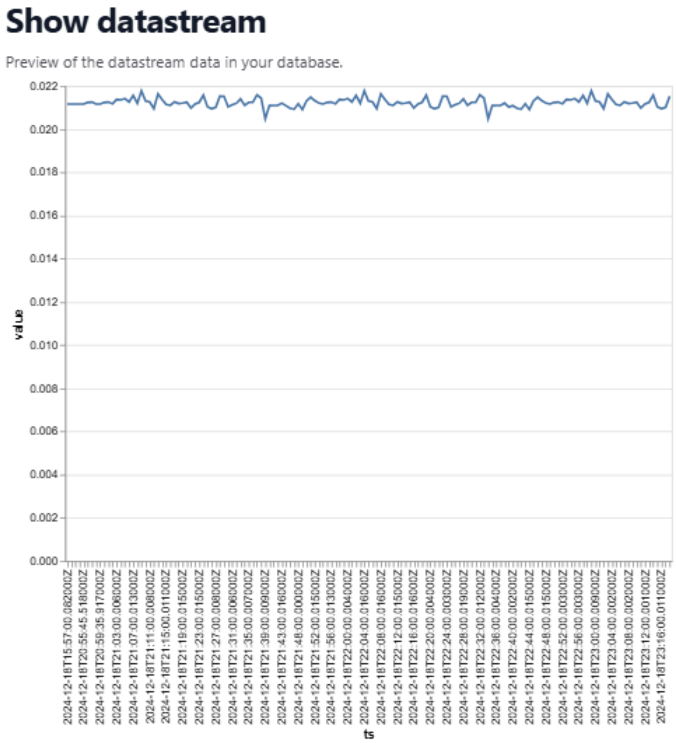


Figure 4 Example of current measurements in the ecoDR dataset.

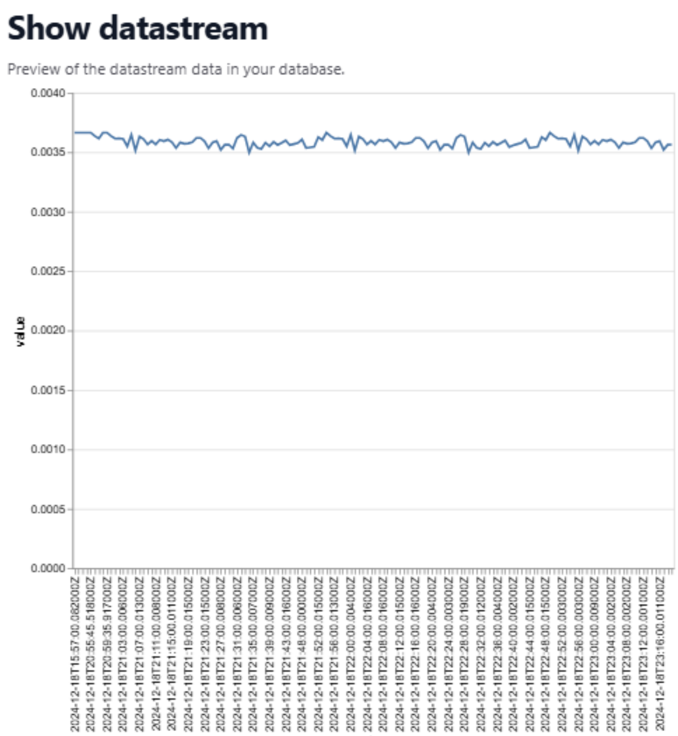


Figure 5 Example of reactive power measurements in the ecoDR

DR_2UC2.1: Scheduling of loads

The below figure shows that load scheduling appears on the router interface. Unfortunately, it was not possible to fully demonstrate this feature due to technical issues and considering the long delays in the arrival of the equipment from India. Due to the very small nominal power of ecoDR (3 kW), this scheduling would have minimum impact on the Bornholm island overall demonstration.

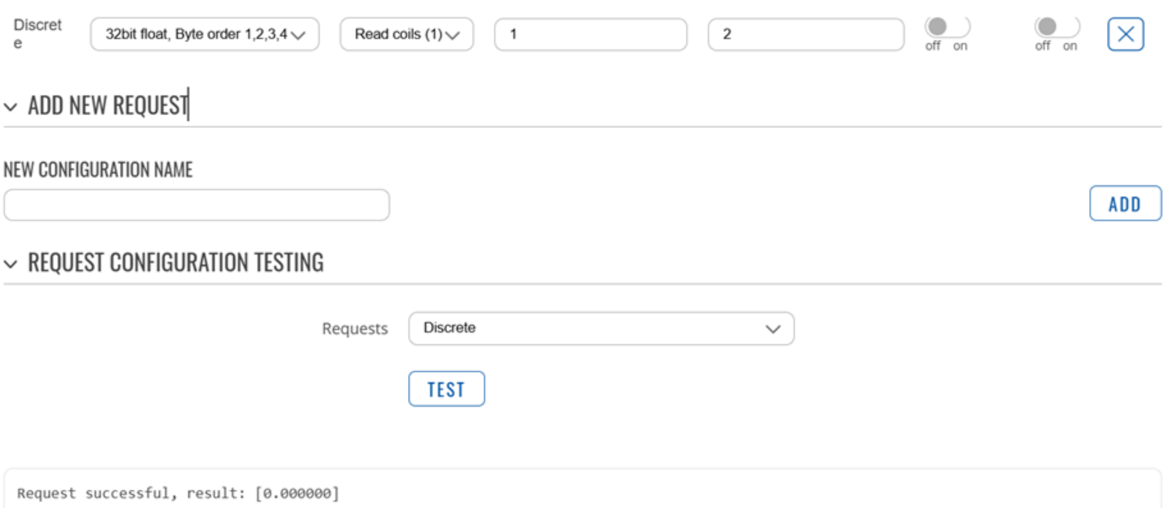


Figure 6 Configuration of the router and readings showing load scheduling with ecoDR

3.1.3 ecoPlatform

In the first round of the demonstration phase, each use case was examined to demonstrate the stable exchange of information among key tools, including ecoEMS, ecoCommunity, ecoDR, ecoMonitor, and additional assets such as forecasting services and edge device data. Building on the success of the first demonstration phase, the second round focuses on expanding the scope with further examples and details, as well as conducting multiple full-cycle data exchanges to thoroughly evaluate the platform's functionality. This phase aims to ensure consistent information exchange across all key tools and assets, confirming the platform's readiness and robustness for real-world applications.

PT_2UC1.1: Connect to sensors and acquire data through designated communication network and protocols

This use case was demonstrated in D7.4.

PT_2UC1.2: Data cleansing to ensure consistency and human machine interface

This use case was demonstrated in D7.4.

PT_2UC2.1: Facilitate data exchange between dependent tools

This use case was demonstrated in D7.4.

PT_2UC2.2: Facilitate access to controllable assets for dependent tools

In D7.4 [2] the integration between ecoTools and the district heating system was documented. In the following detailed documentation of the process for control of the electrical boiler on the heat plant is illustrated.

As illustrated in D7.4 [2], the setpoints for the electrical boilers (in MWh) are calculated in ecoEMS, then transferred to ecoPlatform, followed by a transfer to the BV's company data platform (stored in SQL database). Next, they are handled by the OPC Router which writes the value to the PLCs controlling the boilers.

Therefore, when ecoEMS updates the setpoints every hour the production on the boilers should react. This is exactly documented below and finalizes the use case of facilitating the control of controllable assets through the ecosystem of ecoTools.

First the setpoint value was changed in the SQL database. As expected, the value read in OPC router reacted. See figures below:

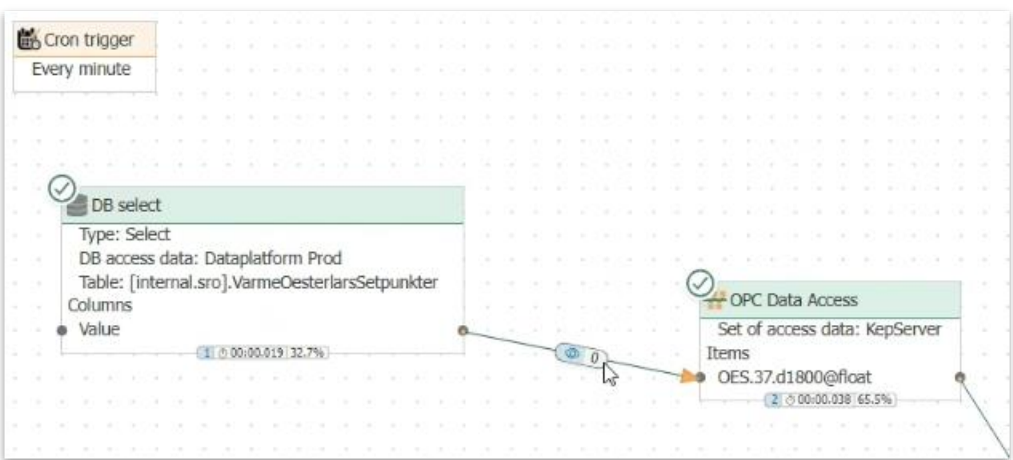


Figure 7 OPC router-Value from Data platform-VarmeOesterlarsSetpunkter = 0 MWh

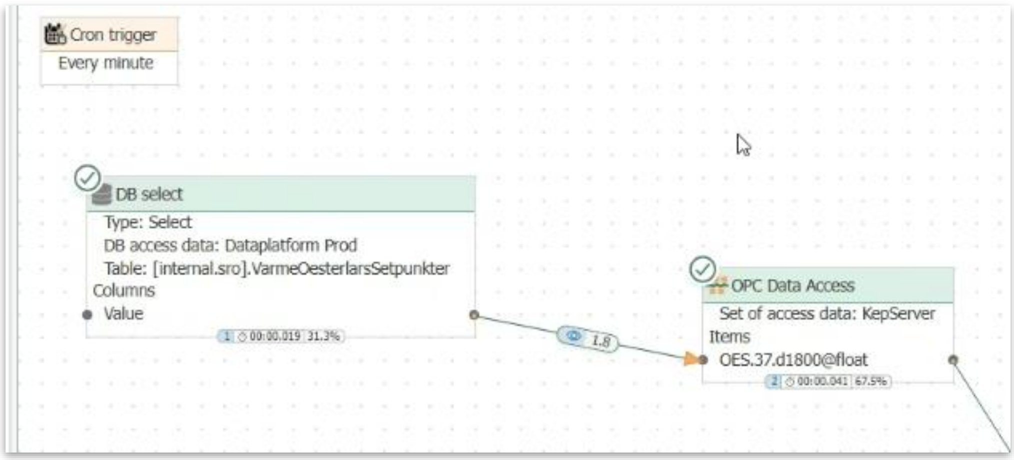


Figure 8 OPC router-Value from Data platform-VarmeOesterlarsSetpunkter = 75% capacity

Afterwards, setpoints were adjusted to test various setpoints. In the figures below a couple of screenshots from the SCADA system illustrate the difference between an active and inactive boiler. Image on the left shows a given setpoint of zero. This means that the electrical boilers is off. Image on the right shows a setpoint given of 0.6 MWh which is 25% of the total capacity.

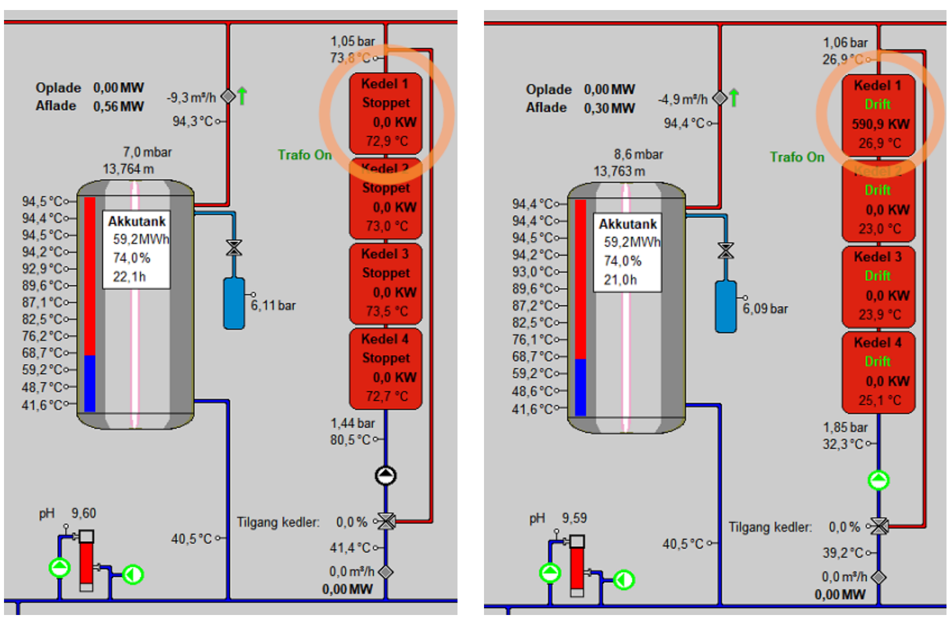


Figure 9 SCADA system at Østerlars heat plant

The final test concerned changing the setpoint of the boiler by receiving a new setpoint from ecoEMS. In the forecasted prognosis for the setpoints it was found that the next setpoint was set to zero. To illustrate the functionality the setpoint was manually changed to 0,6 MWh with the anticipation that the electrical boiler would be turned off once the next job was completed.

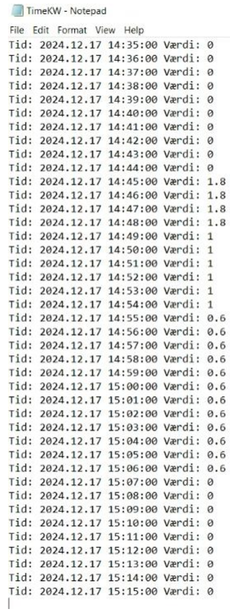


Figure 10 Screenshot from logfile (Tid = time). Screenshots contain timestamps and value (Værdi)

In the picture above the setpoint was set to 0.6 MWh at 14:55. The job inside the company data platform was started at 15:00 and completed at 15:06. It can be seen that the setpoint of the boilers was set to 0 at 15:06 as expected.

This finalizes the implementation of the controllable assets from ecoEMS and all the way to the boiler.

PT_2UC3.1: Route the microgrid data and data from dependent tools to cloud database

This use case was demonstrated in D7.4. Additionally, Figure 11 and Figure 12 illustrate all datasets created in the ecoPlatform interface by the ecoTools including ecoEMS, ecoCommunity, ecoDR, ecoMonitor and relevant services including edge device measurements and hourly and daily forecasts.

Provider ▲	Name	Description	MQTT namespace	MQTT subtopic		
BV	consumer_consumption	Consumption data for demand side management (Neogrid)	BV	consumer_consumption	Edit	Delete
BV	heat_plant	Measurements from the SCADA system (Heat Plant in Østerlars)	BV	heat_plant	Edit	Delete
DTU	Daily_El_Load	Once in a day forecast	test_demo	DA_EL_L	Edit	Delete
DTU	Daily_PV	Once in a day forecast, does not roll in time.	test_demo	DA_PV	Edit	Delete
DTU	Daily_Wind	Once in a day forecast, not rolling in time.	test_demo	DA_Wind	Edit	Delete
DTU	HourlyForecast	This dataset will include 24 datastreams regarding the forecasted PV power.	test_demo	hourly_PV_forecast	Edit	Delete
DTU	WindForecast	here, there are 24 datastreams one for each hour	test_demo	hourly_wind_forecast	Edit	Delete
DTU	ThermalLoadForecast	The thermal load consumption forecast has 24 separate DataStreams, one for each hour.	test_demo	hourly_heat_forecast	Edit	Delete
DTU	ElectricLoadForecast	The electric load consumption forecast has 24 separate DataStreams, one for each hour.	test_demo	hourly_electric_forecast	Edit	Delete
DTU	Daily_Th_Load	Once in a day forecast not rolling in time	test_demo	DA_TH_L	Edit	Delete
EMS	ecoems_das	hourly temperature adjustment for 22891 device	ecoems	22891_temperature	Edit	Delete
EMS	ecoems_das	hourly temperature adjustment for 22898 device	ecoems	22898_temperature	Edit	Delete
EMS	ecoems_das	hourly temperature adjustment for 23697 device	ecoems	23697_temperature	Edit	Delete
EMS	ecoems_das	hourly temperature adjustment for 23695 device	ecoems	23695_temperature	Edit	Delete
EMS	ecoems_das	hourly temperature adjustment for 23696 device	ecoems	23696_temperature	Edit	Delete
EMS	predas	datastreams about predas-renewed once per day.	ecoems	pre_das	Edit	Delete
EMS	ecoems_das	hourly temperature adjustment for 22895 device	ecoems	22895_temperature	Edit	Delete
EMS	ecoems_das	hourly temperature adjustment for 22893 device	ecoems	22893_temperature	Edit	Delete
EMS	ecoems_das	hourly temperature adjustment for 22897 device	ecoems	22897_temperature	Edit	Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of electric boilers setpoints	ecoems	electric_boilers	Edit	Delete

Previous 1 2 Next

Figure 11 Datasets created in ecoPlatform by each provider/tool (page-1)

Provider ▲	Name	Description	MQTT namespace	MQTT subtopic	
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of heat tank	ecoems	tank_heat	Edit Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of chp	ecoems	chp	Edit Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of res curtailment	ecoems	curtailment	Edit Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of import	ecoems	import	Edit Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of export	ecoems	export	Edit Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of straw boilers	ecoems	straw_boiler_heat	Edit Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of controllable heat	ecoems	controllable_heat	Edit Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of communal load	ecoems	communal_load	Edit Delete
EMS	ecoems_das	hourly publishing of 24 hours (rolling) ahead scheduling of tank energy	ecoems	tank_energy	Edit Delete
ecoCommunity	Acceptance Summary	Time Slot Acceptance Summary	ecocommunity	ec_summary	Edit Delete
ecoDR	smart_meters	advanced smart meter	ecoDR_measurements	measured_smart_meters	Edit Delete
ecoMonitor	air_quality	digital control platform equipped with multiple sensors and a microcontroller	ecoMonitor_measurements	measured_air_quality	Edit Delete

Previous 1 2 Next

Figure 12 Datasets created in ecoPlatform by each provider/tool (page-2)

PT_2UC3.2: Facilitate archived data access for dependent tools using API

This use case was demonstrated in D7.4.

3.1.4 ecoMonitor

As detailed in D7.3 [4] and D7.4 [2], the ecoMonitor device was installed directly at the DTU laboratory, leveraging secure testing facilities within the same climatic region to ensure a safe setup and operational reliability. Currently, ecoMonitor is connected to the Bornholm demo-site through router, internet connection and ecoPlatform, minimizing the impact of this relocation on the project's activities.

MN_2UC1.1: Acquisition and transmission of air quality parameters data

The deployed measurement device has been operating without issues in terms of measuring the units, confirming the stability and reliability of the system. During the first demonstration round, the device was successfully connected to a router for data transfer. However, only one measurement variable was being transmitted instead of the complete dataset. This issue has been resolved in the current round. **The ecoMonitor now successfully measures and transmits eight distinct variables via the router**. Table 6 provides a complete list of the data readings supported by ecoMonitor.

	Starting Address	quantity	Purpose
Input Registers	0x00	16	i) **Register 0 & 1:** 4 byte floating point data for concentration of NO2 gas in ppm ii) **Register 2 & 3:** 4 byte floating point data for concentration of SO2 gas in ppm iii) **Register 4 & 5:** 4 byte floating point data for concentration of CO gas in ppm iv) **Register 6 & 7:** 4 byte floating point data for concentration of O3 gas in ppm v) **Register 8 & 9:** 4 byte floating point data for concentration of particles 2.5 in ug/m^3 vi) **Register 10 & 11:** 4 byte floating point data for concentration of par-ticles 10 in ug/m^3 vii) **Register 12 & 13:**4 byte floating point data for temperature in °C viii) **Register 14 & 15:** 4 byte floating point data for humidity in %RH.

Table 6 Complete list of ecoMonitor readings

The router has been successfully connected to the ecoMonitor, and the configurations showed in Figure 13 and Figure 14 have been completed to facilitate the transfer of ecoMonitor data readings to the Teltonika (router) interface.

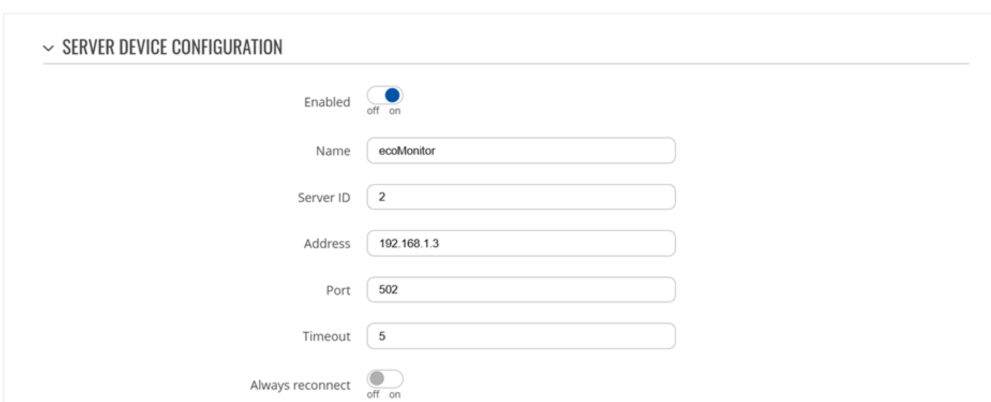


Figure 13 Configuration of router that communicates with ecoMonitor - 1

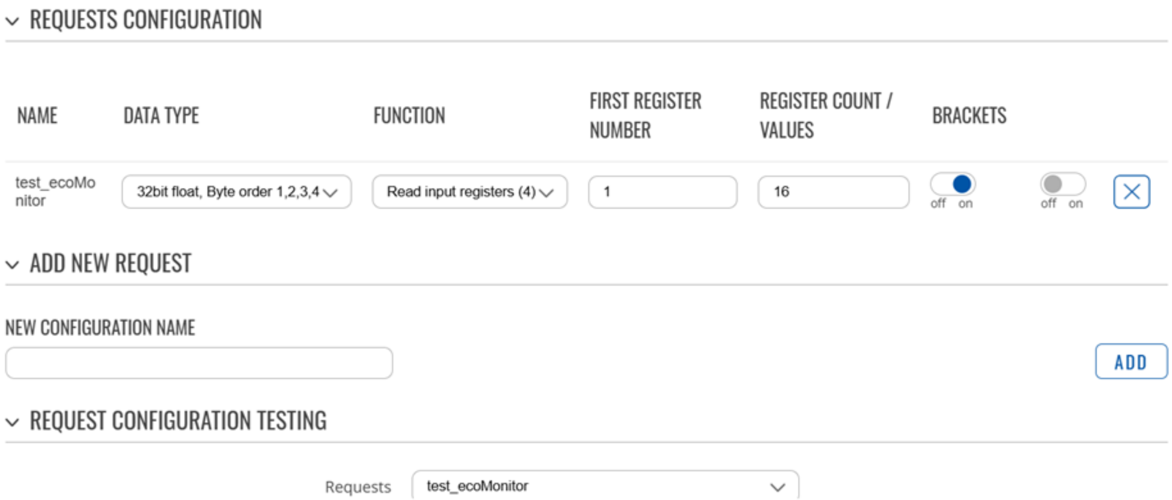


Figure 14 Configuration of router that communicates with ecoMonitor - 2

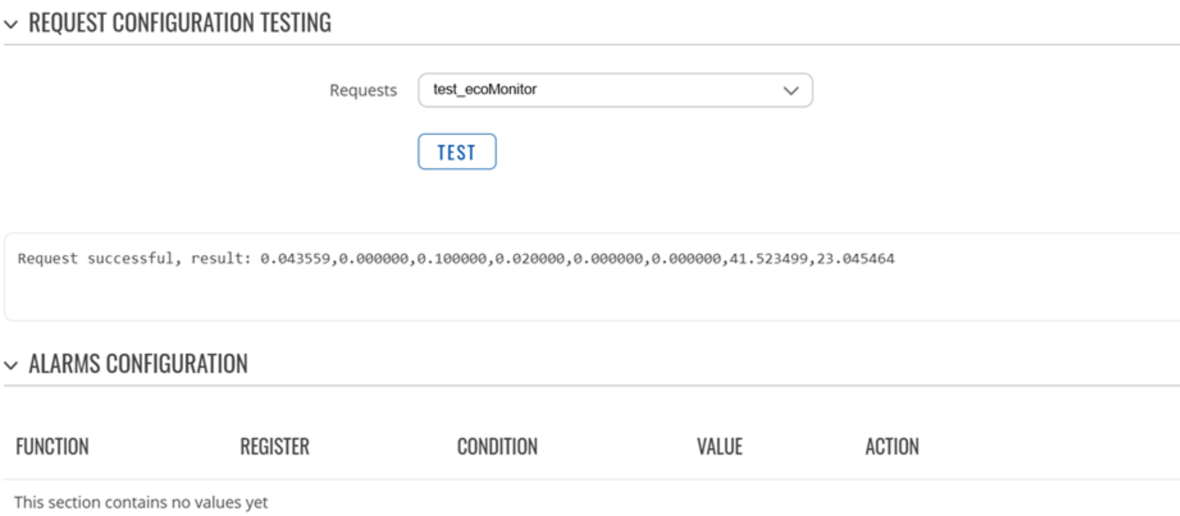
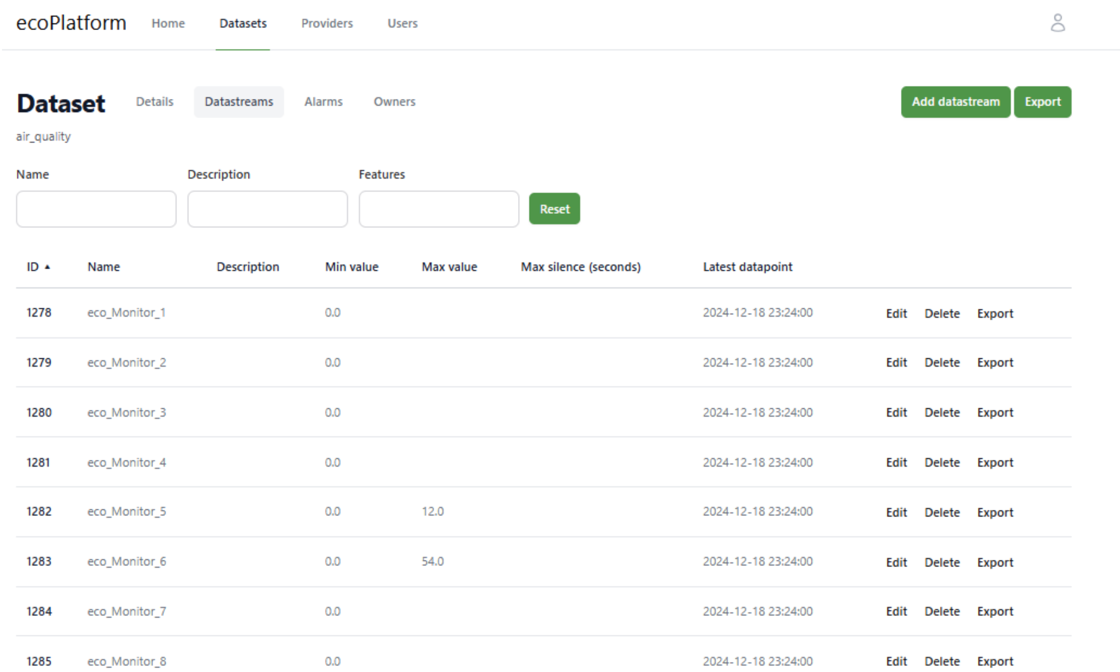


Figure 15 Test connection where all measurement data are read successfully from ecoMonitor

MN_2UC1.2: Data processing and evaluation

The ecoMonitor measures eight different parameters, including SO_2, NO_2, CO, O_3, $PM_{2.5}$, PM_{10}, temperature, and humidity. These measurements are transmitted to the ecoPlatform via the router with the help of manual data acquisition. Details of the datastream, along with an example of temperature measurements, are illustrated in Figure 16 and Figure 17.



ID ▲	Name	Description	Min value	Max value	Max silence (seconds)	Latest datapoint			
1278	eco_Monitor_1		0.0			2024-12-18 23:24:00	Edit	Delete	Export
1279	eco_Monitor_2		0.0			2024-12-18 23:24:00	Edit	Delete	Export
1280	eco_Monitor_3		0.0			2024-12-18 23:24:00	Edit	Delete	Export
1281	eco_Monitor_4		0.0			2024-12-18 23:24:00	Edit	Delete	Export
1282	eco_Monitor_5		0.0	12.0		2024-12-18 23:24:00	Edit	Delete	Export
1283	eco_Monitor_6		0.0	54.0		2024-12-18 23:24:00	Edit	Delete	Export
1284	eco_Monitor_7		0.0			2024-12-18 23:24:00	Edit	Delete	Export
1285	eco_Monitor_8		0.0			2024-12-18 23:24:00	Edit	Delete	Export

Figure 16 Overview of the 8 measurements mapped to the ecoMonitor dataset.

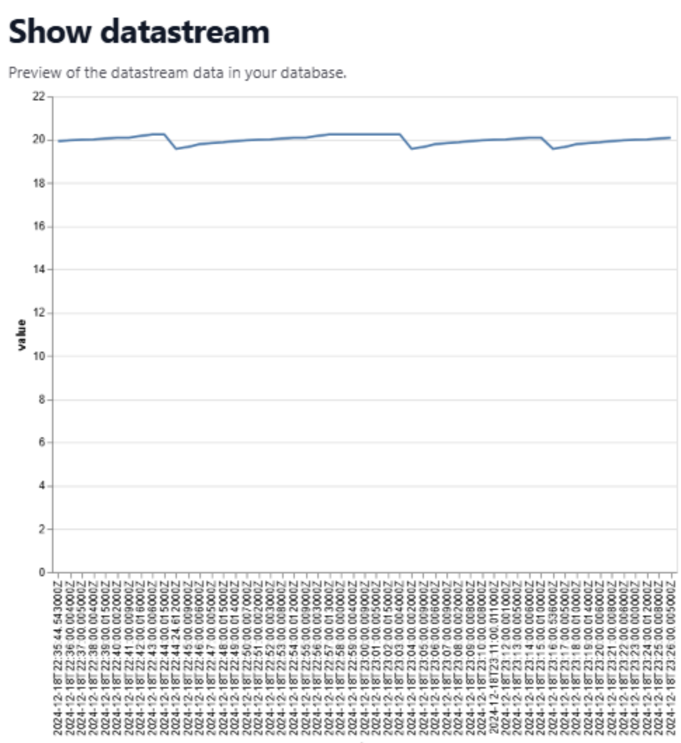


Figure 17 Example of temperature measurements in the ecoMonitor dataset.

3.1.5 ecoCommunity

CM_2UC3.1: Feedback and suggestions from users about the tools

A questionnaire was distributed to selected participants of the Bornholm demo site in order to assess the usefulness of the app's modules. The feedback was in general positive. The feedback received was related to the graphs for consumption in the app.

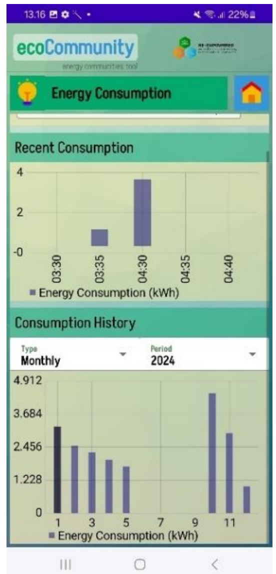


Figure 18 Illustrates the skewed scales that was suggested to change in future versions of the app.

CM_2UC3.2: Reporting of problem

A feature in the application is to report problems, should they occur. The list of problems can be filtered among "Submitted", "In progress", "Rectified" or "All". The filtering options allow the user to follow the status of a reported problem in order to mitigate the risk of more people reporting the same problem.

Figure 19 Problem reporting page

CM_2UC3.3: Forum to share experiences

Community participants can connect and exchange knowledge through a Forum in ecoCommunity. All project participants can contribute to the success and engage with site administrator or each other. A post about energy consumption exists in the application. In the post the author asks if others experience less energy consumption compared to normal. In Figure 20, the forum is accessed from the main page (left). Existing posts are displayed in the Forum and new posts can be created (middle). Edits to post can be done when selecting a specific post (right).

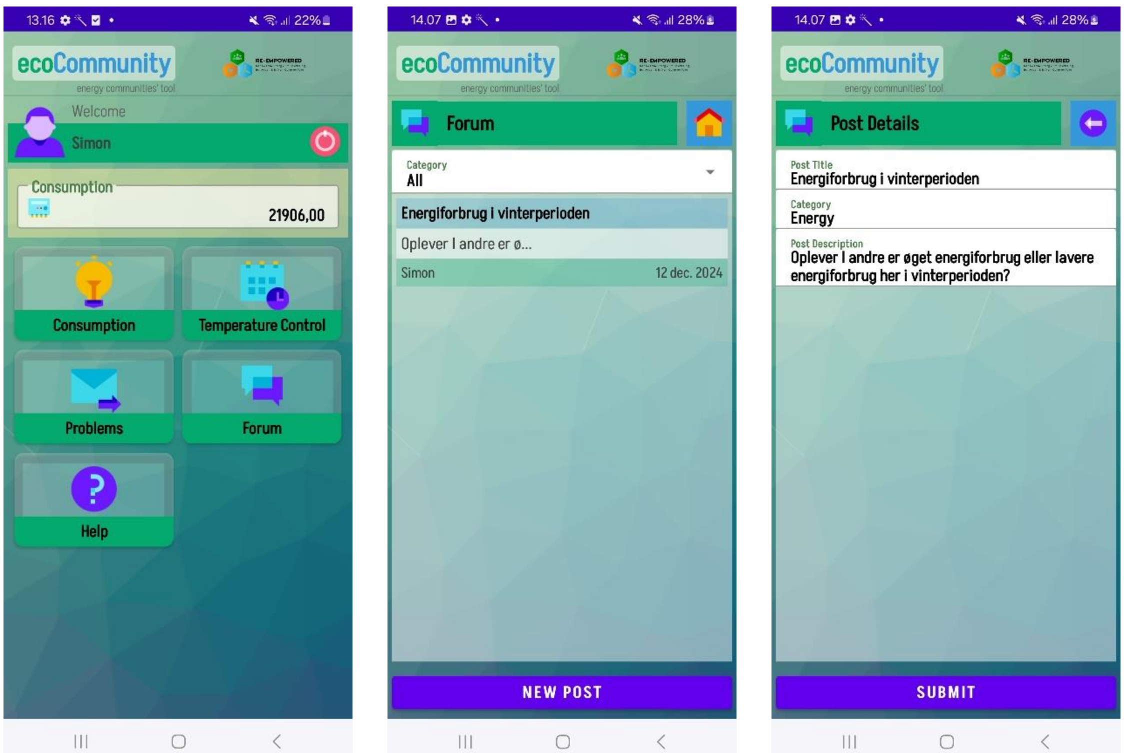
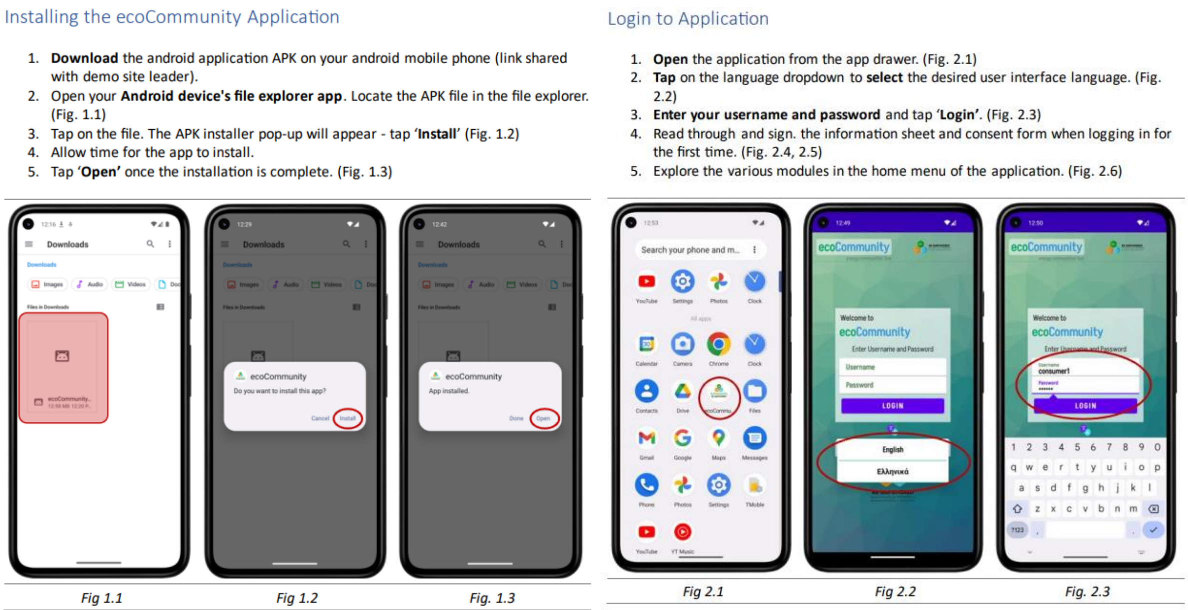


Figure 20 Screenshots of the Forum in ecoCommunity

CM_2UC4.1: Training material (troubleshooting)

Training and installations materials have been carried out by the tool's developer. A comprehensive yet easy to read guide is illustrated below.


Installing the ecoCommunity Application

1. **Download** the android application APK on your android mobile phone (link shared with demo site leader).
2. Open your **Android device's file explorer app**. Locate the APK file in the file explorer. (Fig. 1.1)
3. Tap on the file. The APK installer pop-up will appear - tap **'Install'** (Fig. 1.2)
4. Allow time for the app to install.
5. Tap **'Open'** once the installation is complete. (Fig. 1.3)

Login to Application

1. **Open** the application from the app drawer. (Fig. 2.1)
2. **Tap** on the language dropdown to **select** the desired user interface language. (Fig. 2.2)
3. **Enter your username and password** and tap **'Login'**. (Fig. 2.3)
4. Read through and sign. the information sheet and consent form when logging in for the first time. (Fig. 2.4, 2.5)
5. Explore the various modules in the home menu of the application. (Fig. 2.6)

Fig 1.1 *Fig 1.2* *Fig. 1.3* *Fig 2.1* *Fig 2.2* *Fig. 2.3*

Figure 21 Screenshots of selected parts of the installation guide for ecoCommunity

CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)

Participants can access training material through the application. Under Help (purple question mark) a dropdown menu lists the available tools. Under each tool there are options to show "manual", "FAQ", "Videos" and "Others". Content for each tool varies based on the application and options for guidance provided by the tool.

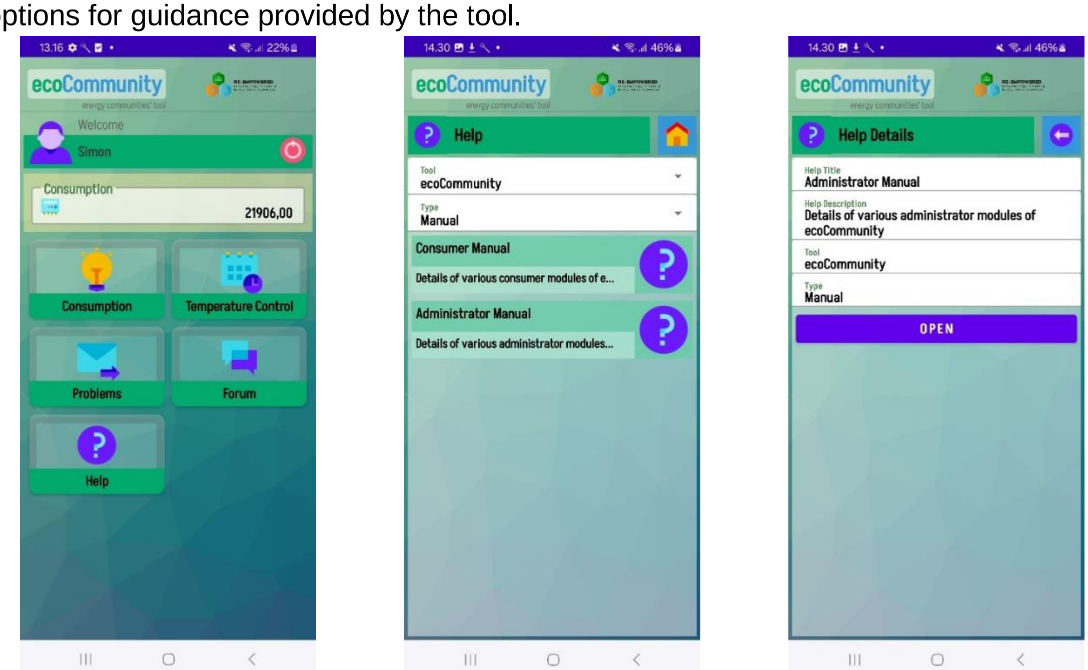


Figure 22 Help section of the application. In the pictures a manual for the ecoCommunity application is found and can be downloaded to the phone by pressing "OPEN".

CM_2UC5.1: Monitoring of heating system at load centers

Implementation and integration between each individual district heating unit and the entire ecosystem of ecoTools including ecoCommunity has been established. The variables for monitoring and a functioning tool were early on carried out. In the figure below, the five data streams are return temperature, supply temperature, consumption, volume and flowrate.

ID ▲	Name	Description	Min value	Max value	Max silence (seconds)	Latest datapoint	Features
51	22895_RETURN_TEMPERATURE	Temperature at heat meter - Return	0.0	100.0		2024-12-17 08:40:00	data_owner:BV physical_unit:C sensor_owner:BV
52	22895_FLOW_TEMPERATURE	Temperature at meat meter - Supply	0.0	100.0		2024-12-17 08:40:00	data_owner:BV physical_unit:C sensor_owner:BV
53	22895_ENERGY	Energy consumption - Accumulated values				2024-12-17 08:40:00	data_owner:BV physical_unit:MWh sensor_owner:BV
1052	22895_VOLUME	Volume in m3, values are cumulated				2024-12-17 08:55:00	data_owner:BV physical_unit:m3 sensor_owner:BV
1053	22895_VOLUME_FLOW	Flowrate running through the smart meter				2024-12-17 08:40:00	data_owner:BV physical_unit:m3/h sensor_owner:BV

Figure 23 Selected data streams for a selected user as shown in ecoPlatform.

In the ecoCommunity, the consumption has been made available for the user. Every user can follow consumption on a daily or monthly basis.

Figure 24 ecoCommunity: Consumption is displayed on a daily basis (left) and monthly basis (right)

Project participants can choose to participate in operations of the project. For each hour of the following day a schedule is presented to the user on ecoPlatform. Users can choose to accept or reject to select the hours where they are willing to allow the ecosystems of ecoTools to operate.

Figure 25 Menu presented to user to accept/reject timeslots to participate in project operations

The functionality and data integrations are documented under ecoEMS and ecoPlatform.

3.2 Kythnos

3.2.1 Kythnos Power System

In the 1st demonstration round for Kythnos Power System site, several UCs have been fully tested (EMS_2UC1.1, EMS_2UC1.2, PN_2UC1.1, PN_2UC1.2, PN_2UC2.1, PN_2UC4.1, PN_2UC4.2).

Some use cases were further tested in round 2 (EMS_2UC2.1, EMS_2UC2.3, PN_2UC1.3, PN_2UC2.2, PN_2UC4.3, MN_2UC1.1), and some use cases were tested in round 2 for the 1st time (PN_2UC3.1, PN_2UC3.2, MN_2UC1.2).

3.2.1.1 ecoEMS

EMS_2UC1.1: Real time system monitoring and data acquisition and visualization

This use case was fully demonstrated in D7.4

EMS_ 2UC1.2: Module manager: intercommunications and data exchange

This use case was fully demonstrated in D7.4

EMS_ 2UC2.1: Mid-term and short-term RES and load forecasting

In order to improve the user's experience, an exception catcher has been created, popping a message so that the user may be aware of what the problem is. The prompt, suggests the user to contact the administrator of ecoEMS to provide the solution.

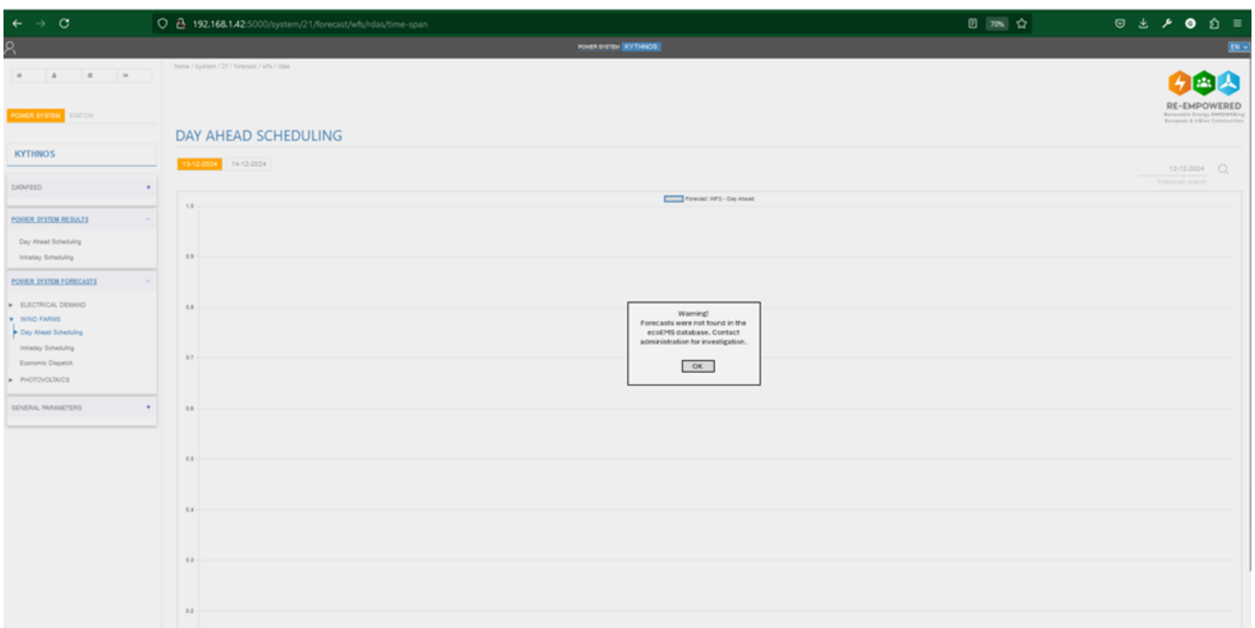


Figure 26 Error message for forecasts unavailability at ecoEMS

EMS_ 2UC2.3: Unit Commitment and Economic Dispatch algorithms

In order to improve the user's experience, an exception catcher has been created, popping a message so that the user may be aware of what the problem is. The prompt, suggests the user to contact the administrator of ecoEMS to provide the solution.

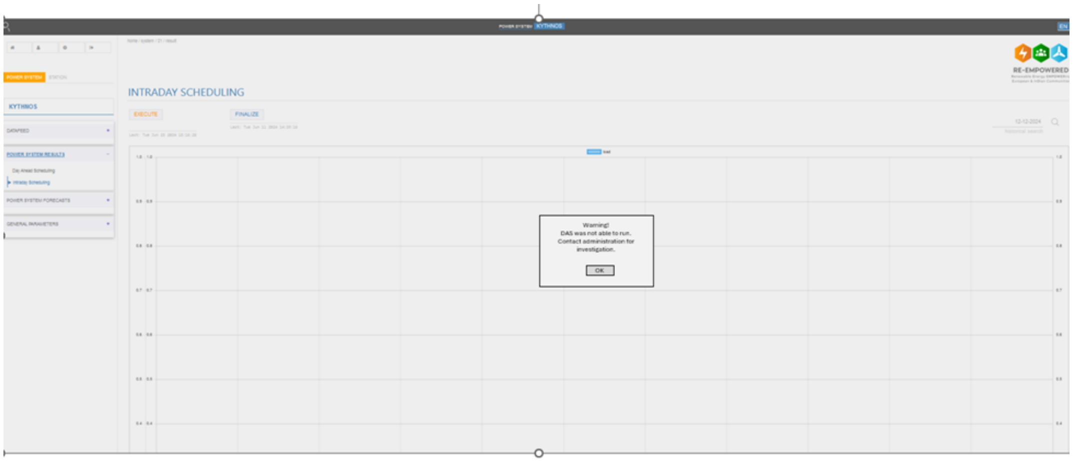


Figure 27 Error message for Day Ahead Scheduling failure at ecoEMS

The Economic Dispatch algorithm was not assessed as the photovoltaic data were not found in a quarter hourly granularity, and the assessment of this point of the UC was achieved in the second demonstration phase. The importance of the data availability was critical in order to perform the Economic Dispatch, which actually is the Unit Commitment closer to real time delivery, in quarter hourly steps. Thus, the execution of this algorithm permitted to capture the output of the suggested orders to the generation units, as depicted below:

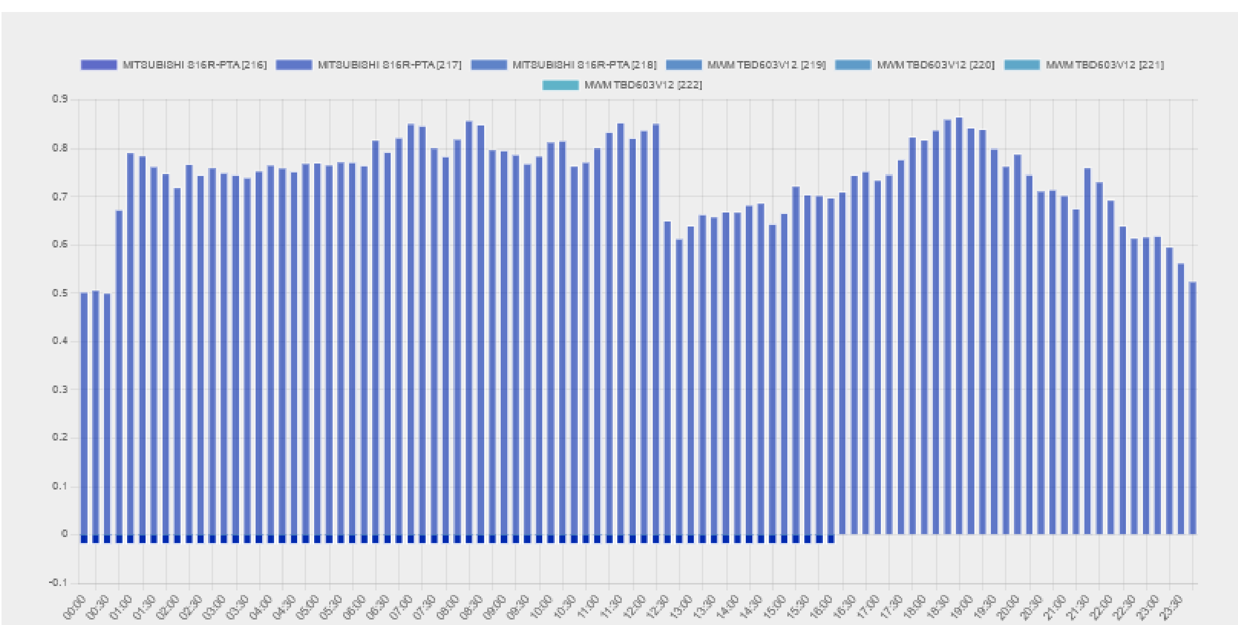


Figure 28 Economic Dispatch orders for generation units.

3.2.1.2 ecoPlanning

PN_2UC1.1: Data collection and storage

This use case was fully demonstrated in D7.4

PN_2UC1.2: Electrical models & demand peak models design, RES & Load estimation

This use case was fully demonstrated in D7.4

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

After the evaluation of demonstration round A (1st demonstration round), the logos of RE-EMPOWERED project have been added to the output results of the ecoPlanning simulations.

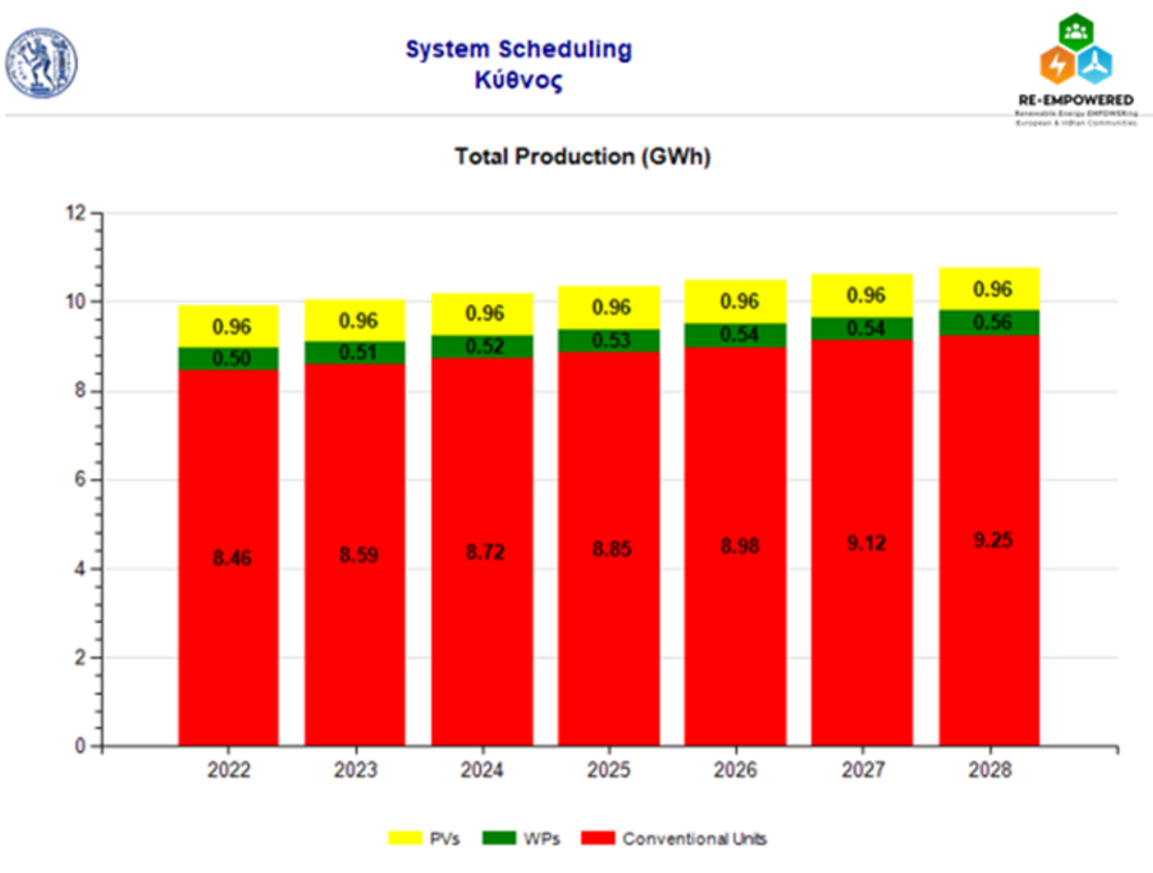


Figure 29 ecoPlanning output displaying the energy mix over the selected horizon simulated

PN_2UC2.1: Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds

This use case was fully demonstrated in D7.4

PN_2UC2.2: Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment

After the evaluation of demonstration round A, the logos of RE-EMPOWERED project have been added to the output results of the ecoPlanning simulations.

RES Hosting Capacity
Κύθνος

System cost

Scenario No	Fuel cost (€)	CO2 emissions allowance cost	Additional variable cost	Variable cost of thermal	RES production cost (€)	Total production cost (€)	Average thermal production	Average system cost (€/MWh)
1	2,884,849.30	153,730.73	28,972.42	3,067,552.45	138,252.77	3,205,805.21	317.64	290.38
2	2,696,507.44	143,694.18	27,002.88	2,867,204.51	203,903.89	3,071,108.40	318.54	278.18
3	2,671,370.84	142,354.68	26,745.29	2,840,470.81	212,630.81	3,053,101.63	318.61	276.55
4	2,508,768.34	133,689.76	25,048.91	2,667,507.01	269,176.98	2,936,683.99	319.48	266.00

RES cost

Scenario No	PV production cost (€)	WP production cost (€)	Total
1	80,213.58	58,039.19	**138,252.77**
2	80,213.58	123,690.32	**203,903.89**
3	160,427.15	52,203.66	**212,630.81**
4	160,427.15	108,749.83	**269,176.98**

Figure 30 ecoPlanning: HC displaying system and RES costs over the simulated scenarios

PN_2UC3.1: Electrical models, demand peak models & interconnections design, RES & Load estimation

The Operator is tasked with exploring the feasibility of interconnecting Non-Interconnected Island Systems (NIS) with each other or with the mainland grid, as part of the European goal for secure electricity supply and the trend towards interconnecting autonomous systems. This includes assessing the benefits and drawbacks of such projects.
The study focuses on both the technical and economic aspects of interconnections. The Operator must evaluate the integration of Island Systems, comparing the operational benefits of an interconnected system versus independent islands. The process starts by identifying the topology of the Island Systems and pinpointing the subsystems involved.
The interconnected systems fall into three categories:

1. Non-Interconnected Islands

2. Grids belonging to the mainland
3. Interconnected islands now part of the mainland grid.

Once the topology is analyzed, the study proceeds with those systems containing at least one Non-Interconnected Island. The integration of these systems typically reduces or eliminates local power generation, as energy is supplied via imports from the mainland. The Operator must also provide reports on both the energy outcomes and the economic impact of the proposed interconnections.

User firstly models the Peak/Demand and Electric System Model, as in the other UCs, and then decides on the combination of the interconnecting elements (NIS, mainland) and other technical characteristics such as length, resistance, year of implementation, etc.
Afterwards, the user may actually run the scenario of the interconnection implementation.

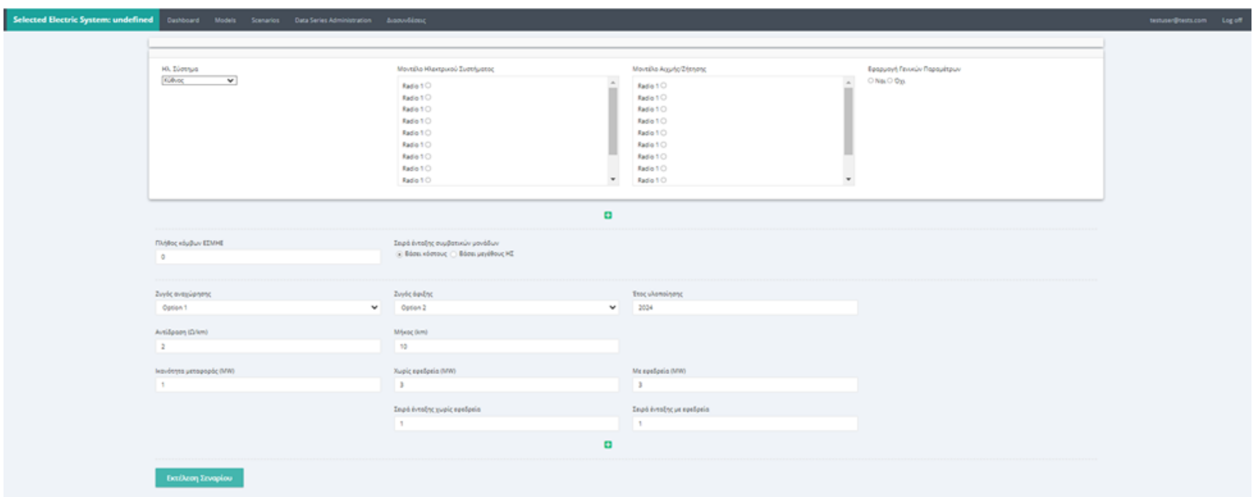


Figure 31 ecoPlanning interconnection study inputs

PN_2UC3.2: Hourly Unit Commitment, through optimization algorithm for mid to long term horizon

Since the successful completion of PN_2UC3.1, this UC is satisfied with the output of the optimization of the Unit Commitment. For this type of study, no actual report is generated, yet it can be designed by the user who can use the input information of the exported CSV files.
Using these output files, a simple summary could be the following:

Kythnos								
	Load (KWh)	Thermal generatiom (KWh)	RES generation (KWh)	Rejected RES energy	Energy deficit (KWh)	Kythnos - Keonjhar (KWh)	RES utilization (%)	Injected energy (KWh)*
2022	9,696.00	9,215.04	480.96	1,265.16	-	-	27.54%	
2023	9,906.80	9,417.34	489.46	1,256.66	-	-	28.03%	
2024	10,077.40	9,579.09	498.31	1,247.81	-	-	28.54%	
2025	10,248.00	9,741.56	506.44	1,239.68	-	-	29.00%	
2026	10,418.60	9,900.55	518.05	1,228.07	-	-	29.67%	
2027	10,589.20	7,263.66	528.20	1,217.92	-	619.40	65.72%	-2,797.34
2028	10,765.60	7,617.90	536.90	1,209.22	-	589.71	64.52%	-2,610.80

Table 7 Results summary from ecoPlanning interconnection study

PN_2UC4.1: Energy carriers' identification, data collection and quantification of impact on total load (hourly)

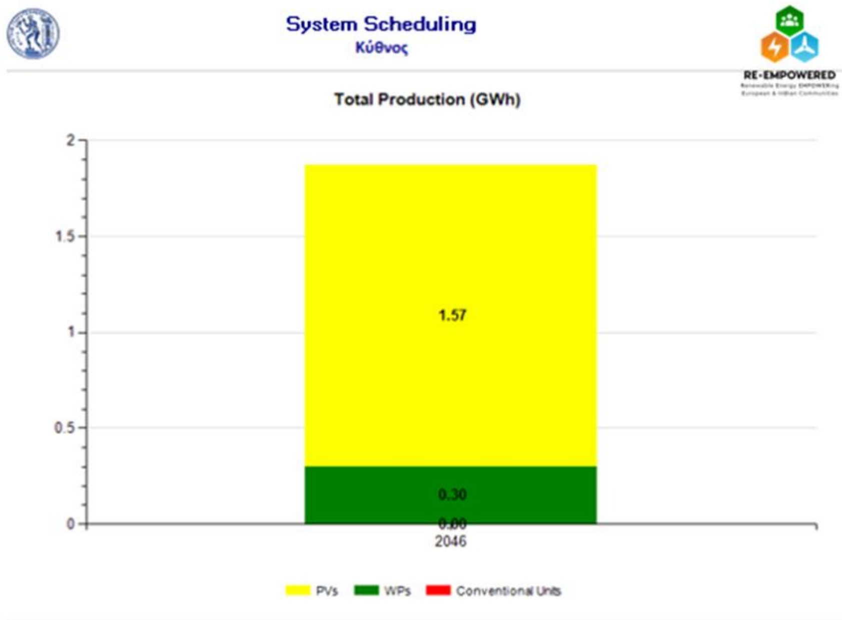
This use case was fully demonstrated in D7.4

PN_2UC4.2: Electrical models & demand peak design, RES & Load estimation, energy carriers' scenarios integration

This use case was fully demonstrated in D7.4

PN_2UC4.3: Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers

After the evaluation of demonstration 1st round, the logos of RE-EMPOWERED project have been added to the output results of the ecoPlanning simulations.



Aggregated results

	2024
Thermal production (MWh)	0.00
RES production (MWh)	1,875.71
Demand (MWh)	2,624.00
Annual RES penetration (% of load)	71.48
Maximum instantaneous	78.67
WPs equivalent full load	979.63
WPs capacity factor (%)	6.88
Diesel consumption (klt)	0.00
Mazut consumption (tn)	0.00
CO2 emissions (tn)	0.00

Figure 32 ecoPlanning - DR displaying aggregated results over the simulated scenario

3.2.1.3 ecoMonitor

MN_2UC1.1: Acquisition and transmission of air quality parameters data

The first round of demonstrations focused on validating the monitoring capabilities of the ecoMonitor platform. During this round, an issue was identified regarding the integration of the ecoMonitor tool with the ecoPlatform. This integration issue prevented the successful transmission and analysis of air quality data, and unfortunately, it could not be resolved within the first round.

In the second round, efforts were dedicated to further investigating and troubleshooting the integration issue. A series of steps were taken to mitigate the communication challenges, allowing for data transmission and analysis. Despite these efforts, full resolution of the integration issues was not achieved within this phase, due to issues with the firmware provided by the Indian tool developer.

Results and Observations:

A comprehensive series of diagnostic steps were taken to isolate the root cause of the problem. This involved close collaboration with the tool developers, analyzing data transmission failures, and testing various configurations to ensure system compatibility. While these efforts provided valuable insights into the underlying causes, the full resolution of the integration issue was not achieved during this phase.

As a temporary solution, manual data acquisition was utilized to collect air quality parameters directly from the ecoMonitor system. This approach ensured that air quality monitoring could continue without interruption, even while communication issues with the ecoPlatform persisted.

Manual data acquisition allowed the monitoring of key air quality indicators (CO, Ozone, SO_2, NO_2, PM2.5, PM10, temperature, and humidity) to continue. The data collected manually was stored locally for subsequent analysis, ensuring that the air quality monitoring remained uninterrupted despite the challenges faced with integration.

MN_2UC1.2: Data processing and evaluation

In this use case, the goal is to process and evaluate the air quality data collected over a two-week period within December 2024. This data processing phase focus on evaluating the air quality parameters against permissible limits and ensuring that the air quality remains within acceptable thresholds.

Data Collection Overview:

During the period of December 2024, air quality data for the parameters mentioned have been manually collected at regular intervals. The data taken every 6 hours to provide sufficient granularity while ensuring consistent monitoring. For each parameter, the values recorded, and the results are presented in to Table 8.

Timestamp	CO (ppm)	Ozone (ppm)	SO_2 (ppm)	NO_2 (ppm)	PM2.5 (µg/m³)	PM10 (µg/m³)
2024-12-02 07:10:00	0,14	0,01	0,001	0,02	0,02	0,03
2024-12-02 11:00:00	0,21	0,014	0,002	0,03	0,03	0,04
2024-12-02 14:15:00	0,42	0,019	0,003	0,04	0,04	0,05
2024-12-02 17:30:00	0,35	0,017	0,002	0,02	0,03	0,04
2024-12-03 08:00:00	0,19	0,011	0,001	0,03	0,02	0,03
2024-12-03 12:15:00	0,26	0,015	0,002	0,02	0,03	0,04
2024-12-03 15:40:00	0,47	0,02	0,003	0,04	0,05	0,05
2024-12-04 07:20:00	0,12	0,009	0,001	0,02	0,02	0,03
2024-12-04 10:45:00	0,22	0,013	0,002	0,03	0,03	0,04
2024-12-04 13:55:00	0,39	0,016	0,003	0,03	0,04	0,05
2024-12-04 16:40:00	0,32	0,018	0,002	0,01	0,03	0,04
2024-12-05 07:05:00	0,16	0,01	0,001	0,02	0,02	0,03
2024-12-05 11:20:00	0,25	0,014	0,002	0,03	0,03	0,04

2024-12-05 14:30:00	0,45	0,019	0,003	0,04	0,05	0,05
2024-12-06 08:15:00	0,15	0,011	0,002	0,03	0,02	0,03
2024-12-06 12:00:00	0,24	0,015	0,001	0,02	0,03	0,04
2024-12-06 15:50:00	0,41	0,017	0,003	0,03	0,04	0,05
2024-12-09 08:00:00	0,17	0,011	0,001	0,03	0,02	0,03
2024-12-09 12:20:00	0,28	0,015	0,002	0,02	0,03	0,04
2024-12-09 15:45:00	0,46	0,02	0,003	0,04	0,05	0,05
2024-12-10 07:10:00	0,11	0,009	0,001	0,02	0,02	0,03
2024-12-10 10:50:00	0,22	0,013	0,002	0,03	0,03	0,04
2024-12-10 14:05:00	0,4	0,017	0,003	0,03	0,04	0,05

Table 8 Air quality parameters (CO, Ozone, SO_2, NO_2, PM2.5, PM10) recorded over a two-week period in December 2024

Demonstration Results

The air quality data collected over the two-week period in December 2024 indicates that all monitored parameters (CO, Ozone, SO_2, NO_2, $PM_{2.5}$, PM10) remain much lower than the acceptable limits. Temperature and humidity levels were not monitored since they are not relevant to the air quality parameters, and data can be retrieved more easily from other sources.

3.2.2 Gaidouromandra Microgrid

In the 1st demonstration round for Gaidouromantra site, several use cases have been fully tested (MG_2UC1.1, MG_2UC1.3, MG_2UC2.1, PT_2UC2.1, PT_2UC3.1, CM_2UC1.1, CM_2UC1.3, CM_2UC2.1, CM_2UC5.1).

Some use cases were further tested in round 2 (DR_2UC1.1, PT_2UC3.2, CM_2UC4.2, RS _2UC3.2), and some use cases were tested in round 2 for the 1st time (MG_2UC1.2, MG_2UC2.3, CM_2UC3.1, CM_2UC3.2, CM_2UC3.3, CM_2UC4.1).

3.2.2.1 ecoMicrogrid

The first round of demonstration activities at the Gaidouromantra pilot site focused on validating the fundamental functionalities required to support the more advanced operations of the ecoMicrogrid system. In this second round of demonstration activities, the focus shifted to testing and validating the advanced functionalities of the ecoMicrogrid system, showcasing its capabilities for more complex operations like the Energy Management of the MG.

MG_2UC1.1: Real time microgrid monitoring and data acquisition

This use case was fully demonstrated in D7.4.

MG_2UC1.2: RES production estimation

This use case demonstrates the forecasting capabilities of the ecoMicrogrid system, with a focus on PV production estimation. PV forecasting is essential for effective energy management and optimizing the operation of the microgrid.

PV forecasts rely on weather data obtained from databases offering numerical weather prediction (NWP) for locations worldwide, such as GFS and ECMWF. The retrieved weather data is stored internally and utilized by the PV forecast module to predict energy production. Each PV module has an independent forecast since their orientations and parameters may differ. Key weather parameters—temperature, wind speed, and cloud coverage—are used as inputs for PV production forecasts (D4.1 [5]).

Figure 33 and Figure 34 illustrate the weather and PV production forecasts respectively as stored within the ecoMicrogrid system's storage device. In Figure 33 the different weather properties correspond to: 1 for Temperature (°C), 2 for Wind Speed (m/s), and 3 for Cloud Coverage Ratio (%). The Quality ID offers insights into the reliability of the forecast (scale Good-1 to Bad-3). In Figure 34 the forecast is calculated for each PV installation on an hourly basis for the defined horizon, which in this case is 48 hours (16 points). The Quality ID offers insights into the reliability of the forecast (scale Good-1 to Bad-3).

TimestampRef datetime	WeatherProper	Point0 float	Point1 float	Point2 float	Point3 float	Point4 float	QualityID
Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter
2024-01-29 15:00:00	2	15.540827751159668	15.834151268005371	16.70378875732422	15.533500671386719	16.569250106811523	1
2024-01-29 15:00:00	1	10.29779052734375	9.9473876953125	9.59075927734375	8.871612548828125	9.380706787109375	1
2024-01-29 15:00:00	3	100	100	100	100	100	1
2024-01-29 16:00:00	3	100	100	100	100	99.5999984741211	1
2024-01-29 16:00:00	1	10.29779052734375	9.9473876953125	9.59075927734375	8.871612548828125	9.380706787109375	1
2024-01-29 16:00:00	2	15.540827751159668	15.834151268005371	16.70378875732422	15.533500671386719	16.569250106811523	1
2024-01-29 17:00:00	2	15.834151268005371	16.70378875732422	15.533500671386719	16.569250106811523	17.006683349609375	1
2024-01-29 17:00:00	1	9.9473876953125	9.59075927734375	8.871612548828125	9.380706787109375	9.397125244140625	1
2024-01-29 17:00:00	3	100	100	100	100	99.5999984741211	1
2024-01-29 18:00:00	3	100	100	100	100	99.80000305175781	1
2024-01-29 18:00:00	2	15.7257719039917	17.246639251708984	17.320940017700195	16.76353645324707	17.08604621887207	1
2024-01-29 18:00:00	1	9.80584716796875	9.954986572265625	9.3828125	9.591827392578125	9.145965576171875	1
2024-01-29 19:00:00	2	15.7257719039917	17.246639251708984	17.320940017700195	16.76353645324707	17.08604621887207	1
2024-01-29 19:00:00	1	9.80584716796875	9.954986572265625	9.3828125	9.591827392578125	9.145965576171875	1
2024-01-29 19:00:00	3	100	100	100	99.80000305175781	99.80000305175781	1
2024-01-29 20:00:00	1	9.954986572265625	9.3828125	9.591827392578125	9.145965576171875	10.044708251953125	1

Figure 33 Snapshot taken from the WeatherForecastsView table of ecoMicrogrid

AssetID int	TimestampRef	Point0 float	Point1 float	Point2 float	Point3 float	Point4 float	Point5 float	QualityID tin
Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter
17	2024-12-11 09:00:00	726.2747002025908	593.2712960571821	-0.6072	-0.6072	-0.6072	-0.6072	1
21	2024-12-11 09:00:00	1578.888284415626	1316.5995401606112	0	0	0	0	1
22	2024-12-11 09:00:00	1984.3837100842613	1654.7851480911095	0	0	0	0	1
19	2024-12-11 08:00:00	1856.6834443929602	2438.9527925870807	325.8549153004874	0	0	0	1
17	2024-12-11 08:00:00	566.7003531977473	734.5246746749824	98.94453042626253	-0.6072	-0.6072	-0.6072	1
18	2024-12-11 08:00:00	1356.0690479337325	1492.76545893198	191.96333765277979	0	0	0	1
21	2024-12-11 08:00:00	1227.0892431651878	1613.019963784214	213.02389088174715	0	0	0	1
22	2024-12-11 08:00:00	1542.3123035127196	2027.2805664776001	268.9764485918452	0	0	0	1
20	2024-12-11 08:00:00	758.9607781756717	1000.0942368103836	126.99034503552399	0	0	0	1
20	2024-12-11 07:00:00	396.81267888307747	1045.2013864335263	441.71692179837345	0	0	0	1
18	2024-12-11 07:00:00	762.9139665592281	1684.5770201260252	558.2798002977585	0	0	0	1
21	2024-12-11 07:00:00	646.4076215399241	1685.1454588032211	718.4845756873779	0	0	0	1
19	2024-12-11 07:00:00	980.0035207753258	2547.7255723108315	1088.8340396904866	0	0	0	1
17	2024-12-11 07:00:00	302.6463184136952	772.5395286005971	321.9412740306369	-0.6072	-0.6072	-0.6072	1
22	2024-12-11 07:00:00	812.8263376239015	2117.9216117109045	903.3346770460124	0	0	0	1
17	2024-12-11 06:00:00	11.166507924297736	722.6297257770234	601.1772070707797	-0.6072	-0.6072	-0.6072	1

Figure 34 Snapshot taken from the PVForecastsView table of ecoMicrogrid

Demonstration Activities:

Key activities conducted during this phase include:

- **Integration Validation:** Collection and integration of real-time meteorological and environmental data from sensors installed at the site.
- **Validation:** Testing and fine-tuning predictive models for RES production estimation using historical and real-time data.
- **System Integration:** Ensuring the estimated production data is accurately fed into the EMS module for further processing.

Demonstration Summary:

The focus of this validation was not to assess the precision of the forecasting model—this evaluation was conducted within Task 8.4: Technical and Economic Assessment of Demos and Tools. Instead, the objective was to confirm that the entire chain of processes across different ecoMicrogrid modules operates as intended and ensures functional integration.

The demonstration successfully showcased the system's ability to estimate PV production with a high degree of reliability, supporting enhanced energy management for the Gaidouromantra microgrid. The accompanying Figure 35 compares the results from the PV forecasting module with actual PV production data from the field, offering valuable insights into the system's performance.

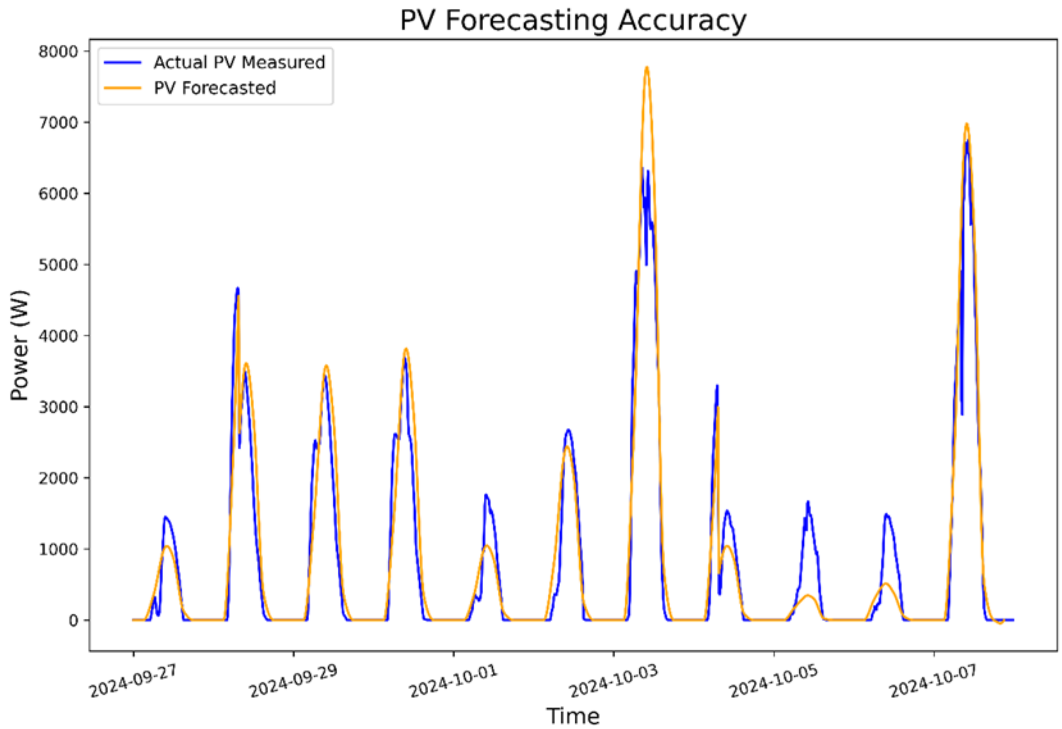


Figure 35 Comparison between the PV production forecast generated by the *ecoMicrogrid* system and the actual PV production data measured at the Gaidouromantra microgrid.

MG_2UC1.3: Data concentration, storage, and management

This use case was fully demonstrated in D7.4.

MG_2UC2.1: Effective communication with controllable assets

This use case was fully demonstrated in D7.4.

MG_2UC2.3: Multi-energy vector microgrid management of operation

This use case aims to demonstrate the multi-energy vector optimization capabilities of the ecoMicrogrid system, evaluating its operation within the microgrid to ensure optimal energy management across various energy vectors such as electricity and cooling, enhancing energy distribution and resource utilization across various forms. Additionally, the ecoMicrogrid system optimizes the coordination between energy generation, storage, and consumption to maintain energy availability while minimizing operational costs. This is achieved through advanced forecasting and control strategies based on model predictive control.

Integration and validation efforts confirmed the ecoMicrogrid system's compatibility with both renewable (e.g., solar, wind) and non-renewable energy sources (e.g., diesel generators), showcasing its capability to manage real-time operations while supporting grid stability.

The demonstration highlights the ecoMicrogrid's ability to cohesively manage multiple energy resources, validate the system's operational efficiency in optimizing energy vector coordination, and showcase real-time adaptability to varying energy demands and generation conditions. Overall, this use case underscores the potential of the ecoMicrogrid tool to transform microgrid management into a more sustainable, cost-effective, and resilient process.

Demonstration Activities

Key activities conducted during this phase include:

Efficient Multi-Energy Vector Management:

Demonstrate the system's ability to manage multiple energy vectors within the microgrid environment.

Enhance energy distribution and resource utilization across various energy forms.

Real-Time Optimization:

Optimize coordination between energy generation, storage, and consumption to maintain energy availability and minimize operational costs.

Integration and Validation:

Validate the entire integration chain, starting from low-level microgrid (MG) assets to the retrieval of weather predictions.

Ensure seamless internal software operation, covering data acquisition, forecasting processes, optimization routines, and the final activation of operational setpoints.

Demonstration Outcomes

The second round of demonstrations, spanning several months since July 2024, highlighted the robustness and reliability of the ecoMicrogrid tool in managing the Gaidouromantra microgrid.

Multi-Vector Optimization Validation: During the summer months, the ecoMicrogrid system demonstrated its ability to significantly enhance RES utilization by leveraging the cooling vector. Key results included:

22% Increase in RES Utilization: Achieved through strategic use of cooling systems.

18% Reduction in RES Curtailment: Excess renewable energy was effectively redirected to the cooling vector.

Expanding the HVAC cooling system to accommodate four additional inhabitants can lead to a substantial increase in RES utilization, potentially rising by **up to 117%**. This expansion would also contribute to a noteworthy reduction in RES curtailment, with a decrease **of 71.21%.**

Figure 36a and Figure 36b provide a visual representation of these effects. Figure 36b specifically highlights RES curtailment during the summer months, indicated by the yellow area, which arises from excess energy production that cannot be used. In contrast, Figure 36a demonstrates how this excess energy can be effectively redirected towards the cooling vector. This redirection plays a critical role in minimizing curtailed power, depicted in the green area. More specifically, Figure 36a Illustrates the increase in RES utilization with the integration of four additional inhabitants into the HVAC cooling system. Figure 36b shows seasonal RES curtailment.

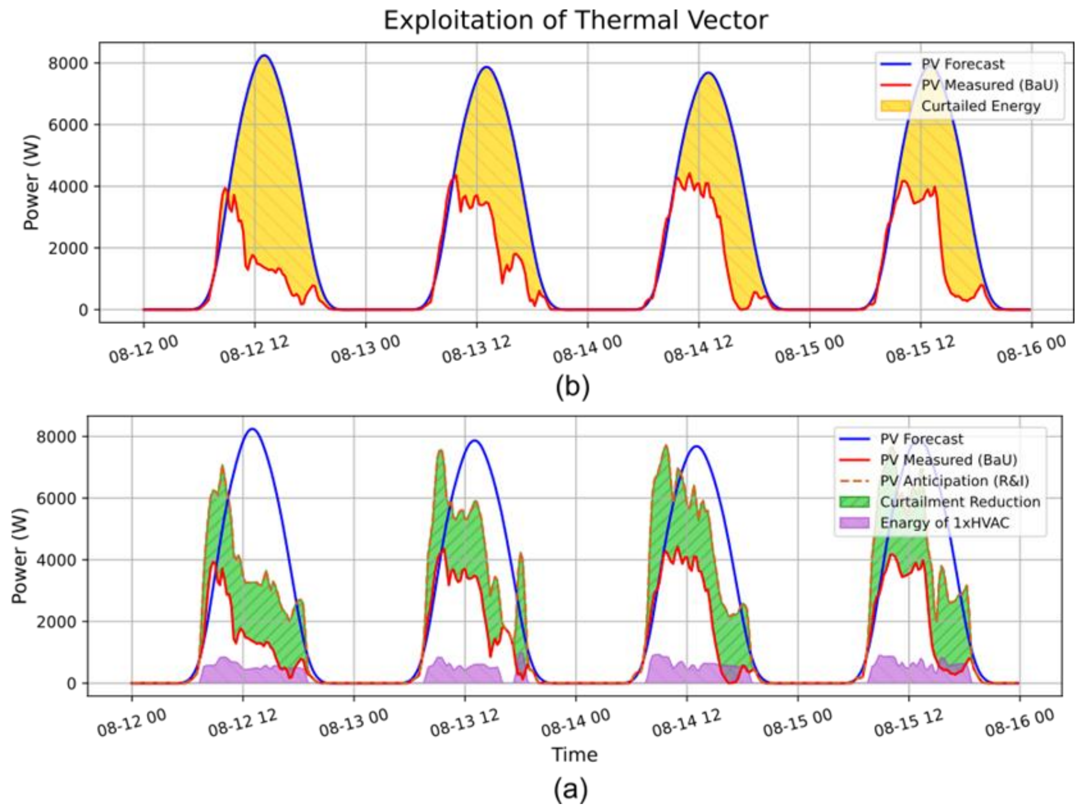


Figure 36 Impact of HVAC System Expansion on Renewable Energy Source

Dispatch Functionality Validation: A specially designed test was conducted in late September (September 26–29), supported by NTUA, to showcase specific EMS functionalities, particularly the dispatch of the diesel generator. The test aimed to simulate a critical scenario where the backup generator would need to be activated:

- Three out of six PV systems were intentionally deactivated to balance generation with load.
- The battery storage system was discharged over the initial days to a critical state (approximately 55% SOC), ensuring that minimum SOC thresholds would be reached in subsequent days.

The test demonstrated the following:

66.40% Reduction in DG Runtime: Achieved through optimal EMS management.

55.54% Cost Reduction: Directly attributed to reduced DG usage.

Figure 37 provides a snapshot from the ecoPlatform at 07:45 on September 28th, illustrating the operational energy mix over the previous 12 hours. The figure also projects the estimated energy mix for the next 9-hour horizon, showcasing the EMS's ability to forecast and manage operations effectively.

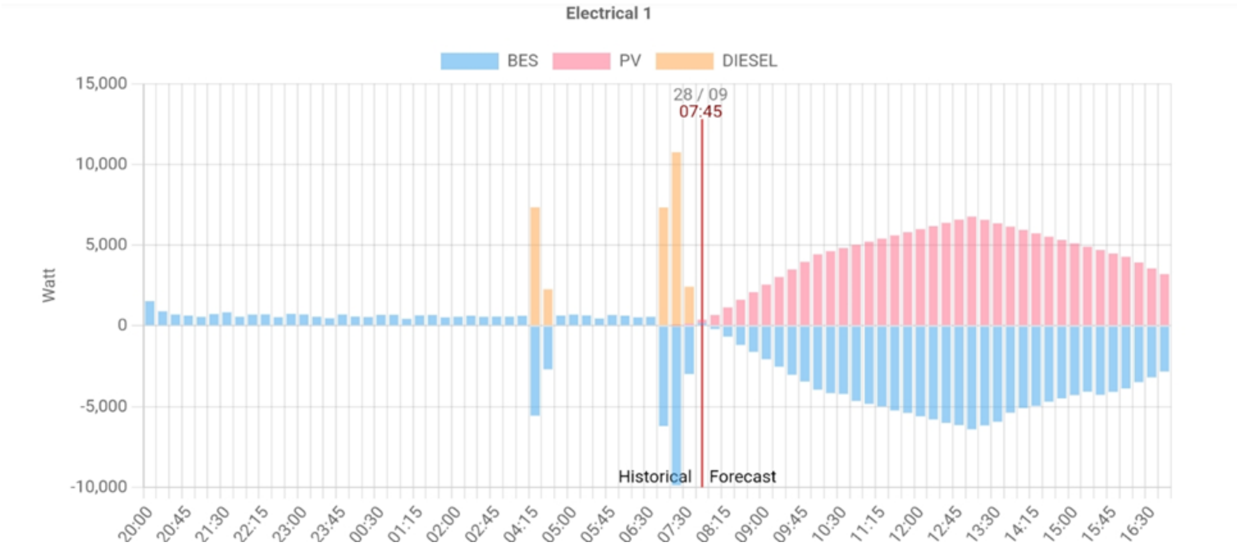


Figure 37 Real-time snapshot illustrating the operational status of the ecoMicrogrid system

Overall, the demonstration validated the advanced capabilities of the ecoMicrogrid system to manage microgrid operations in real-time, optimizing multiple energy vectors. These optimizations resulted in:

- Significant **reduction in energy costs** through effective energy management.
- **Improved utilization** of renewable energy sources, **reducing their curtailment**.
- **High system reliability** ensures secure operation, minimizing downtime and operational risks

The demonstrated capabilities ensure the Gaidouromantra microgrid operates as a cost-effective, sustainable, and resilient energy system.

3.2.2.2 ecoDR

DR_2UC1.1: Real time monitoring of energy consumption

The second round of demonstration focuses on validating the Modbus interface of ecoDR. The primary objective of this phase is to ensure that the ecoDR system effectively monitors energy-related parameters and validates its Modbus TCP interface.

Demonstration Summary

The validation process for the ecoDR system's Modbus interface was conducted in two stages. Initially, the interface was tested using a commercial Modbus client to confirm the accuracy of the information model and corresponding registers. This preliminary step identified a limitation where fast Modbus requests at a one-second interval caused the ecoDR system to crash, whereas slower requests were handled reliably. A detailed bug report was subsequently generated and submitted to the ecoDR development team to address this issue.

In the next phase, the ecoDR system was integrated with the ecoMicrogrid platform, using an updated communication frequency of one minute to ensure stability. Figure 38 provides a screenshot from the variable diagnosis debug screen of ecoMicrogrid, highlighting the Modbus registers utilized during this integration.

Name	Identific...	Actual value	Write set value	M...	Minimum	Maximum	Status	Timestamp	Timestamp intern...	Timestamp exter...	S...	Address
Project1*	Filter ...	Filter text	Filter text		Filter text	Filter text	Filter text	Filter text	Filter text	Filter text		Filter text
Project1/Global/Reactive_Power_Mdbs_All		0.00	0.50		-32767.00	32768.00	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Ipeak_Mdbs_All		0.84	0.00		-327670...	327670...	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Total_Active_Energy_Mdbs_All		1.31	0.50		-32767.00	32768.00	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Threshold_Limit_For_Load_Mdbs_All		2.00	0.00		-327670...	327670...	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Meter_ID_Mdbs_All		32744.00	16384.00		0.00	32768.00	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MW (0) 0000.00
Project1/Global/Active_Energy_Mdbs_All		0.00	0.50		-32767.00	32768.00	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Vrms_Mdbs_All		229	32768		0	65535	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Vpeak_Mdbs_All		229.46	0.00		-327670...	327670...	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Irms_Mdbs_All		0	1		-32767	32768	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Status_For_Critical_Output_Port_Mdbs_All		0	1		0	1	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		M (0) 0000.00
Project1/Global/Power_Factor_Mdbs_All		1.00	0.00		-1.00	1.00	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/trigger_logic		0	1		0	1	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		M (0) 0000.00
Project1/Global/Threshold_Limit_For_Energy_Mdbs_All		4.00	0.00		-327670...	327670...	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Apparent_Power_Mdbs_All		0.01	0.50		-32767.00	32768.00	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Active_Power_Mdbs_All		0.01	0.50		-32767.00	32768.00	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		MF (0) 0000.00
Project1/Global/Status_For_Non_Critical_Output_Port_Mdbs_All		0	1		0	1	SPONT,T_STD_E,T_STD	11/28/2023 11:1...	11/28/2023 9:16:...	11/28/2023 9:16:...		M (0) 0000.00

Figure 38 ecoDR data collected within the Variable Diagnosis debug screen of ecoMicrogrid

3.2.2.3 ecoPlatform

PT_2UC2.1: Facilitate data exchange between dependent tools

This use case was fully demonstrated in D7.4.

PT_2UC3.1: Route the microgrid data and data from dependent tools to cloud database

This use case was fully demonstrated in D7.4.

PT_2UC3.2: Facilitate archived data access for dependent tools using API

The ecoPlatform in the microgrid enabled dependent tools to retrieve archived data efficiently through an API. This functionality allowed various tools, such as energy management systems and forecasting algorithms, to access historical microgrid data, including energy consumption, generation, and storage metrics. The API-based data retrieval was critical in ensuring that these tools had real-time access to the historical data they needed without manual intervention, thereby improving the accuracy and responsiveness of the energy management processes.

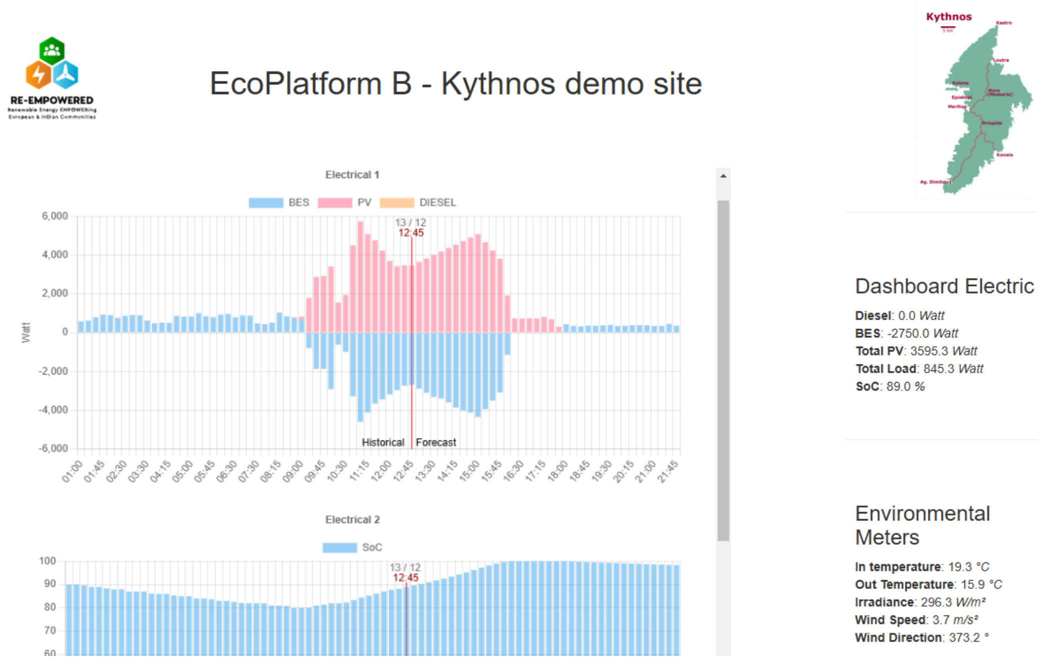


Figure 39 ecoPlatform – B dashboard in Kythnos via API

3.2.2.4 ecoCommunity

The second round of demonstrations of the ecoCommunity tool in the Gaidouromandra demo site was conducted on 11th October 2024 and 16th October 2024. The various use cases demonstrated are described below.

CM_2UC1.1: Displaying the dynamic pricing based on shape of energy profile

This use case was fully demonstrated in D7.4

CM_2UC1.3: Data security and privacy

This use case was fully demonstrated in D7.4.

CM_2UC2.1: Facilitating(display) of the scheduling and shifting of non-critical and flexible loads

This use case was fully demonstrated in D7.4.

CM_2UC3.1: Feedback and suggestions from users about the tools

The users of the tool did not experience any difficulties in the booking of the timeslots for the water pumps loads, except for some minor problems. The feedback was that the tool was quite easy to operate.

CM_2UC3.2: Reporting of problem

The consumers report any problem they face in the interaction with the ecoCommunity tool or any issues faced in the microgrid system.

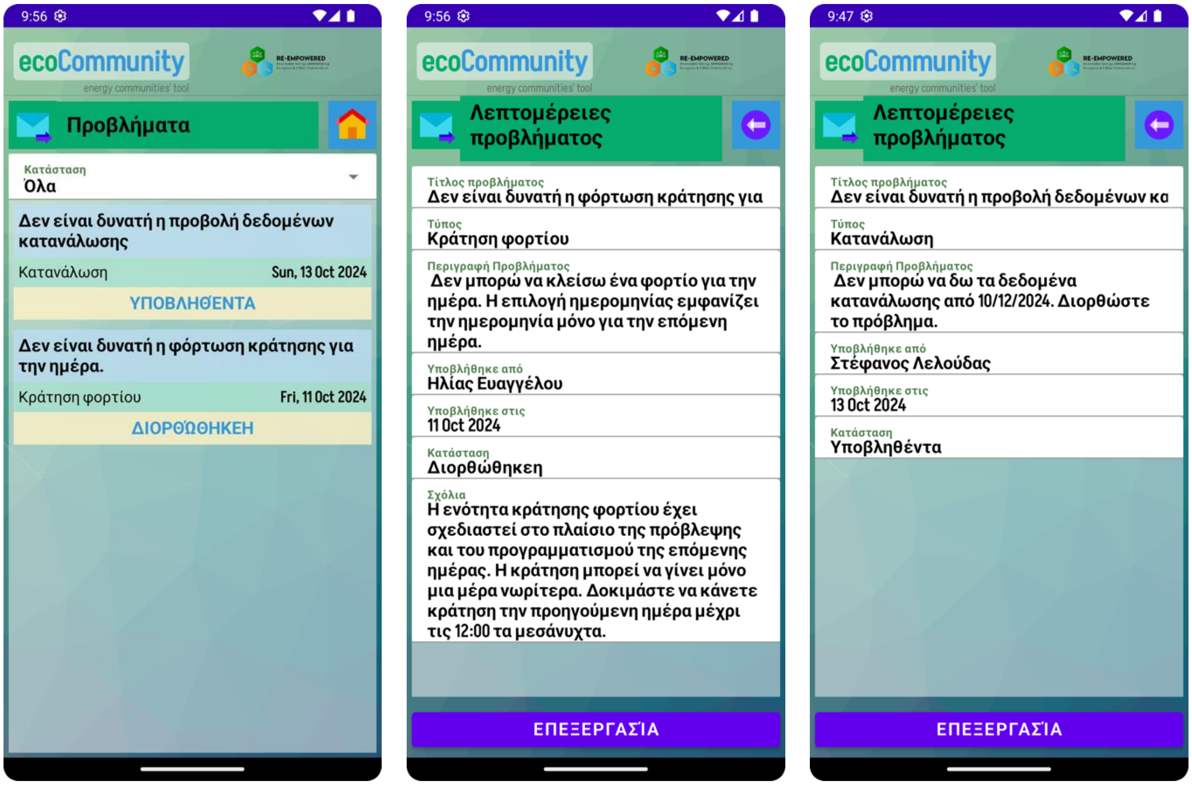


Figure 40 Problem reporting module demonstration (a) administrator level summary of problems (b-c) detailed status and administrative comments for the reported problems.

CM_2UC3.3: Forum to share experiences

The forum module is used to share user experiences or discussions on energy topics which have a common interest. Screenshots of the forum module with posts added as part of the demonstration are shown below.

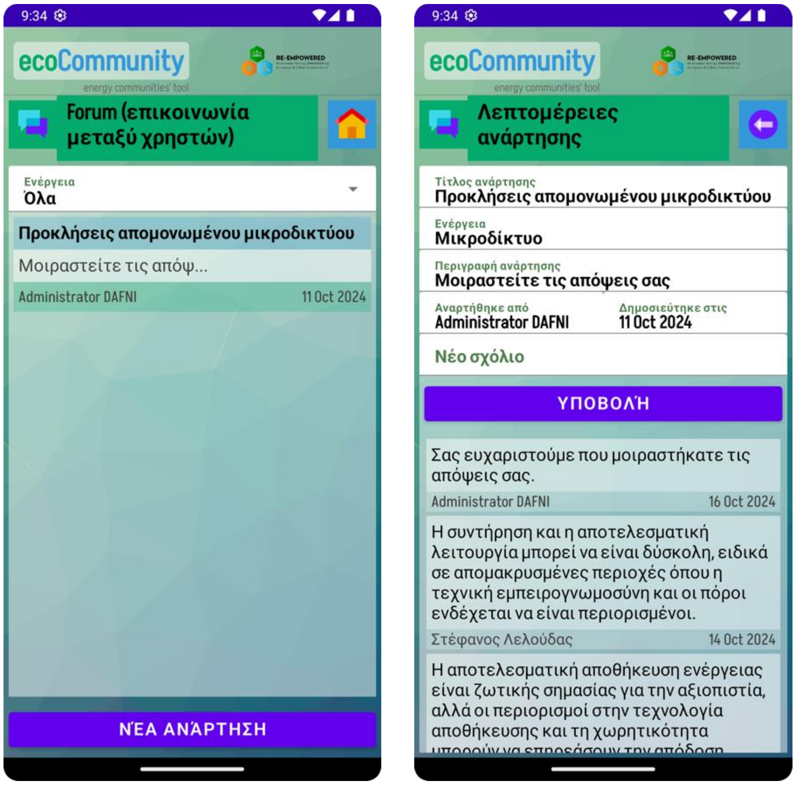


Figure 41 Screenshots of the forum modules (a) main page (b) post details

CM_2UC4.1: Training material (troubleshooting)

In June 2024, an informative brochure was created by DAFNI. This brochure contained information and step-by-step guides for the download and the use of ecoCommunity. This brochure was shared by e-mail and in person to the residents of Gaidouromantra.

Figure 42 Informative brochure for the use of ecoCommunity in Gaidouromandra-1

Figure 43 Informative brochure for the use of ecoCommunity in Gaidouromandra-2

Figure 44 Informative brochure for the use of ecoCommunity in Gaidouromandra-3

CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)

The help module provides access to training materials like manuals and troubleshooting manuals. These are arranged and categorized based on the type and ecoTool. The screenshots of the help documents uploaded for ecoCommunity toll as part of the demonstration are given below.

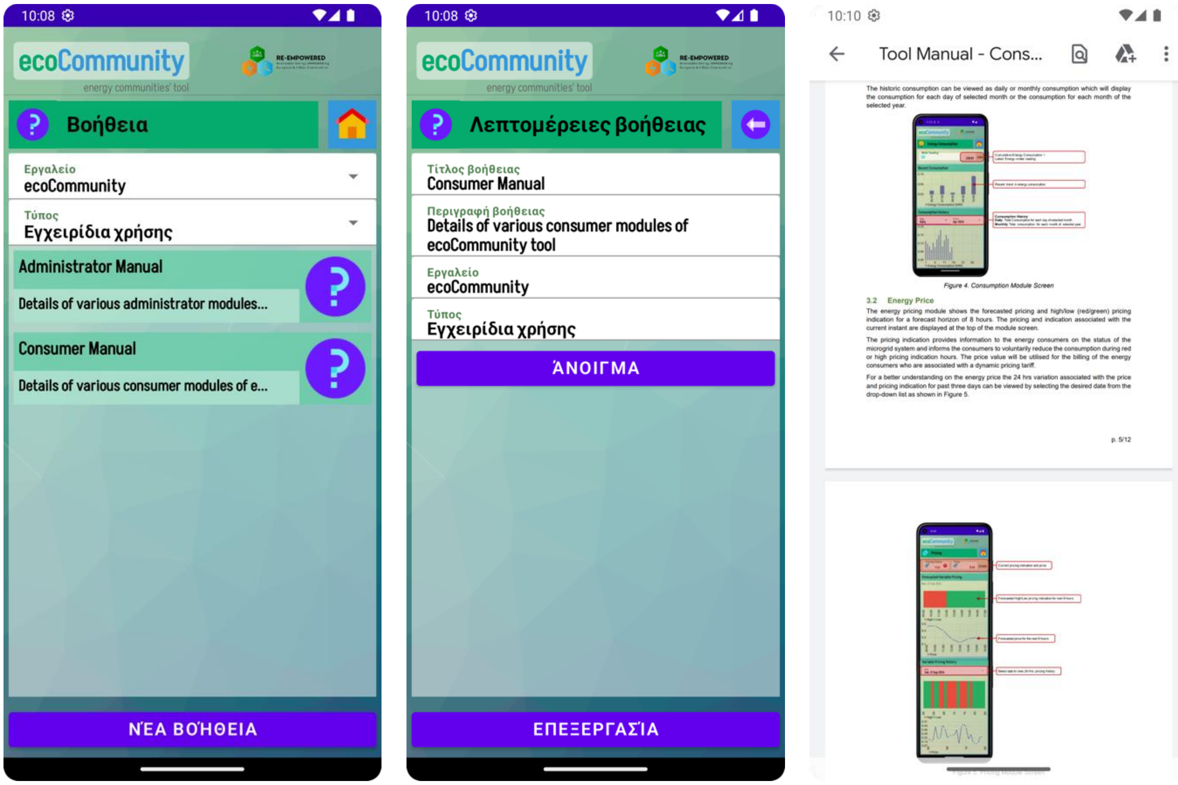


Figure 45 Help module demonstration (a) list of help items categorised (b) details of help item (c) help and troubleshooting document.

CM_2UC5.1: Monitoring of electricity consumption of energy consumers

This use case was fully demonstrated in D7.4

3.2.2.5 ecoResilience

RS _2UC3.2: Testing of Small Wind Turbines using Standards

The small wind turbine manufactured locally under the ecoResilience tool, was tested in the Gaidouromandra microgrid using guidelines from the IEC international standard IEC 61400-12-1: Power Performance Measurements of electricity producing wind turbines, and specifically from Annex H, which refers to small wind turbine testing. Details of these measurements can be found in Deliverable “D7.4 Report demonstration round 1 (testing)” [2].

During the second testing round which lasted for three weeks in Nov-Dec 2024, more data collection campaigns were performed, until there were enough data points, especially in areas of interest such as the rated wind speed region around 10 m/s. Figure 46, shows a scatter plot of the logged data, for 10 second intervals, displaying values of AC power versus wind speed. From these, 1 minute averages are calculated and the results are binned per 0.5 m/s. The resulting power curve can be seen in Figure 47, with adequate data points and consistent values, and a maximum power output for the locally manufactured small wind turbine of 2.6 kW at 11 m/s.

The wind energy conversion system's efficiency can be seen in Figure 48, with a maximum efficiency of 0.32 at a wind speed of 5 m/s., which corresponds to a typical mean wind speed for a small wind turbine site. In Figure 49 the annual energy production of the locally manufactured small wind turbine can be seen, with a production of 5586 kWh at a 5 m/s mean wind speed site.

Based on these data, the capacity factor for the locally manufactured small wind turbine can be calculated, resulting in a 23 % capacity factor for a 5 m/s mean wind speed site, such as Gaidouromandra.

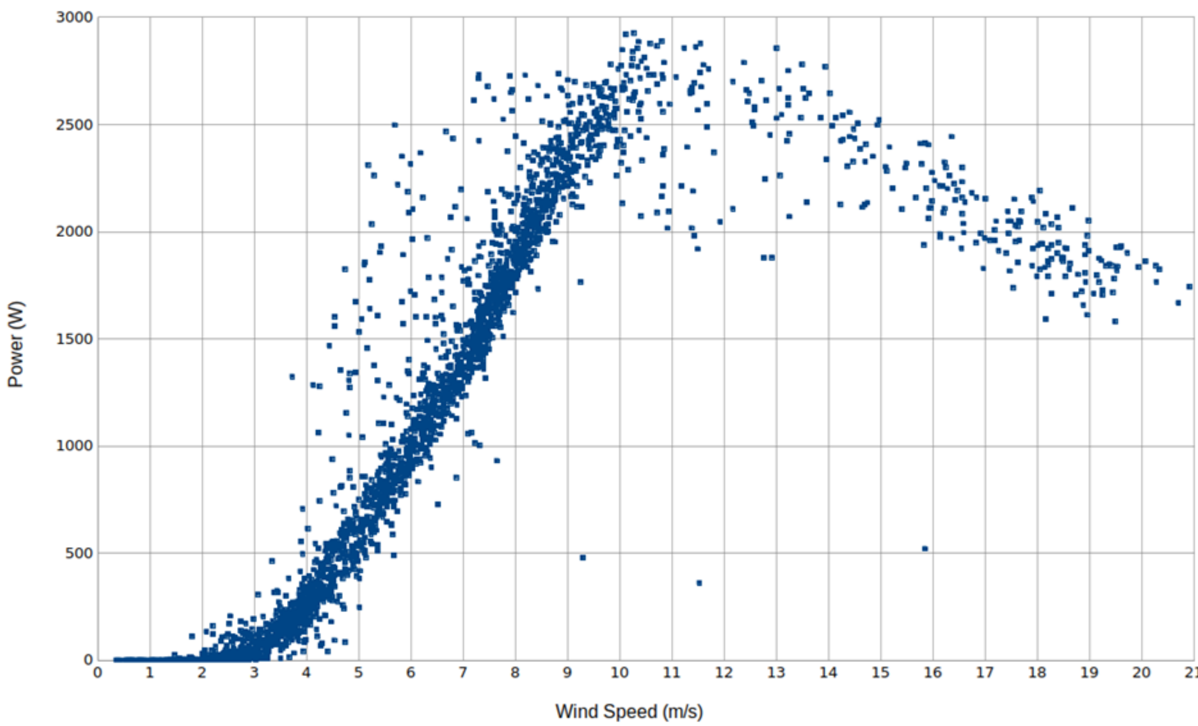


Figure 46 Scatter plot of logged electrical and meteorological data

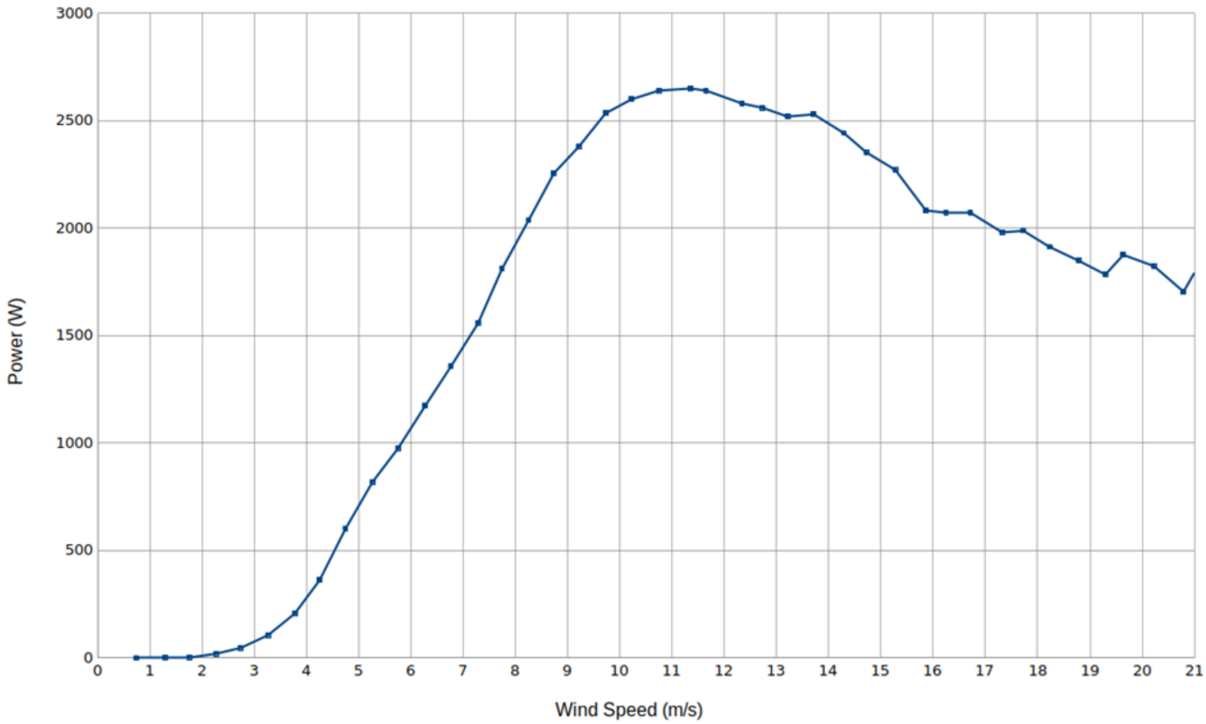


Figure 47 Locally manufactured small wind turbine power curve

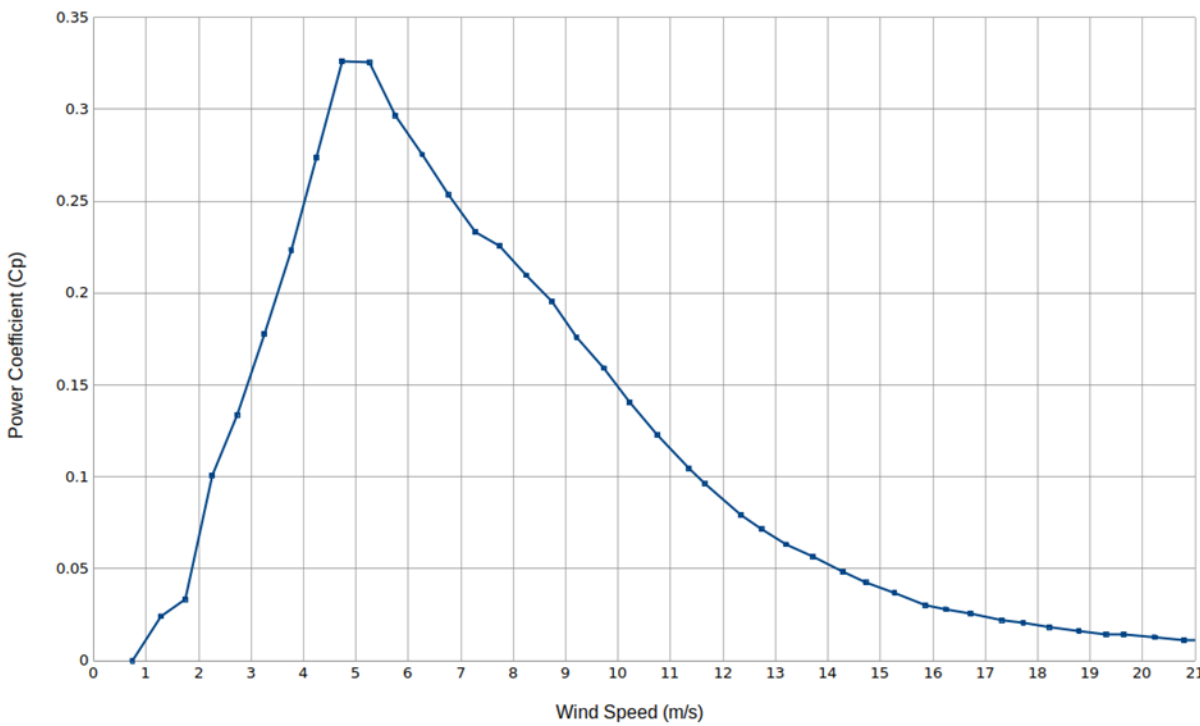


Figure 48 Wind energy conversion system efficiency

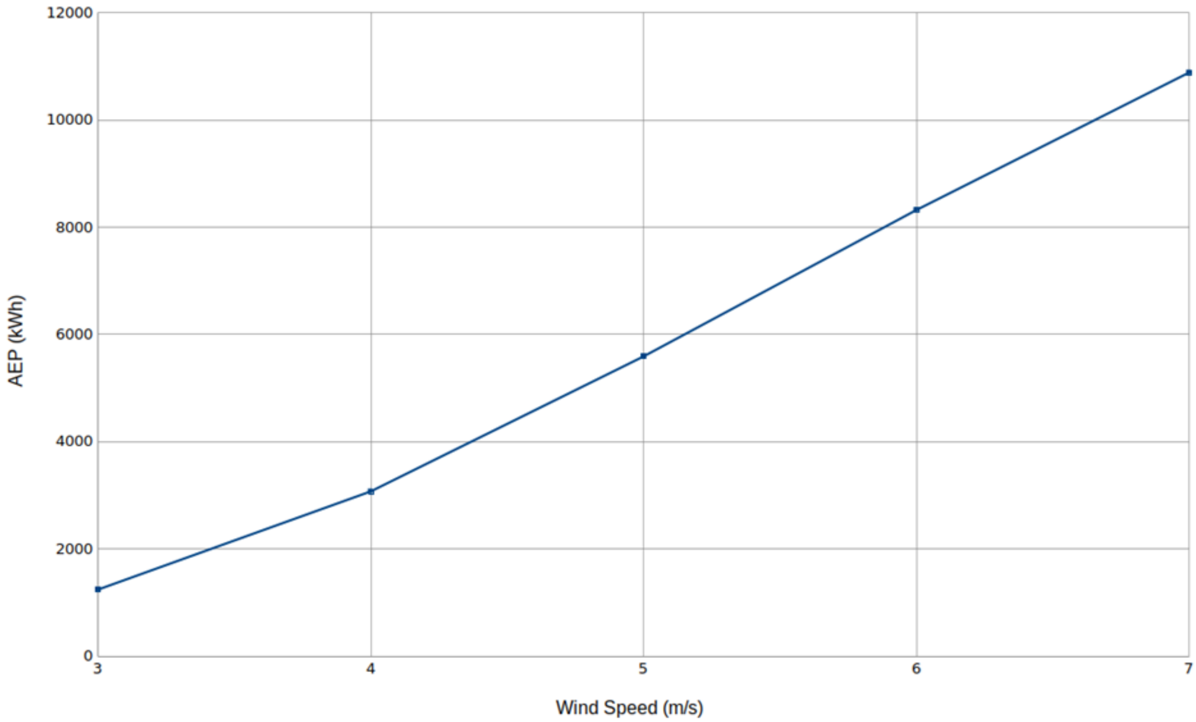


Figure 49 Annual energy production of the locally manufactured small wind turbine

3.3 Ghoramara

In the 1st demonstration round for Ghoramara site, several use cases have been fully tested (MG_2UC1.1, DR_2UC1.1, DR_2UC2.1, DR_2UC2.2, MN_2UC1.1, PT_2UC2.1, PT_2UC3.1, PT_2UC3.2, RS_2UC1.1, RS_2UC1.2, RS_2UC1.3, RS_2UC1.4, RS_2UC2.1, RS_2UC2.2, RS_2UC2.3, RS_2UC2.4, C_2UC1.1, VH_2UC2.2, VH_2UC3.1).

Some use cases were tested in round 2 for the 1st time (CM_2UC3.2, CM_2UC3.3, CM_2UC4.2, RS_2UC3.1) while some use cases were partially implemented and are in progress by the Indian partners (MG_2UC1.3, CM_2UC1.1, CM_2UC1.2, CM_2UC2.1, CM_2UC2.2, CM_2UC3.1, CM_2UC4.1, CM_2UC5.1, RS _2UC3.2, C_2UC1.2).

3.3.1 ecoMicrogrid

The ecoMicrogrid instance at the Ghoramara pilot site has been deployed to interface with a 10kW microgrid system based on the ecoConverter. The tool communicates with external meters to collect data from various energy sources, including solar, wind, and energy storage, as well as from the loads.
During the initial demonstration phase, conducted alongside the tool deployment, the feasibility of data collection from the energy meters interfacing with the ecoConverter was successfully

showcased. The ecoMicrogrid's data aggregation capabilities were verified, highlighting its potential for comprehensive energy monitoring in remote and challenging environments.

The Ghoramara island site presented unique operational challenges, most notably the absence of reliable internet connectivity due to its remote location. This infrastructure limitation necessitated upgrades to the communication infrastructure that could not be implemented within the current project timeline. Moreover, ecoConverter faced technical challenges that could not be resolved on time. ecoMicrogrid was connected to ecoConverter, so this situation posed significant difficulties. While these constraints impacted the full extent of system validation, the initial demonstration provided valuable insights into the ecoMicrogrid's technological framework and its potential for deployment in resource-constrained settings.

Consequently, the second demonstration period could not be fully completed.

MG_2UC1.1: Real time microgrid monitoring and data acquisition

This use case was fully demonstrated in D7.4.

MG_2UC1.3: Data concentration, storage, and management

Implementation of use case MG_2UC1.3 was not achieved within the project's duration, due to weak internet connection and technical difficulties of ecoConverter. The resolution of these issues is in progress by the Indian partners.

3.3.2 ecoDR

DR_2UC1.1: Real time monitoring of energy consumption

The use case DR_2UC1.1 was fully demonstrated in D7.4

DR_2UC2.1: Scheduling of loads

The use case DR_2UC2.1 was fully demonstrated in D7.4

DR_2UC2.2: Programmable Load shedding controller

The use case DR_2UC2.2 was fully demonstrated in D7.4

3.3.3 ecoMonitor

MN_2UC1.1: Acquisition and transmission of air quality parameters data

The use case MN_2UC1.1 was fully demonstrated in D7.4

3.3.4 ecoPlatform

PT_2UC2.1: Facilitate data exchange between dependent tools

The use case PT_2UC2.1 was fully demonstrated in D7.4

PT_2UC3.1: Route the microgrid data and data from dependent tools to cloud database

The use case PT_2UC3.1 was fully demonstrated in D7.4

PT_2UC3.2: Facilitate archived data access for dependent tools using API

The use case PT_2UC3.2 was fully demonstrated in D7.4

3.3.5 ecoCommunity

The demonstration of the ecoCommunity tool in the Ghoramara demo site was conducted on December 2024. The basic login interface where all three languages are available English, Hindi and Bengali is depicted in the following figure. In that interface the user can select among these three languages for further navigation in the app.

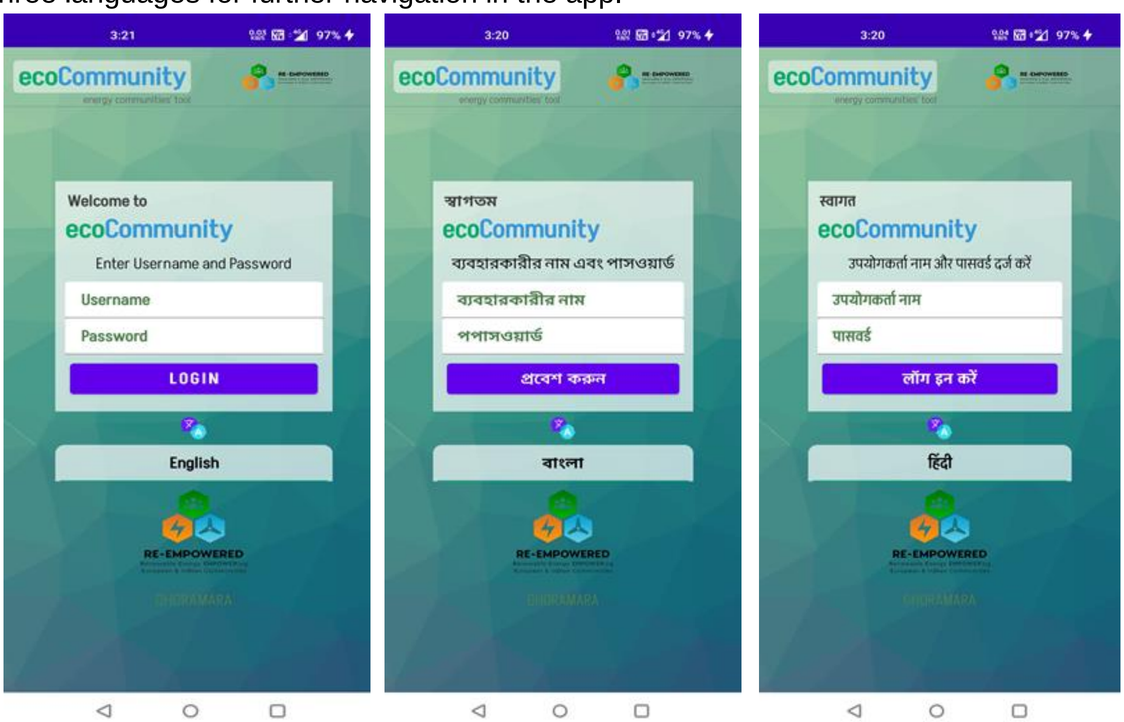


Figure 50 Login interface for ecoCommunity in Ghoramara

For different purposes Administrator, Manager and Consumer interfaces have been created that depend on the credentials used to enter the app as shown below:

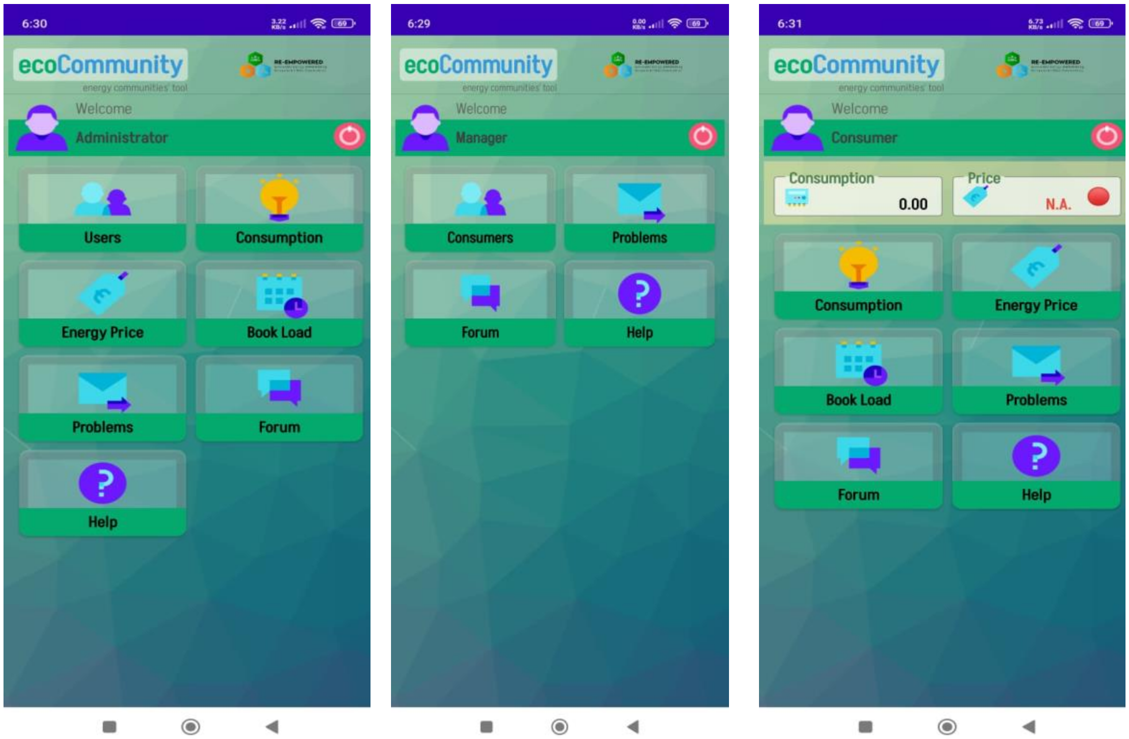


Figure 51 Different app interfaces based on the role of the user

The various use cases demonstrated are described below:

CM_2UC1.1: Displaying the dynamic pricing based on shape of energy profile

Due to technical difficulties of ecoConverter, which posed challenges to ecoMicrogrid that transfers the measurement to ecoCommunity, as well as poor internet connection, this UC has not been completed. This use case is in progress by the Indian partners.

CM_2UC1.2: Billing and payments

This use case did not have practical value for Ghoramara.

CM_2UC2.1: Facilitating(display) of the scheduling and shifting of non-critical and flexible loads

Due to technical difficulties of ecoConverter, which posed challenges to ecoMicrogrid that transfers the measurement to ecoCommunity, as well as poor internet connection, this UC has not been completed. This use case is in progress by the Indian partners.

CM_2UC2.2: Coordination of communal/shared loads

Due to technical difficulties of ecoConverter, which posed challenges to ecoMicrogrid that transfers the measurement to ecoCommunity, as well as poor internet connection, this UC has not been completed. This use case is in progress by the Indian partners.

CM_2UC3.1: Feedback and suggestions from users about the tools

The users provided generally positive feedback on the ecoCommunity app.

CM_2UC3.2: Reporting of problem

The consumers report any problem they face in the interaction with the ecoCommunity tool or any issues faced in the microgrid system.

Figure 52 Problem reporting module demonstration (a) administrator level summary of problems (b) detailed status and administrative comments for the reported problems

CM_2UC3.3: Forum to share experiences

The forum module is used to share user experiences or discussions on energy topics which has a common interest. Screenshots of the forum module with posts added as part of the demonstration are shown below.

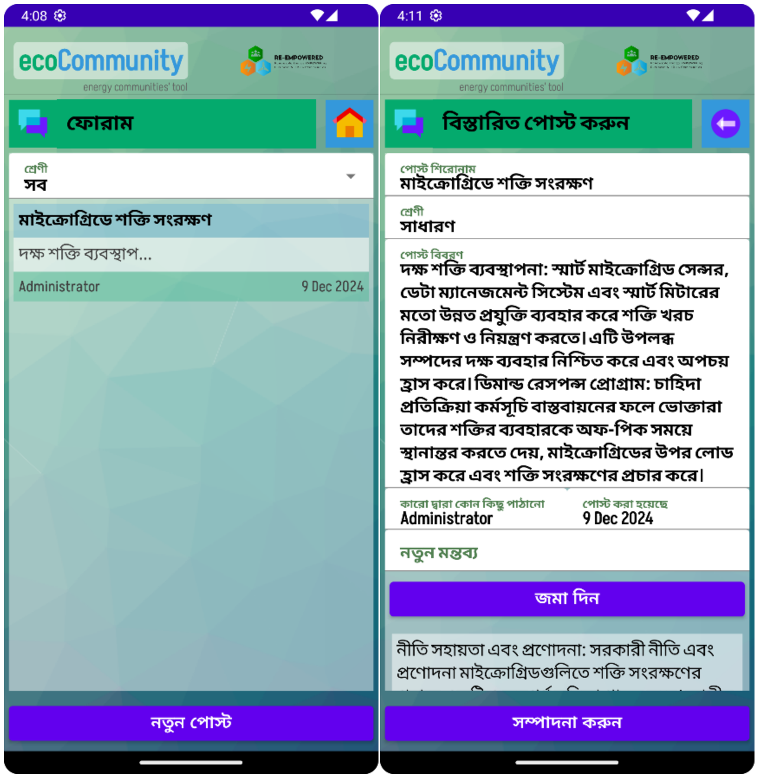


Figure 53 Screenshots of the forum modules (a) main page (b) post details

CM_2UC4.1: Training material (troubleshooting)

This use case is in progress by the Indian partners.

CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)

The help module provides access to training materials like manuals and troubleshooting manuals. These are arranged and categorized based on the type and ecoTool. The screenshots of the help documents uploaded for ecoCommunity tool as part of the demonstration are given below.

Figure 54 Help module demonstration (a) list of help items categorised (b) details of help item

CM_2UC5.1: Monitoring of electricity consumption of energy consumers

Due to technical difficulties of ecoConverter, which posed challenges to ecoMicrogrid that transfers the measurement to ecoCommunity, as well as poor internet connection, this UC has not been completed. This use case is in progress by the Indian partners.

3.3.6 ecoResilience

RS_2UC1.1: Optimal selection of parameters

This use case was fully demonstrated in D7.4

RS_2UC1.2: Computational fluid dynamics and structural analysis of support structures

This use case was fully demonstrated in D7.4

RS_2UC1.3: Experimental validation of the designed structure through wind tunnel testing

This use case was fully demonstrated in D7.4

RS_2UC1.4: Design of resilient foundation for solar photovoltaic system

This use case was fully demonstrated in D7.4

RS_2UC2.1: Preliminary design of a tower truss structure and its optimization

This use case was fully demonstrated in D7.4

RS_2UC2.2: Design of a resilient mechanism to reduce wind loads on blades and its optimization

This use case was fully demonstrated in D7.4

RS_2UC2.3: Laboratory and field testing of the mechanism

This use case was fully demonstrated in D7.4

RS_2UC2.4: Resilient foundation for wind turbine tower structure

This use case was fully demonstrated in D7.4

RS_2UC3.1: Small Wind Turbine Manufacturing and installation

This use case is fully demonstrated in D7.4

RS _2UC3.2 Testing of Small Wind Turbines using Standards

The RE-EMPOWERED-manufactured 3 kW wind turbine generator was tested in the laboratory by providing rotation of the blades manually. The output voltage agreed with the rotational speed of the wind turbine blades. The complete wind turbine system was transported to the Ghoramara demo site. The probable location for the guy wires of the 3-kW wind turbine system's monopole foundation is finalized, which was delayed due to many constraints in the available space in the demo site. The locally manufactured small wind turbine is planned to be installed and tested in Ghoramara by the Indian partners.

3.3.7 ecoConverter

C_2UC1.1: Development and control of power electronic converters

This use case was fully demonstrated in D7.4

C_2UC1.2: Testing and on-field demonstration of the power electronic converters satisfying various standards

The power electronic converters have been successfully tested at the laboratory of IIT KGP. They were then transferred to Ghoramara for deployment. Unexpected technical difficulties occurred, which did not allow the full demonstration at the demo site. Troubleshooting is in progress to resolve the issue by the Indian partners.

3.3.8 ecoVehicle

VH_2UC2.2: Customization of the vehicle to the demo site requirements

The use case VH_2UC2.2 was fully demonstrated in D7.4

VH_2UC3.1: PV Integration with e-Boat

The use case VH_2UC3.1 was fully demonstrated in D7.4

3.4 Keonjhar

In the 1st demonstration round for Keonjhar site, several use cases have been fully tested (MG_2UC1.1, MG_2UC1.3, PN_2UC1.1, PN_2UC1.2, PN_2UC2.1, PN_2UC4.1, PN_2UC4.2, PT_2UC2.1, PT_2UC3.1, PT_2UC3.2).

Some use cases were further tested in round 2 (PN_2UC1.3, PN_2UC2.2, PN_2UC4.3, CM_2UC1.2, CM_2UC2.1, CM_2UC3.2, CM_2UC3.3, CM_2UC4.2,), and some use cases were tested in round 2 for the 1st time (MG_2UC1.2, MG_2UC2.2, PN_2UC3.1, PN_2UC3.2, CM_2UC3.1, CM_2UC4.1). Some use cases are in progress by the Indian partners (DR_2UC1.1, DR_2UC2.1, DR_2UC2.2).

3.4.1 ecoMicrogrid

The initial demonstration phase at the Keonjhar pilot site centered on verifying the core functionalities of the ecoMicrogrid system, such as data monitoring, storage, and management, along with its seamless integration with pilot assets. These foundational activities established the groundwork for implementing and testing the system's energy management capabilities.

The second phase of demonstrations focused on evaluating the optimization of the hybrid microgrid. This stage highlighted the ecoMicrogrid's ability to adapt to various operational scenarios and reliably execute advanced functionalities, including efficient energy management across the microgrid.

The demonstration took place for several weeks during November and December of 2024.

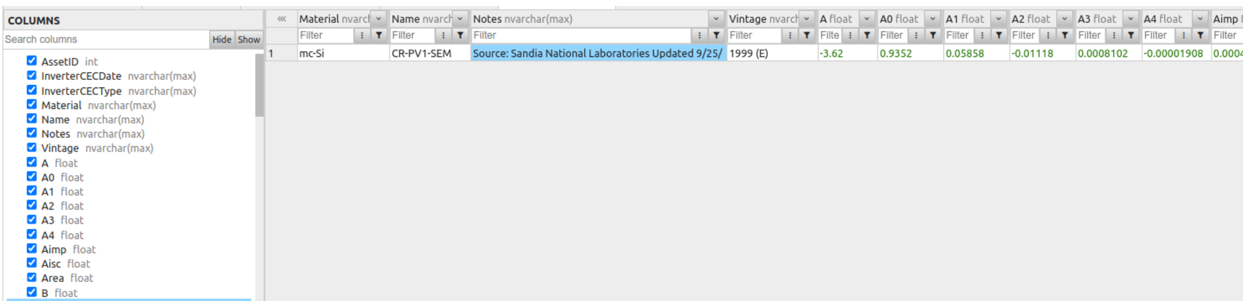
MG_2UC1.1: Real time microgrid monitoring and data acquisition

This use case was fully demonstrated in D7.4

MG_2UC1.2: RES production estimation

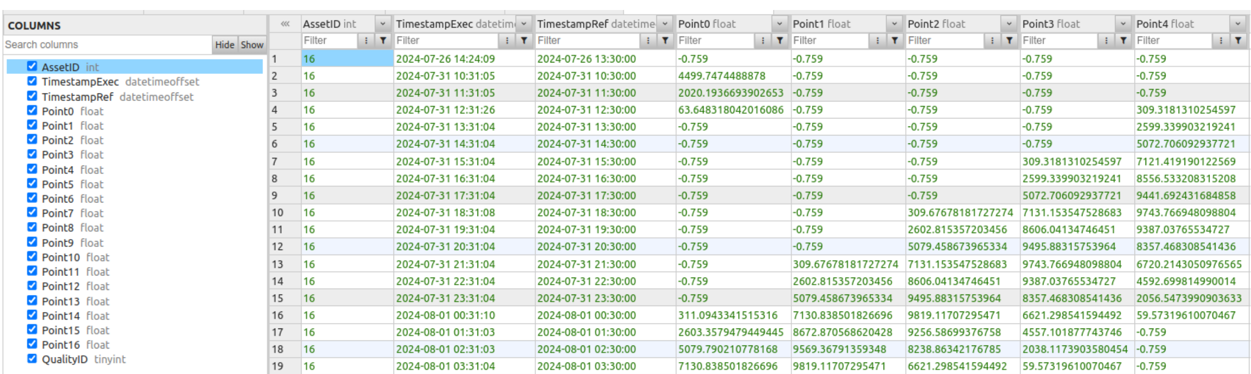
This use case showcases the forecasting capabilities of the ecoMicrogrid system at the Keonjhar pilot site. The Keonjhar implementation leverages PV and load forecasts to ensure optimal energy management and operational efficiency.
Weather forecast data for Keonjhar is retrieved from the NCEP Global Forecast System (GFS), which provides global forecasts with a spatial resolution of 0.25 degrees latitude by 0.25 degrees longitude. This high-resolution dataset, offering analysis and forecast grids at 3-hour intervals, is utilized to drive the forecasting process.
The dataset includes a variety of atmospheric and surface variables, with the PV forecast specifically relying on temperature, wind speed, and cloud coverage. The retrieved weather data

is stored within the ecoMicrogrid system and utilized by the PV forecast module to estimate energy production. The Keonjhar pilot features a single PV installation with a capacity of 30 kWp.
The accompanying Figure 55 illustrates the configuration parameters for PV production forecasts, as stored in the ecoMicrogrid system's storage device. These parameters include the orientation of the PV panels, technology specifications, and datasheet-related details, such as open-circuit voltage (Voc) and inverter efficiency (69 parameters in total). Figure 56 shows how the PV production forecasts are stored within the ecoMicrogrid system. The forecast is calculated for the PV installation on an hourly basis for the defined horizon, which in this case is 48 hours (16 points).



	Material nvarchar	Name nvarchar	Notes nvarchar(max)	Vintage nvarchar	A float	A0 float	A1 float	A2 float	A3 float	A4 float	Aimp fl
1	mc-Si	CR-PV1-SEM	Source: Sandia National Laboratories Updated 9/25/	1999 (E)	-3.62	0.9352	0.05858	-0.01118	0.0008102	-0.00001908	0.0004

Figure 55 Snapshot taken from the PVStaticView table of ecoMicrogrid installed at Keonjhar



	AssetID int	TimestampExec datetime	TimestampRef datetime	Point0 float	Point1 float	Point2 float	Point3 float	Point4 float
1	16	2024-07-26 14:24:09	2024-07-26 13:30:00	-0.759	-0.759	-0.759	-0.759	-0.759
2	16	2024-07-31 10:31:05	2024-07-31 10:30:00	4499.7474488878	-0.759	-0.759	-0.759	-0.759
3	16	2024-07-31 11:31:05	2024-07-31 11:30:00	2020.1936693902653	-0.759	-0.759	-0.759	-0.759
4	16	2024-07-31 12:31:26	2024-07-31 12:30:00	63.648318042016086	-0.759	-0.759	-0.759	309.3181310254597
5	16	2024-07-31 13:31:04	2024-07-31 13:30:00	-0.759	-0.759	-0.759	-0.759	2599.339903219241
6	16	2024-07-31 14:31:04	2024-07-31 14:30:00	-0.759	-0.759	-0.759	-0.759	5072.706092937721
7	16	2024-07-31 15:31:04	2024-07-31 15:30:00	-0.759	-0.759	-0.759	309.3181310254597	7121.419190122569
8	16	2024-07-31 16:31:04	2024-07-31 16:30:00	-0.759	-0.759	-0.759	2599.339903219241	8556.533208315208
9	16	2024-07-31 17:31:04	2024-07-31 17:30:00	-0.759	-0.759	-0.759	5072.706092937721	9441.692431684858
10	16	2024-07-31 18:31:08	2024-07-31 18:30:00	-0.759	-0.759	309.67678181727274	7131.153547528683	9743.766948098804
11	16	2024-07-31 19:31:04	2024-07-31 19:30:00	-0.759	-0.759	2602.815357203456	8606.04134746451	9387.03765534727
12	16	2024-07-31 20:31:04	2024-07-31 20:30:00	-0.759	-0.759	5079.458673965334	9495.88315753964	8357.468308541436
13	16	2024-07-31 21:31:04	2024-07-31 21:30:00	-0.759	309.67678181727274	7131.153547528683	9743.766948098804	6720.2143050976565
14	16	2024-07-31 22:31:04	2024-07-31 22:30:00	-0.759	2602.815357203456	8606.04134746451	9387.03765534727	4592.699814990014
15	16	2024-07-31 23:31:04	2024-07-31 23:30:00	-0.759	5079.458673965334	9495.88315753964	8357.468308541436	2056.5473990903633
16	16	2024-08-01 00:31:10	2024-08-01 00:30:00	311.0943341515316	7130.838501826696	9819.11707295471	6621.298541594492	59.57319610070467
17	16	2024-08-01 01:31:03	2024-08-01 01:30:00	2603.3579479449445	8672.870568620428	9256.58699376758	4557.101877743746	-0.759
18	16	2024-08-01 02:31:03	2024-08-01 02:30:00	5079.790210778168	9569.36791359348	8238.86342176785	2038.1173903580454	-0.759
19	16	2024-08-01 03:31:04	2024-08-01 03:30:00	7130.838501826696	9819.11707295471	6621.298541594492	59.57319610070467	-0.759

Figure 56 Snapshot taken from the PVForecastsView table of ecoMicrogrid installed at Keonjhar

Demonstration Activities:
Key activities conducted during this phase include:

- **Integration Validation:** Collection and integration of real-time meteorological and environmental data from sensors installed at the site.
- **Validation:** Testing and fine-tuning predictive models for RES production estimation using historical and real-time data.
- **System Integration:** Ensuring the estimated production data is accurately fed into the EMS module for further processing.

Demonstration Summary:

The objective of the demonstration was to validate that the entire chain of processes across the required ecoMicrogrid modules operates seamlessly and ensures functional integration.
The system effectively showcased its ability to estimate PV production with a high degree of reliability. However, it is important to note that assessing forecasting performance was challenging due to significant curtailment of PV generation during the evaluation period. This curtailed production limited the availability of real data for direct comparison with forecasted values.
This limitation is illustrated in Figure 57, which compares the PV forecasting module's results with the actual PV production data from the field. The graph reveals the PV production derating starting to occur before midday. Despite the constraints, the demonstration successfully highlighted the system's forecasting capabilities within the given operational conditions.

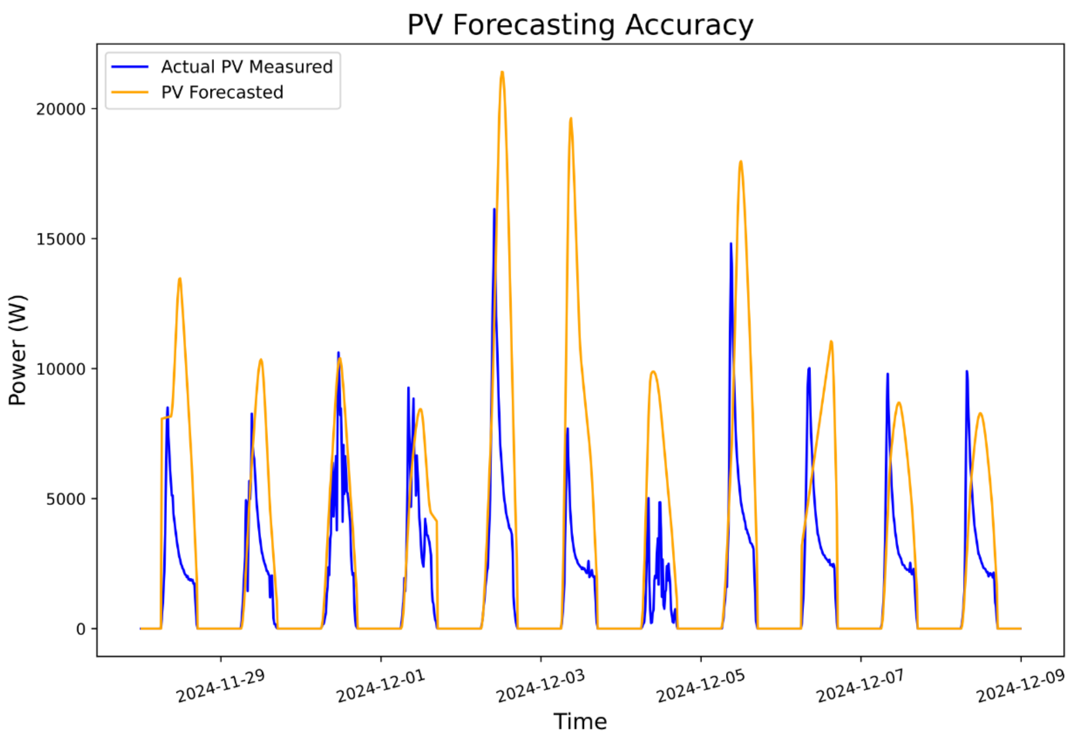


Figure 57 Comparison of PV production forecasts generated by the ecoMicrogrid system and actual PV production data measured at the Keonjhar microgrid.

MG_2UC1.3: Data concentration, storage, and management

This use case was fully demonstrated in D7.4

MG_2UC2.2: Multi objective microgrid management - Optimization of Energy Production, Storage and Purchase

This use case at the Keonjhar pilot site focuses on demonstrating the optimization capabilities of the ecoMicrogrid system, highlighting its ability to manage diverse energy sources such as biogas, biomass, PV, and battery storage. The objective is to evaluate the system's performance in ensuring optimal energy management while minimizing the operational cost of the microgrid.

The ecoMicrogrid leverages advanced predictive algorithms to optimize the dispatch of controllable energy sources. Using a receding horizon approach, the system integrates forecasts for energy demand and generation. This approach enables precise and cost-effective decision-making for resource utilization without relying on highly accurate forecasts, which are often unachievable in small microgrids.

At the Keonjhar site, the ecoMicrogrid does not directly control any assets but provides operational recommendations to the system operator in multiple ways:

1. **SCADA HMI Screen**: A dedicated section on the SCADA interface displays optimization-based suggestions, including recommendations for operating the biomass/biogas system.
2. **ecoPlatform Dashboard**: The ecoPlatform offers a dashboard for Keonjhar, featuring a real-time graph. This rolling window visualization includes 12 hours of historical data on the operational energy mix (PV, biomass/biogas, BESS) and 9 hours of predictive data, showcasing dispatch optimization results (Figure 58 and Figure 59).

Demonstration Activities

Key activities conducted during this phase include:

1. **Real-Time Optimization:**
    - Optimize coordination between energy generation, storage, and consumption to maintain energy availability and minimize operational costs.
2. **Integration and Validation:**
    - Validate the entire integration chain, starting from low-level microgrid (MG) assets to the retrieval of weather predictions.
    - Ensure seamless internal software operation, covering data acquisition, forecasting processes, optimization routines, and the final activation of operational setpoints.

Demonstration Outcomes

The second round of demonstrations took place over several weeks during November and December 2024 at the Keonjhar pilot site. This location operates in a remote area characterized by unstable communication, which inherently makes remote testing challenging for validating the operation of the ecoMicrogrid system.

Despite these constraints, the demonstration successfully showcased the ecoMicrogrid system's capacity to optimize the coordination of energy generation, storage, and consumption in real time. The integration of the ecoMicrogrid system was validated across the entire operational chain, encompassing low-level microgrid assets up to higher-level forecasting and optimization processes. The system excelled in real-time weather data retrieval, internal data processing, and generating actionable suggestions for energy management.

Figure 58 illustrates an example of real-time optimization as visualized through the ecoPlatform. The graph displays the optimal dispatch forecast for the defined optimization horizon, which in this case spans 9 hours. Additionally, Figure 59 shows the actual state of charge of the system over the last 12 hours, along with the estimated SoC for the next 9 hours.

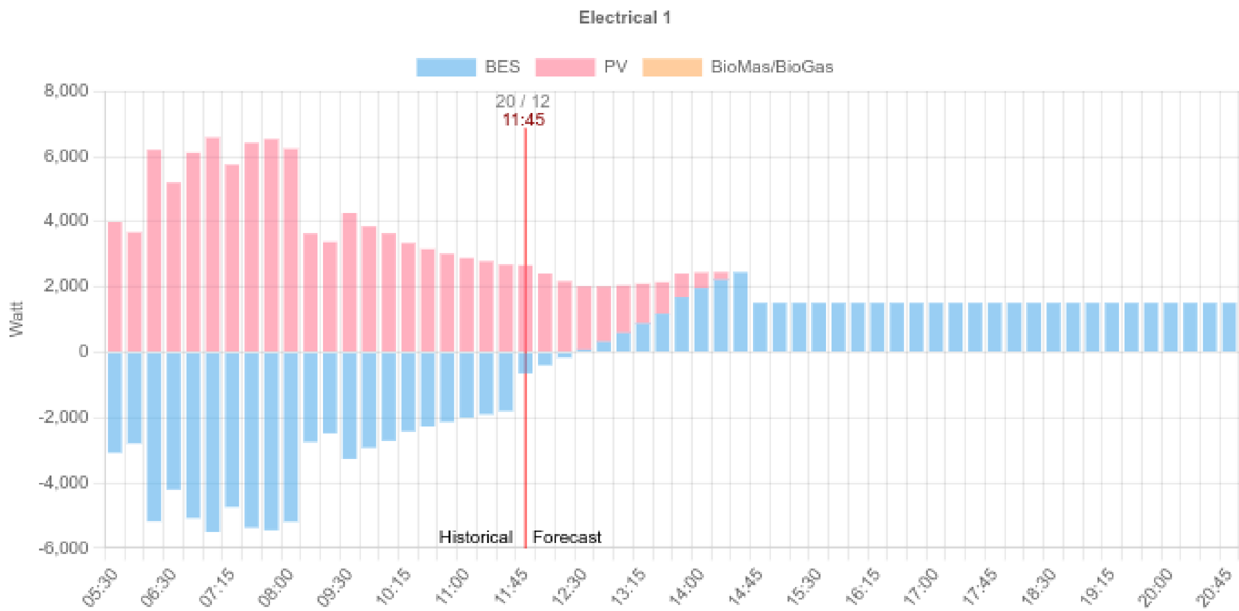


Figure 58 Real-time operational status of the ecoMicrogrid system at the Keonjhar pilot site, representing the solution at 11:45 on 20/12/2024. It shows the historical energy mix of the last 12 hours and the forecasted operational mix for the next 9 hours.

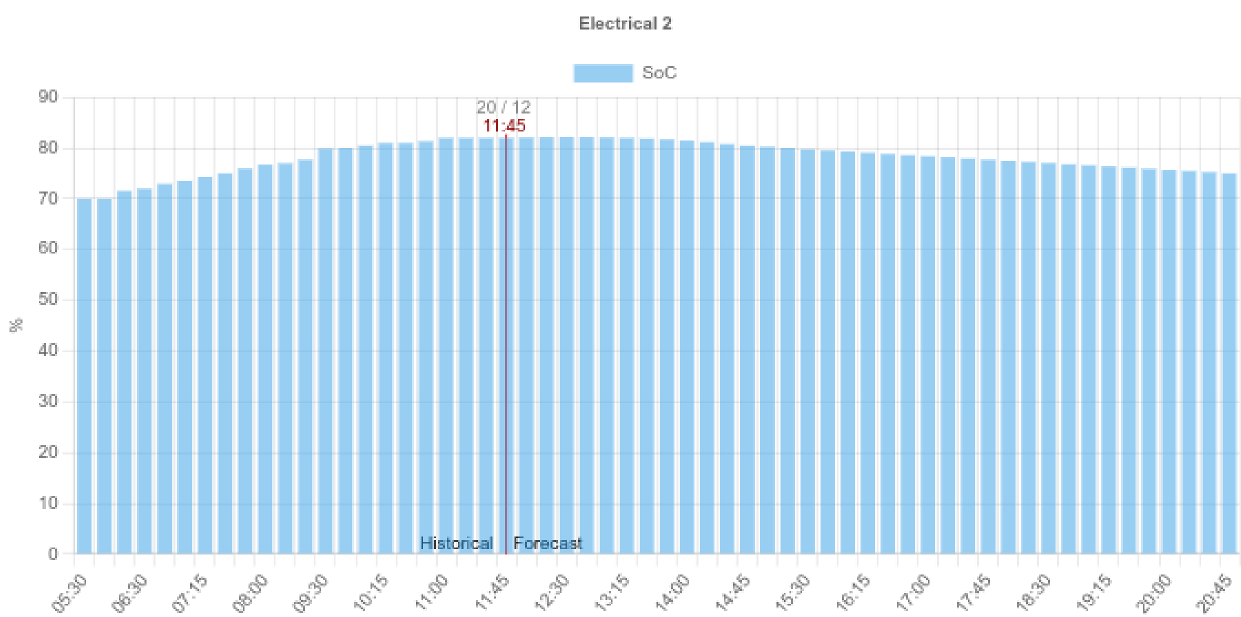


Figure 59 Real-time operational status of the ecoMicrogrid system at the Keonjhar pilot site, representing the solution at 11:45 on 20/12/2024. It shows the actual SoC of the last 12 hours and the estimation of the SoC for the next 9 hours.

However, it is important to note that dispatch validation could not be achieved during the demonstration period due to the unavailability of biomass/biogas fuel. This limitation restricted the system's ability to validate its operation under conditions that require backup systems, necessitating a specially designed test for comprehensive evaluation.

3.4.2 ecoPlanning

PN_2UC1.1: Data collection and storage

This use case was fully demonstrated in D7.4

PN_2UC1.2: Electrical models & demand peak models design, RES & Load estimation

This use case was fully demonstrated in D7.4

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

After the evaluation of demonstration round A, the logos of RE-EMPOWERED project have been added to the output results of the ecoPlanning simulations.

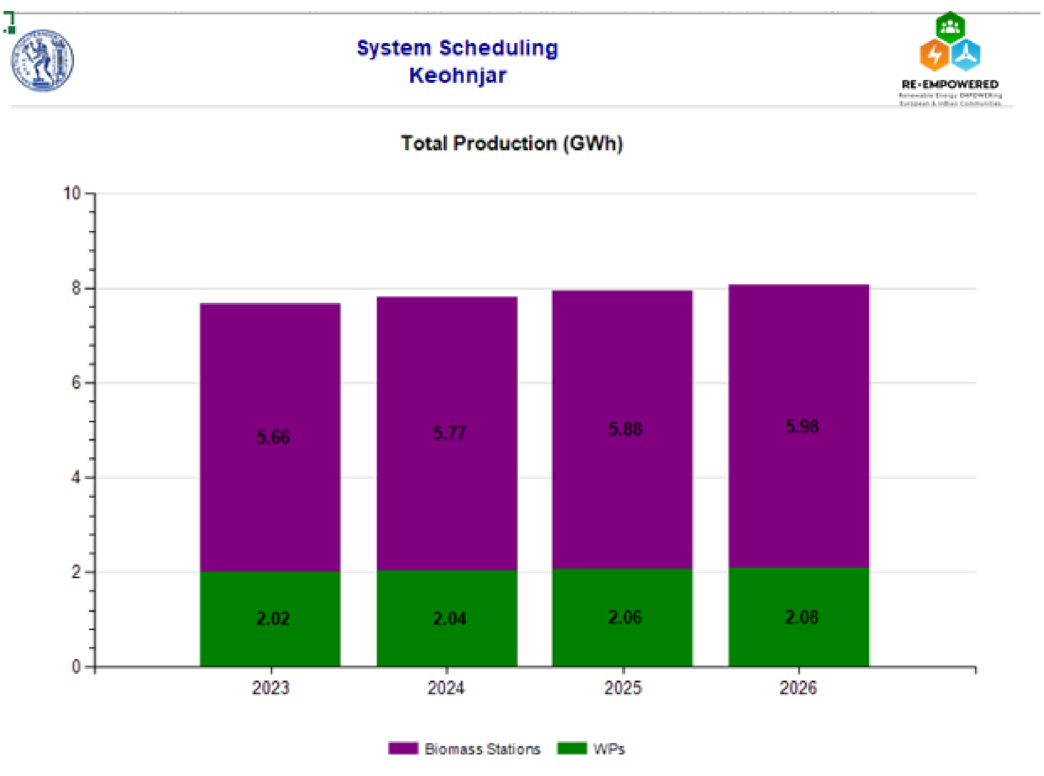


Figure 60 ecoPlanning output displaying the energy mix over the selected horizon for Keonjhar

PN_2UC2.1: Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds

This use case was fully demonstrated in D7.4

PN_2UC2.2: Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment

After the evaluation of 1st round demonstration, the logos of RE-EMPOWERED project have been added to the output results of the ecoPlanning simulations.

RES Hosting Capacity
Keohnjar

RE-EMPOWERED

System cost

Scenario No	Fuel cost (€)	CO2 emissions allowance cost (€)	Additional variable cost (O&M) (€)	Variable cost of thermal production (€)	RES production cost (€)	Total production cost (€)	Average thermal production variable cost (€/MWh)	Average system cost (€/MWh)
1	0.00	0.00	0.00	0.00	903,874.96	903,874.96	NaN	94.14
2	0.00	0.00	0.00	0.00	679,928.93	679,928.93	NaN	70.82
3	0.00	0.00	0.00	0.00	923,122.19	923,122.19	NaN	96.15
4	0.00	0.00	0.00	0.00	696,785.36	696,785.36	NaN	72.57

RES cost

Scenario No	WP production	Biomass	Total
1	101,344.54	802,530.41	**903,874.96**
2	53,946.69	625,982.24	**679,928.93**
3	170,833.44	752,288.75	**923,122.19**
4	102,429.25	594,356.11	**696,785.36**

Figure 61 ecoPlanning - HC displaying various costs over the simulated scenarios for Keonjhar

PN_2UC3.1: Electrical models, demand peak models & interconnections design, RES & Load estimation

The Operator is tasked with exploring the feasibility of interconnecting Non-Interconnected Island Systems (NIS) with each other or with the mainland grid, as part of the European goal for secure electricity supply and the trend towards interconnecting autonomous systems. This includes assessing the benefits and drawbacks of such projects.

The study focuses on both the technical and economic aspects of interconnections. The Operator must evaluate the integration of Island Systems, comparing the operational benefits of an interconnected system versus independent islands. The process starts by identifying the topology of the Island Systems and pinpointing the subsystems involved.

The interconnected systems fall into three categories:

1. Non-Interconnected Islands
2. Grids belonging to the mainland
3. Interconnected islands now part of the mainland grid.

Once the topology is analyzed, the study proceeds with those systems containing at least one Non-Interconnected Island. The integration of these systems typically reduces or eliminates local power generation, as energy is supplied via imports from the mainland. The Operator must also provide reports on both the energy outcomes and the economic impact of the proposed interconnections.

User firstly models the Peak/Demand and Electric System Model, as in the other Use Cases, and then decides on the combination of the interconnecting elements (NIS, mainland) and other technical characteristics such as length, resistance, year of implementation, etc.
Afterwards, user may actually run the scenario of the interconnection implementation.

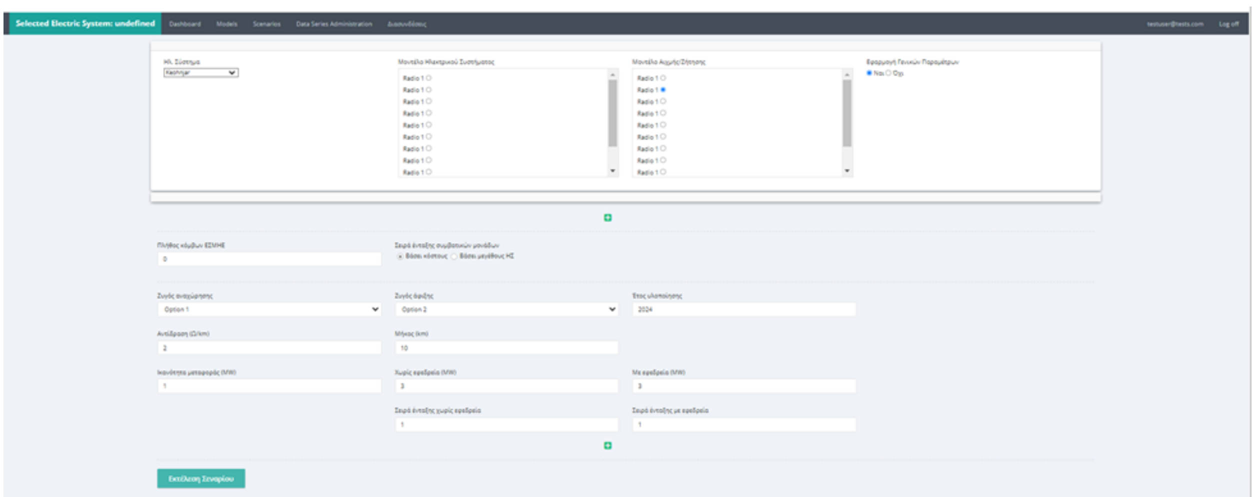


Figure 62 Page from ecoPlanning interconnection study inputs

PN_2UC3.2: Hourly Unit Commitment, through optimization algorithm for mid to long term horizon

Since the successful completion of PN_2UC3.1, this UC is satisfied with the output of the optimization of the Unit Commitment. For this type of study, no actual report is generated, yet it can be designed by the user who can use the input information of the exported CSV files. Using these output files, a simple summary could be the following:

Keonjhar								
	Load (KWh)	Thermal generatiom (KWh)	RES generation (KWh)	Rejected RES energy (KWh)	Energy deficit (KWh)	Keonjhar - Kythnos (KWh)	RES utilization (%)	Injected energy (KWh)*
2022	9,291.70	6,147.77	3,126.79	3,524.12	0.017	-	47.01%	
2023	9,412.50	6,206.50	3,189.33	3,494.47	0.017	-	47.72%	
2024	9,533.40	6,271.35	3,244.63	3,470.75	0.017	-	48.32%	
2025	9,654.30	6,339.98	3,296.92	3,448.24	0.017	-	48.88%	
2026	9,775.20	6,404.77	3,355.91	3,417.28	0.015	-	49.55%	
2027	9,896.00	5,854.16	3,408.00	3,421.61	-	2,797.34	90.86%	-619.40
2028	10,016.90	5,948.08	3,465.91	3,359.79	-	2,610.80	89.03%	-589.71

Table 9 Results summary from ecoPlanning interconnection study

PN_2UC4.1: Energy carriers' identification, data collection and quantification of impact on total load (hourly)

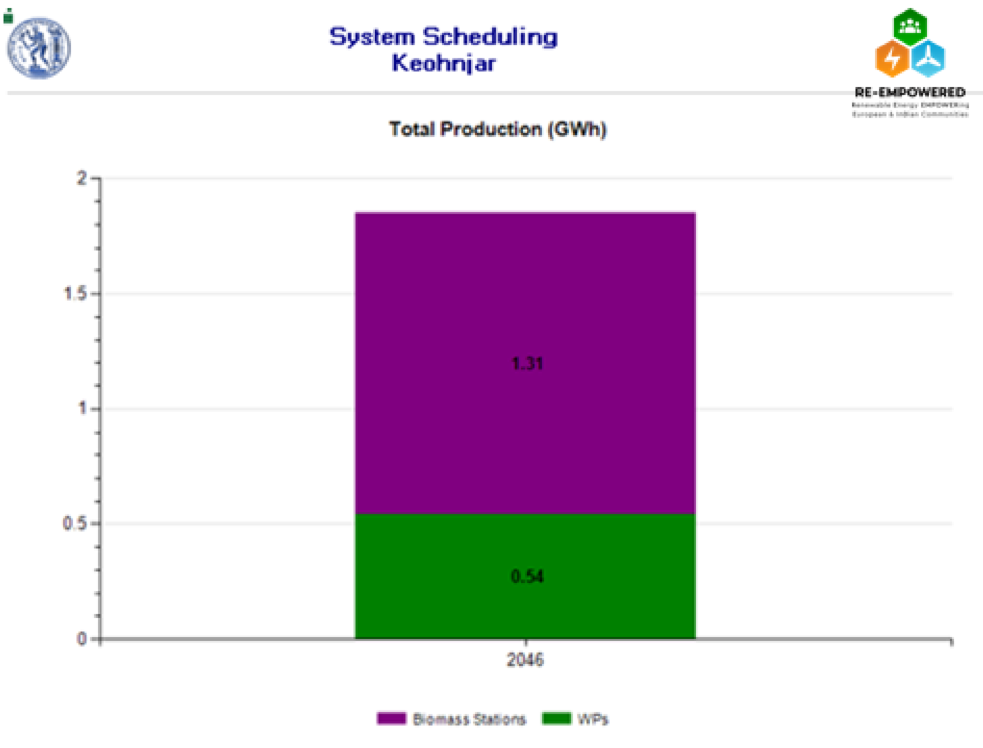
This use case was fully demonstrated in D7.4

PN_2UC4.2: Electrical models & demand peak design, RES & Load estimation, energy carriers' scenarios integration

This use case was fully demonstrated in D7.4

PN_2UC4.3: Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers

After the evaluation of demonstration round A, the logos of RE-EMPOWERED project have been added to the output results of the ecoPlanning simulations.



Aggregated results

	2046
Thermal production (MWh)	0.00
RES production (MWh)	1,854.29
Demand (MWh)	2,624.00
Annual RES penetration (%	70.67
Maximum instantaneous	46.67
WPs equivalent full load	1,082.77
WPs capacity factor (%)	6.20
Diesel consumption (klt)	0.00
Mazut consumption (tn)	0.00
CO2 emissions (tn)	0.00

Figure 63 ecoPlanning - DR displaying energy mix over the simulated scenario for Keonjhar

3.4.3 ecoDR

DR_2UC1.1: Real time monitoring of energy consumption

This use case is in progress by the Indian partners.

DR_2UC2.1: Scheduling of loads

This use case is in progress by the Indian partners.

DR_2UC2.2: Programmable Load shedding controller

This use case is in progress by the Indian partners.

3.4.4 ecoPlatform

PT_2UC2.1: Facilitate data exchange between dependent tools

The use case PT_2UC2.1 was fully demonstrated in D7.4

PT_2UC3.1: Route the microgrid data and data from dependent tools to cloud database

The use case PT_2UC3.1 was fully demonstrated in D7.4

PT_2UC3.2: Facilitate archived data access for dependent tools using API

The use case PT_2UC3.2 was fully demonstrated in D7.4

3.4.5 ecoCommunity

The second round of demonstrations of the ecoCommunity tool in Keonjhar demo site was conducted on 10th December 2024 and 13th December 2024. The various use cases demonstrated are described below.

CM_2UC1.2: Billing and payments

This use case did not have practical value for Keonjhar since each household is charged a fixed amount of ₹80 per month. The collected payments are deposited into the bank account of the Ranipada Energy Community. The proof of concept of this functionality for Keonjhar has been reported in D7.4 [2].

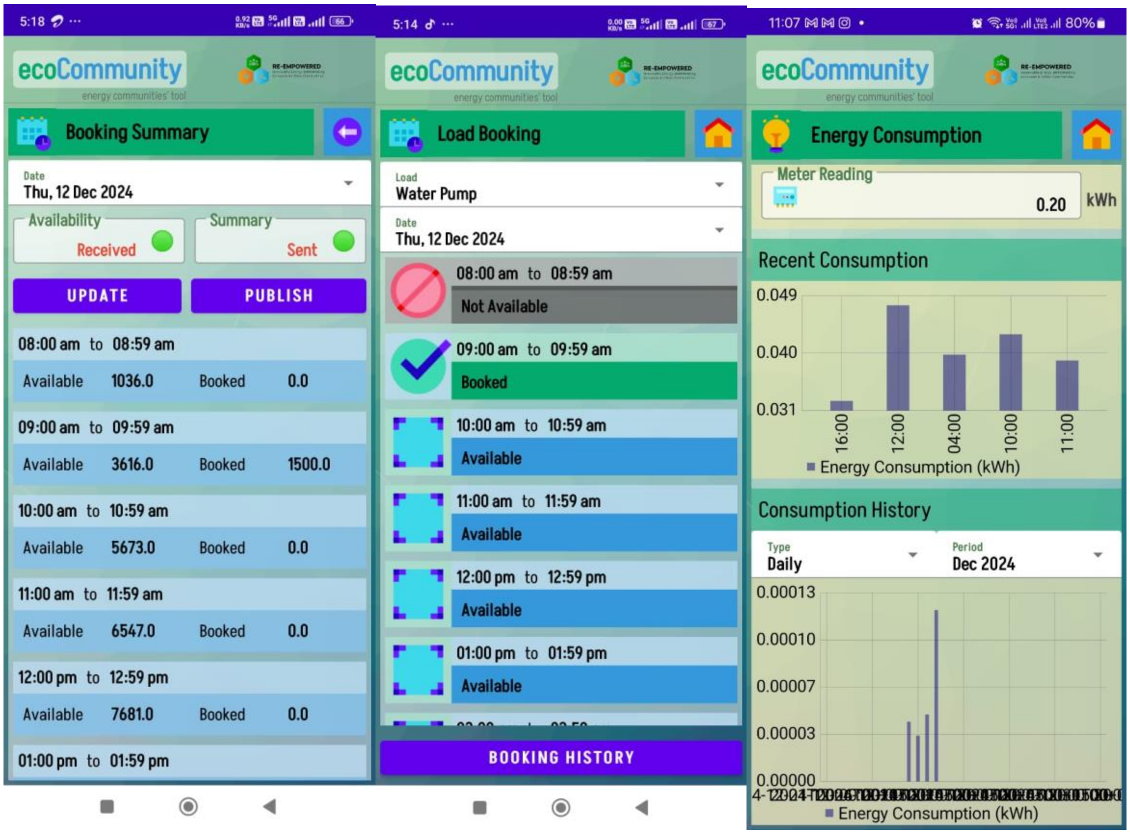
CM_2UC2.1: Facilitating(display) of the scheduling and shifting of non-critical and flexible loads

The use case was demonstrated by indicating a set of time slots which can be booked by the consumers for the use of noncritical consumer loads. In case of Keonjhar, the consumers utilized this facility to book time slots for the use of water pumps based on the available energy. The screenshots of the booked time slot from the consumer user interface and the increase in energy consumption during that period are shown in the following screenshots. In Figure 64 the flexible load booking use case in Keonjhar demo site is presented where (a) depicts the load booking summary page, (b) depicts the consumer interface showing the booking details and (c) depicts the consumer consumption during the booked period.

3.4.6 ecoVehicle

VH_2UC2.2: Customization of the vehicle to the demo site requirements

The use case VH_2UC2.2 was fully demonstrated in D7.4



(a) (b) (c)

Figure 64 Flexible load booking use case in Keonjhar demo site

The administrator user manages the creation of the time slots based on the availability data received from ecoMicrogrid and the booking summary is sent back to ecoMicrogrid at the end of the day. The following screenshot shows the booking summary page from administrator user.

CM_2UC3.1: Feedback and suggestions from users about the tools

The users of the tool did not experience any difficulties in the booking of the timeslots for the water pumps loads. The feedback was that the tool was quite easy to operate.

CM_2UC3.2: Reporting of problem

Screenshots of some of the problems reported during the demonstration are given below.

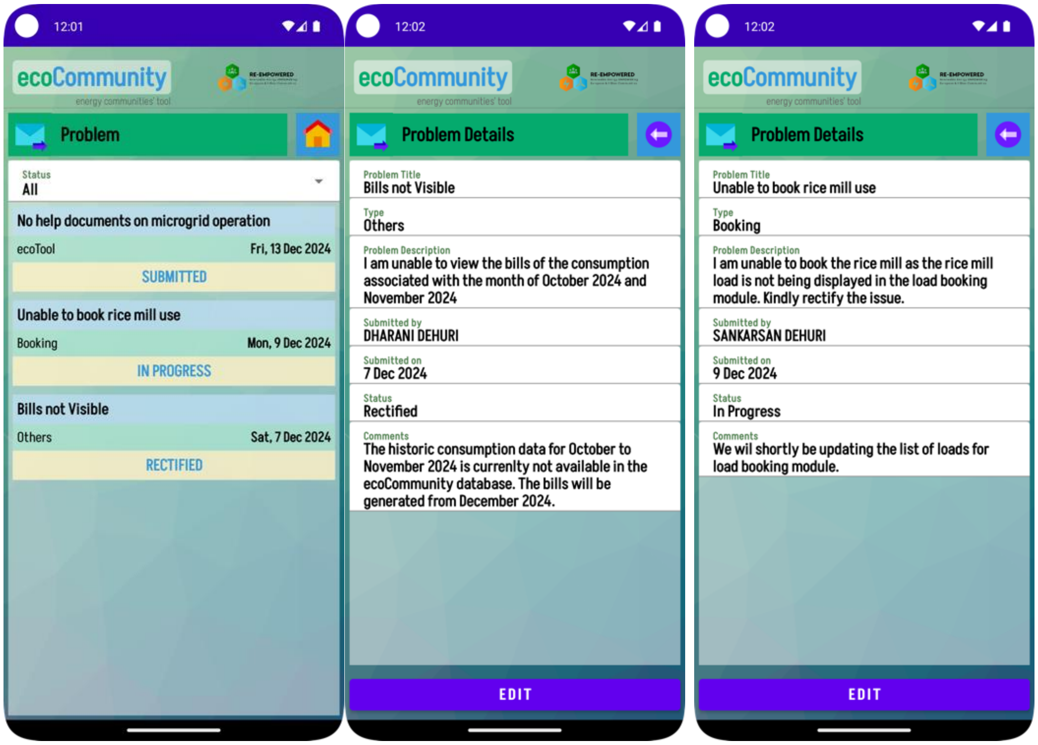


Figure 65 Screenshots of (a) summary of the reported problem from administrative access (b,c)Detailed status and administrative comments on an 'in-progress' and 'rectified' problem

CM_2UC3.3: Forum to share experiences

Screenshots of a forum post reported in the demonstration stage is given below.

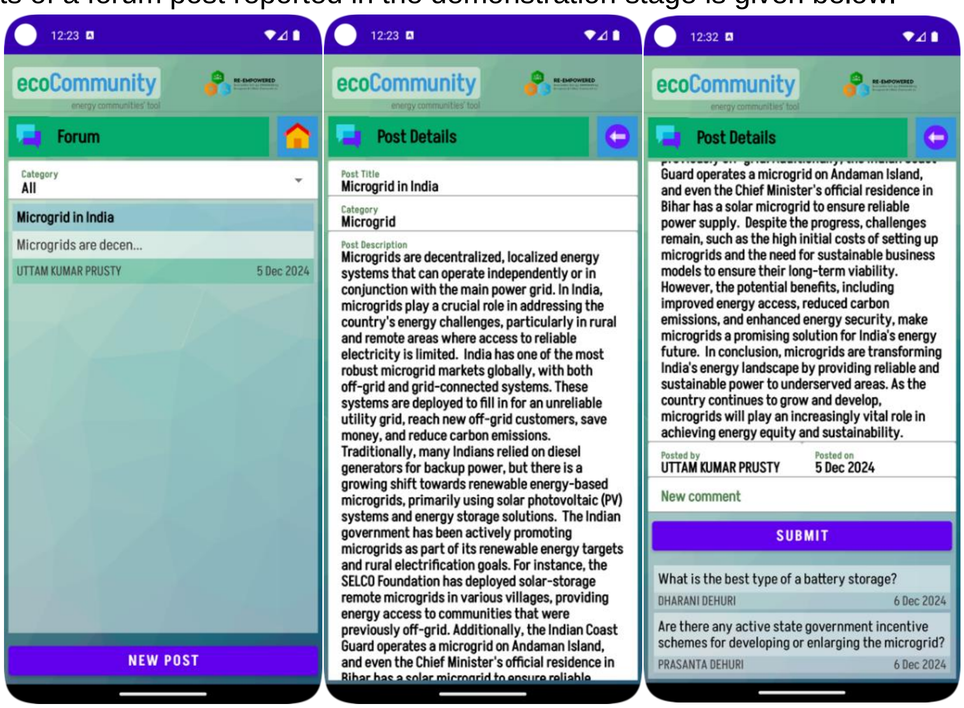


Figure 66 Screenshots of (a) summary of forum posts (b,c) details of a post and its associated comments

CM_2UC4.1: Training material (troubleshooting)

Training and installations materials have been carried out by the tool's developer. A comprehensive yet easy to read guide is illustrated below.

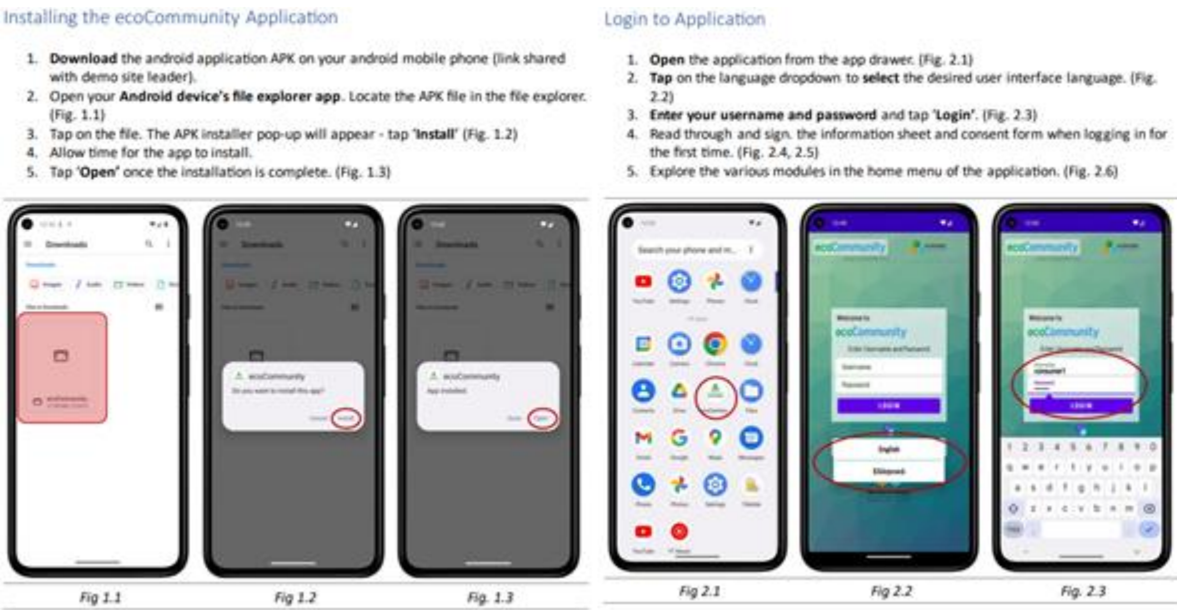


Figure 67 Screenshots of selected parts of the installation guide for ecoCommunity

CM_2UC4.2: Easy-to-use multimedia material and step-by-step guides (walkthroughs)

Manuals and help materials are added to the tool which provides guide to the tool users and demo site administrators.

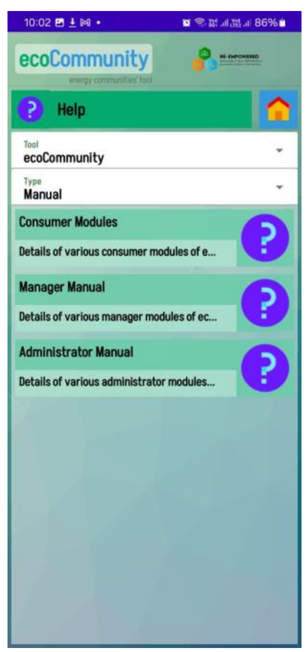


Figure 68 Screenshots of help module in Keonjhar demo site

4 Conclusions

This deliverable provides a detailed report on the status of the second demonstration round activities which is dedicated to the testing and validation of the ecoTools and their functionalities in real-world conditions at the four demo sites: Bornholm (Denmark), Kythnos (Greece), Ghoramara (India) and Keonjhar (India). The UCs defined in D7.1 [1] and D2.1 [3] were suitably refined in D7.4 [2] and served as the foundation for this analysis.

Regarding the demonstration of ecoTools at Bornholm site, the ecoEMS and ecoPlatform were completely tested at the 1st round and minor improvements took place in this round. ecoMonitor and ecoDR were successfully tested locally during the 1st round. Due to the required relocation of these tools to DTU laboratory and communication system difficulties, some use cases had been moved to the second demonstration round. Most of these use cases were successfully demonstrated in the 2nd round. The demonstration activities for the ecoCommunity tool were successfully implemented during the second demonstration round.

At the Kythnos power system and the Gaidouromandra microgrid, the second demonstration round was successfully completed for ecoEMS, ecoPlatform, ecoResilience and ecoDR with slight updates on already demonstrated use cases at the 1st round. The demonstration of ecoMicrogrid, ecoPlanning and ecoCommunity was completed with updated results from the 1st round and new use-cases in the 2nd round. Manual data acquisition was utilized to collect air quality parameters for the ecoMonitor tool, due to issues with the firmware provided by the Indian tool developer.

Regarding Ghoramara demo-site, ecoDR, ecoMonitor, ecoPlatform, and ecoVehicle were fully demonstrated in the 1st round. ecoResilience was mostly demonstrated in the 1st round and the small wind turbine was manufactured locally, while its installation and testing are in progress by the Indian partners. ecoMicrogrid was partially demonstrated in the first round but its demonstration could not be completed due to poor internet connection and technical difficulties of the ecoConverter. ecoConverter forms a small microgrid, which was transferred to Ghoramara for deployment. However, unexpected technical difficulties occurred. ecoMicrogrid obtains measurements from ecoConverter, therefore it was not possible to fully test it, which also affected the transfer of measurements to ecoCommunity. Troubleshooting of ecoConverter is in progress by the Indian partners. Nevertheless, some functionalities of ecoCommunity were demonstrated for the first time in the 2nd round.

Regarding Keonjhar demo-site, the 2nd demonstration phase led to the completion of the use cases of ecoMicrogrid, ecoPlanning and ecoCommunity, providing also updates from the 1st demonstration round. ecoVehicle and ecoPlatform were fully demonstrated in the 1st round. The demonstration of ecoDR is in progress by the Indian partners.

This deliverable presents a comprehensive and detailed report on the demonstration activities of the ecoTools at each demo site, summarizing the work completed in the second part of Task 7.3.

Following the conclusion of the final testing round, the stage is set for the assessment of the tools, based on the data gathered during demonstration, that is currently taking place in D8.4.

It should be noted that DST has provided a 6 month extension of the project to the Indian partners to allow the completion of the installations in India. This extension will be used by the Indian partners only to finalize the tasks noted as “in progress”, while the European activities have been completed.

5 References

[1] RE-EMPOWERED consortium, “D7.1 Deployment and demonstration plan" - September 2022.

[2] RE-EMPOWERED consortium, “D7.4 Report demonstration round 1 (testing)" ,December 2024.

[3] RE-EMPOWERED consortium, “D2.1 Report on requirements for each demo, use cases and KPIs definition" - December 2021.

[4] RE-EMPOWERED consortium, “D7.3 Report on deployment of RE-EMPOWERED solutions"-November 2024.

[5] RE-EMPOWERED consortium, “D4.1 Development of the ecoEMS, ecoMicrogrid and ecoDR", August 2023.