RE-EMPOWERED

Renewable Energy EMPOWERing
European & InDian Communities

Deliverable 2.3: Report on the technical architecture and specifications

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

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EXECUTIVE SUMMARY

This deliverable presents the results related to the architecture of the use cases (UCs) to be developed and tested in the framework of the RE-EMPOWERED project and the implementation of the ecoToolset solutions. The deliverable presents the results of Task T2.4 & Task 2.5 focusing on the development of an open, secure and flexible architecture that forms the high-level basis for achieving active distribution networks/microgrids with dominant RES production, flexible loads, battery storage, etc.

This architecture is mapped on the European SGAM framework and the use cases developed in Task 2.1[1] and determines the principles of operation and control of the basic network components for each use case. Moreover, the operation and the way these UCs will be integrated to the specific needs of the four demo sites (Europe: Bornholm-Denmark, Kythnos-Greece), (India: Keonjhar, Ghoramara island) is considered together with the special requirements of the EU and Indian microgrids, while at the same time the functional specifications of each solution are determined.

To provide a consistent and systematic approach to the modelling of the use cases and the description of the proposed RE-EMPOWERED architecture, the Smart Grid Architecture Model (SGAM) framework is considered. Through the SGAM analysis, the different UCs are represented in different layers starting from the Component layer, which describes the physical layer of the system, including the power equipment, metering infrastructure and network devices. Next comes the Communication Layer which refers to the protocols and mechanisms used for the exchange of information between the different devices and systems. The Function Layer deals with the UC different functionalities while the Information Layer refers to the information exchange between different systems.

The analysis follows the SGAM layers in the following order to help the reader understand better the modelling of the UCs:

- SGAM Component Layer
- SGAM Function Layer
- SGAM Communication Layer
- SGAM Information Layer

The purpose of modelling the ecoToolset UCs through the SGAM framework is mainly to develop a homogenized approach for the description of the UCs providing all the necessary information for the integration of the various systems and hardware components with the tools on each demo site, to the subsequent development phase of the project. To this end, as the SGAM analysis describes interoperability between two or more devices/systems to exchange information and use that information for correct cooperation, only the UCs that include information exchange are considered. Furthermore, although the analysis below is ecoTool-oriented, which means that the majority of the extracted diagrams are common for all demo-sites, there are specific UCs that needed to be considered separately for each demo-site.

Finally, the results of this work will serve as an input to WP3, WP4 and WP5 that focus on the development of the ecoToolset solutions, and also to the planning of the demonstration activities in WP7.

KEYWORDS:

Use Cases, Architecture, Smart Grid Architecture Model, SGAM, Smartgrids, Bornholm, Kythnos, Ghoramara, Keonjhar, ecoEMS, ecoMicrogrid, ecoPlanning, ecoDR, ecoMonitor, ecoPlatform, ecoCommunity, ecoResillience, ecoConverter, ecoVehicle

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Acronyms

Acronym	Description
RES	Renewable Energy Source
PV	Photovoltaic
DSO	Distribution System Operator
SGAM	Smart Grid Architecture Model
MQTT	Message Queue Telemetry Transport
EV	Electric Vehicle
TCP/IP	Transmission Control Protocol/Internet Protocol
FAQ	Frequently Asked Questions
SoC	State of Charge

1 Introduction

1.1 Purpose of the document

In the framework of the RE-EMPOWERED project, a set of solutions (ecoToolset) is developed, that will be implemented in four different Demo sites. These demo sites are located in Europe (Bornholm-Denmark, Kythnos-Greece) and in India (Keonjhar, Ghoramara island). The solutions of the toolset will be tailored to the specific needs of the four pilot cases in both EU and India but will also aim at a wide target group for replication and exploitation in both the developed and developing world. These solutions will range from planning tools for designing or upgrading energy systems, to control and optimization tools for the management of microgrids, interoperable platforms for the integration of the available energy carriers, the digitization of the system and advanced hardware infrastructure for upgrading the local systems.

The purpose of this deliverable is to model with a systematic and harmonized manner the architecture of the use cases to be developed and tested in the framework of the RE-EMPOWERED project.

1.2 Structure of the document

Section 2 presents in detail the SGAM methodology that will be used in order to analyze the UCs applied for each eco-Tool. It is mainly focuses on the Smart Grid interoperability, analysis on the SGAM Framework elements and describes the SGAM methodology. In Section 3, the SGAM analysis in the four layers (Component Layer, Communication Layer, Function Layer and Information Layer) is analytically presented for all the UCs interconnected among the ecoTools set. In Section 4, analysis of the ecoTools functionalities is performed, taking into consideration the progress of the project and the discussions among the ecoTool and Demo sites leaders.

2 The Smart Grid Reference Architecture (SGAM)

2.1 Smart Grid Interoperability

Interoperability acts as the main player in Smart Grid applications. To this end, interoperability needs to be defined in the context of smartgrid architectural models, in which it is applied. A prominent definition describes interoperability as the ability of two or more devices from the same vendor, or different vendors, to exchange information and use that information for correct cooperation [2].

Thus, two or more systems (devices or components) are interoperable, if the two or more systems are able to perform cooperatively a specific function by using information which is exchanged, as it is depicted in Figure 1.

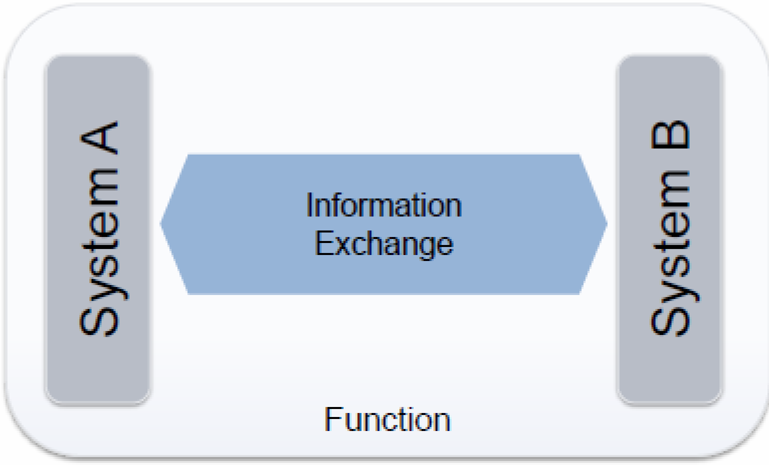


Figure 1 Definition of interoperability – interoperable systems performing a function [3]

GridWise Architecture Council [3] introduced the interoperability categories representing a widely accepted methodology to describe requirements to achieve interoperability between systems or components (Figure 2). Each category is divided among three drivers: Technical, Informational and — Organizational. These interoperability categories underline the definition of interoperability, hence for the realization of an interoperable function, all categories have to be covered, by means of standards or specifications.

Cross-cutting issues are topics which need to be considered and agreed on when achieving interoperability [3]. These topics may affect several or all categories to some extent, as it is presented in Figure 3. Typical cross-cutting issues are cyber security, engineering, configuration, energy efficiency, performance etc.

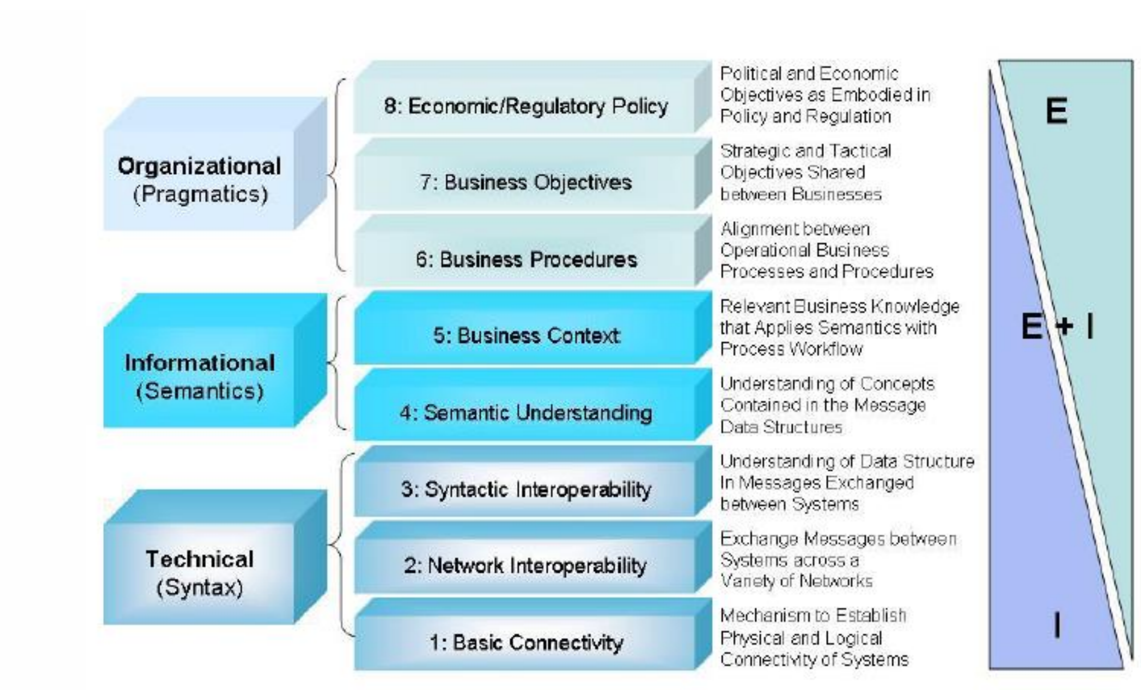


Figure 2 Interoperability Framework Categories [3]

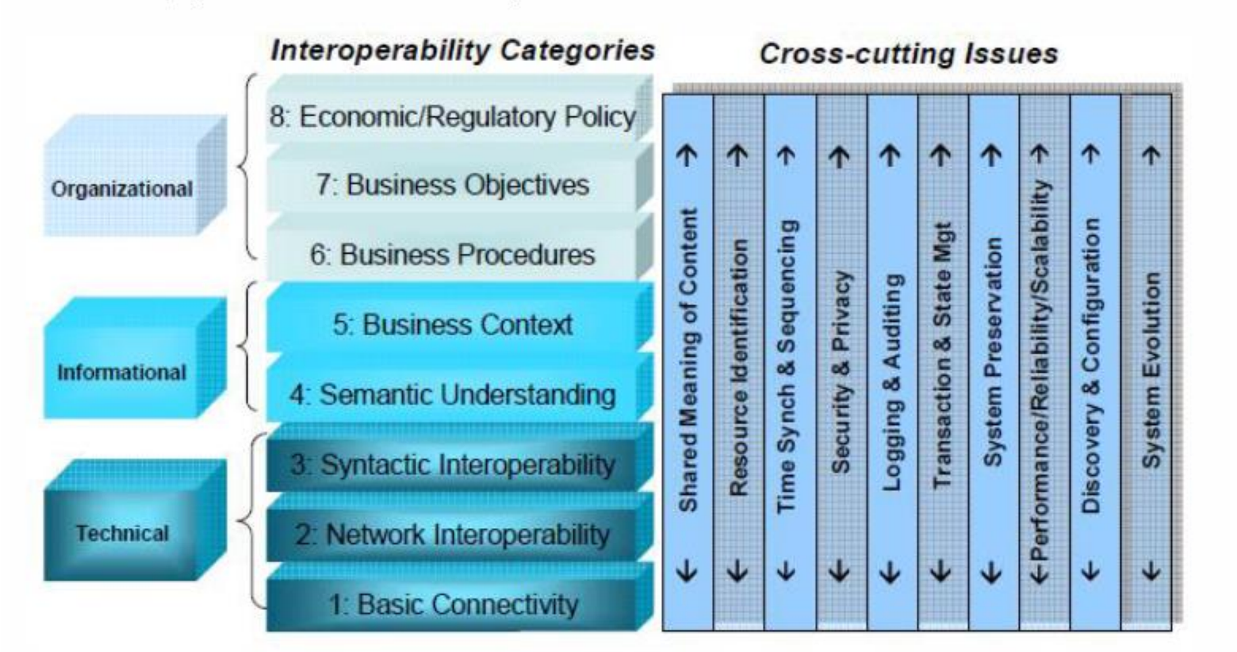


Figure 3 Interoperability Categories and Cross-Cutting Issues [3]

2.2 SGAM Framework Elements

The SGAM framework and its methodology are intended to present the design of smartgrid Use Cases in an architectural viewpoint allowing it both specific but also neutral regarding solution and technology. The SGAM framework allows the validation of smartgrid Use Cases and their support by standards. It consists of five layers representing business objectives and processes, functions, information exchange and models, communication protocols and components. These five layers represent summarized version of the interoperability categories. Each layer covers the smartgrid plane, which is spanned by electrical domains and information management zones. This model intends to represent on which zones of information management interactions between domains can take place. It allows the presentation of the current state of implementations in the electrical grid, but furthermore depicts the evolution to future smart grid scenarios, by supporting the principles universality, localization, consistency, flexibility and interoperability.

2.2.1 SGAM Interoperability Layers

For the clear presentation and simple handling of the architecture model, the interoperability categories described in section 2.1, are grouped into five conceptual interoperability layers (Figure 4). However, in case of a detailed analysis of interoperability aspects, this abstraction can be unfolded. The description of each one of the five interoperability layers is presented in Table 1.

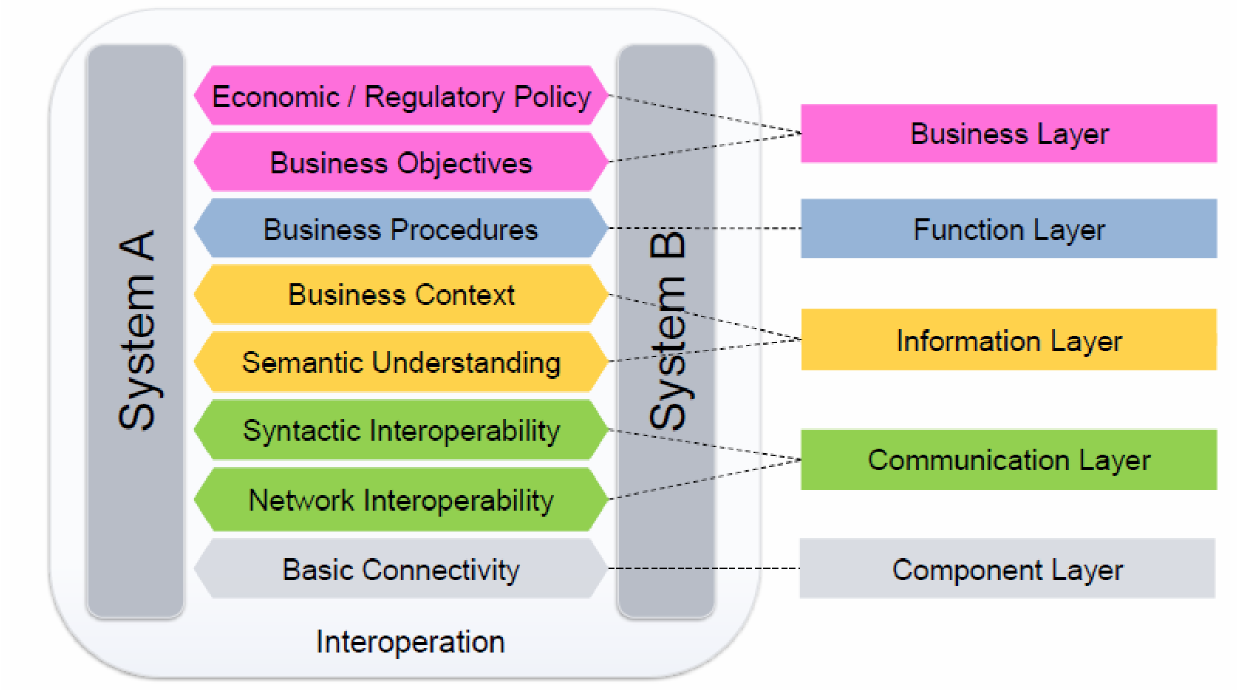


Figure 4 Interoperability layers groups [3]

Table 1 Interoperability Layers description [3]

Layer name	Description
Business Layer	The business layer represents the business view on the information exchange related to smart grids. SGAM can be used to map regulatory and economic structures and policies, business models, business portfolios of market parties involved. Additionally, business capabilities and business processes can be represented in this layer.
Function Layer	The function layer describes functions and services including their relationships from an architectural viewpoint. The functions are represented independent from actors and physical implementations in applications, systems and components. The functions are derived by extracting the use case functionality which is independent from actors.
Information Layer	The information layer describes the information that is being used and exchanged between functions, services and components. It contains information objects and the underlying canonical data models. These information objects and canonical data models represent the common semantics for functions and services in order to allow an interoperable information exchange via communication means.
Communication Layer	The role of the communication layer is to describe protocols and mechanisms for the interoperable exchange of information between components in the context of the underlying use case, function or service and related information objects or data models.
Component Layer	The emphasis of the component layer is the physical distribution of all participating components in the smart grid context. This includes system actors, applications, power system equipment, protection and tele-control devices, network infrastructure and any kind of computers.

2.2.2 SGAM – Smart Grid Plane

A power system management distinguishes between electrical process and information management viewpoints. These viewpoints can be divided into the physical domains of the electrical energy conversion chain and the hierarchical zones (or levels) for the management of the electrical process [4], [5]. Applying this concept to the smart grid conceptual model allows the foundation of the Smart Grid Plane (see Figure 5). This smart grid plane enables the representation on which levels (hierarchical zones) of power system management interactions between domains take place.

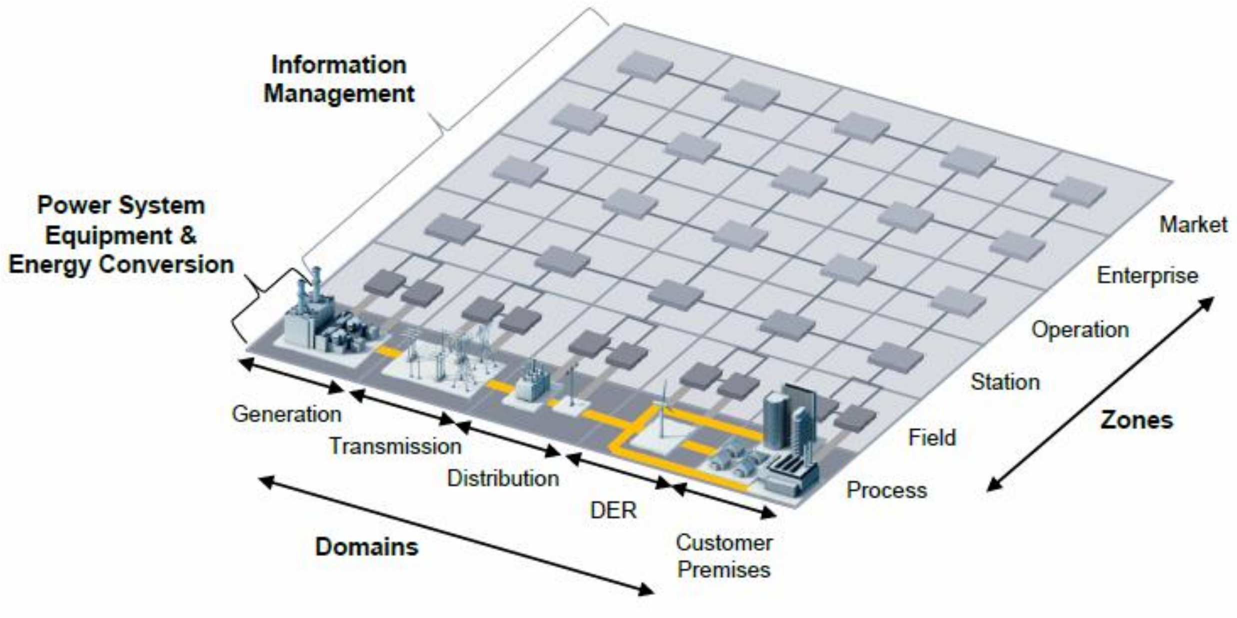


Figure 5 Smart Grid plane [3]

2.2.3 SGAM Domains

The Smart Grid Plane covers the complete electrical energy conversion chain. This includes the domains listed in Table 2:

Table 2 SGAM Domains description SGAM Zones [3]

Domain name	Description
Bulk Generation	Representing generation of electrical energy in bulk quantities, such as by fossil, nuclear and hydro power plants, off-shore wind farms, large scale solar power plant (i.e. PV, CSP) – typically connected to the transmission system
Transmission	Representing the infrastructure and organization which transports electricity over long distances
Distribution	Representing the infrastructure and organization which distributes electricity to customers
DER	Representing distributed electrical resources directly connected to the public distribution grid, applying small-scale power generation technologies (typical range

	from 3 kW to 10.000 kW). *These distributed electrical resources may be directly controlled by DSO*
Customer Premises	Hosting both - end users of electricity, also producers of electricity. The premises include industrial, commercial and home facilities (e.g. chemical plants, airports, harbors, shopping centers, homes). Also, generation in form of e.g. photovoltaic generation, electric vehicles storage, batteries, microturbines are hosted

2.2.4 SGAM Zones

The SGAM zones represent the hierarchical levels of power system management [4]. These zones reflect a hierarchical model which considers the concept of aggregation and functional separation in power system management. The basic idea of this hierarchical model is laid down in the Purdue Reference Model for computer-integrated manufacturing enterprise-control system integration.

Two different aspects of aggregation are mainly applied in power system management:

- **Data aggregation**: Data from the field zone is usually aggregated or concentrated in the station zone for reducing the data to be communicated and processed in the operation zone
- **Spatial aggregation**: Data from distinct location is aggregated to wider area

In addition to aggregation the partitioning in zones follows the concept of functional separation. Different functions are assigned to specific zones due to the specific nature of functions, but also considering user philosophies. Real-time functions are typically in the field and station zone (e.g. metering, protection, etc.). Functions which cover an area, multiple substations or plants, city districts are usually located in operation zone (e.g. wide area monitoring, generation scheduling, load management, etc.).

The aforementioned SGAM zones are presented in Table 3.

Table 3 SGAM Zones [3]

Zone	Description
Process	Physical, chemical or spatial transformations of energy (electricity, solar, heat, water, wind, etc.) and the physical equipment directly involved. (e.g. generators, transformers, circuit breakers, etc).
Field	Equipment to protect, control and monitor the process of the power system, (e.g. protection relays, bay controller, etc).
Station	Representing the areal aggregation level for field level (e.g. for data concentration, functional aggregation, substation automation, local SCADA systems, plant supervision, etc)
Operation	Hosting power system control operation in the respective domain (e.g. distribution management systems (DMS), energy management systems (EMS) in generation and transmission systems, etc).
Enterprise	Commercial and organizational processes, services and infrastructures for enterprises (utilities, service providers, energy traders) such as asset management, logistics, work force management, staff training, etc
Market	Reflecting the market operations possible along the energy conversion chain (e.g. energy trading, mass market, retail market, etc)

2.2.5 SGAM Framework

The SGAM framework is established by merging the concept of the interoperability layers defined with the previous introduced smart grid plane. This merge results in a model which covers three main dimensions (Figure 6):

- Domain
- Interoperability (Layer)
- Zone

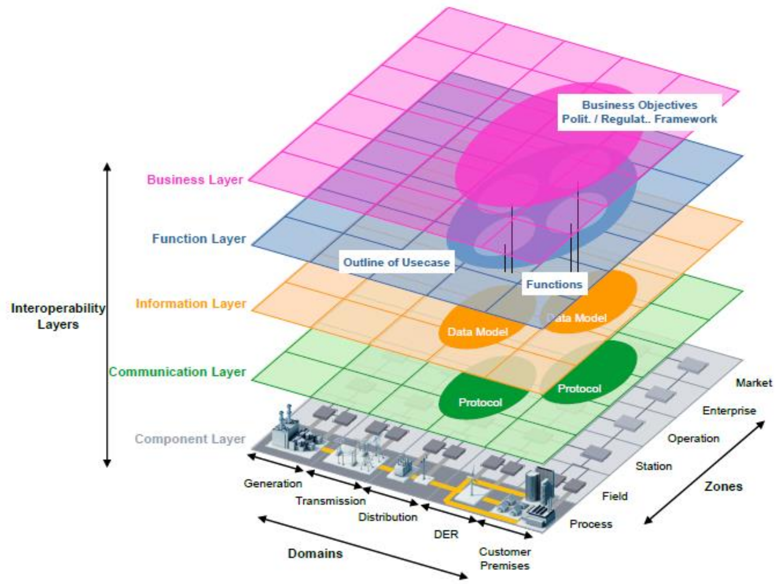


Figure 6 SGAM Framework [3]

2.3 SGAM Methodology

The SGAM framework is based on a specific methodology, which intends to provide users an understanding on its principles and introduce guidelines for its proper use.

The definition of the principles of the SGAM is essential in order to leverage its capabilities for the universal representation of smart grid architectures. In Table 4 the SGAM principles universality, localization, consistency, flexibility, scalability, extensibility and interoperability are described.

Table 4 SGAM principles [3]

Principles	Description
Universality	The SGAM is intended as a model to represent smart grid architectures in a common and neutral view.
Localization	The fundamental idea of the SGAM is to place entities to the appropriate location in the smart grid plane and layer respectively. With this principle an entity and its relation to other entities can be clearly represented in a comprehensive and systematic view.
Consistency	A consistent mapping of a given use case or function means that all SGAM layers are covered with an appropriate entity. If a layer remains open, this implies that there is no specification (data model, protocol) or component available to support the use

	case or function. This inconsistency shows that there is the need for specification or standard in order to realize the given use case or function. When all five layers are consistently covered, the use case or function can be implemented with the given specifications / standards and components.
Flexibility	This principle is essential to enable future mappings as smart grid use cases, functions and services evolve. Furthermore the principle of flexibility allows to map extensibility, scalability and upgradability of a given smart grid architecture.
Scalability	The SGAM encompasses the entire smart grid from a top level view. An enlargement to specific domains and zones is possible in order to detail given use cases, functions and services.
Extensibility	The SGAM reflects domains and zones of organizations which are seen from the current state. In the evolution of the smart grid there might be a need to extend the SGAM by adding new domains and zones.
Interoperability	The consistency of an interoperable interaction can be represented by a consistent chain of entities, interfaces and connections in the SGAM layers.

2.4 Overview of RE-EMPOWERED ecoToolset and Use Cases

A brief description of the ecoToolset is presented in Table 5.

Table 5 ecoToolset Description

No	**Eco Tool Name**	**Description**
1	ecoEMS	This tool will be the energy management system responsible for optimizing the performance of large isolated (e.g. non-interconnected islands) or weakly connected systems.
2	ecoMicrogrid	It will be responsible for the management and optimization of microgrids.
3	ecoPlanning	It will support the planning of rural isolated or weakly interconnected systems, to optimize the installation of a mix of energy technologies aiming to increase renewable generation.
4	ecoDR	It will support demand side management via load scheduling and incentive-based demand response.
5	ecoPlatform	It will be an interoperable platform for the integration of the developed solutions and will facilitate digitization and interoperability of the local energy systems.
6	ecoConverter	It includes the development of modular power electronic converters and their control for dc/ac microgrids.
7	ecoMonitor	It focuses on the surveillance and monitoring of drinking water quality parameters and the deployment of water purification plants.

8	ecoCommunity	It will be the platform dedicated to the energy communities' members and stakeholders aiming to facilitate their active involvement in the energy system
9	ecoVehicle	It will be used to develop and deploy charging stations to facilitate green transportation within Ghoramara island and to nearby island.
10	ecoResilience	It will develop resilient PV and Wind Turbine assets able to withstand extreme weather conditions, such as cyclones and floods.

The analysis of the UCs, developed in WP2 has been thorough presented in Deliverable D2.1 [1]. The analysis was based on the basic needs of each demo site, as well as the functionalities of each ecoTool. In this deliverable the UCs that are presented in Table 6 will be analytically described, in order to finalize the depth of integration of every ecoTool in the Demo sites. The SGAM analysis is performed for all the ecoTools that communicate with each other, thus since the tools ecoResilience, ecoVehicle and ecoMonitor don't have any communication with the other tools, an SGAM analysis has not been performed. Moreover, ecoConverter as a system is included in the SGAM analysis of the ecoMicrogrid tool, with which it exchanges information.

Table 6 RE-EMPOWERED UCs

<table>
<tr><th colspan="3">ecoEMS</th></tr>
<tr><th>UC</th><th>Description</th><th>Association with SGAM analysis</th></tr>
<tr><td>EMS_1UC1</td><td>Real time monitoring and system data visualization</td><td>✓</td></tr>
<tr><td>EMS_2UC1.1</td><td colspan="2">Real time system monitoring and data acquisition and visualization</td></tr>
<tr><td>EMS_2UC1.2</td><td colspan="2">Module manager: intercommunications and data exchange</td></tr>
<tr><td>EMS_1UC2</td><td>Forecasts, Unit Commitment, Economic Dispatch, Multi-energy optimization</td><td>✓</td></tr>
<tr><td>EMS_2UC2.1</td><td colspan="2">Mid-term and short-term RES and load forecasting</td></tr>
<tr><td>EMS_2UC2.2</td><td colspan="2">Forecasting model training</td></tr>
<tr><td>EMS_2UC2.3</td><td colspan="2">Unit Commitment and Economic Dispatch algorithms</td></tr>
<tr><td>EMS_2UC2.4</td><td colspan="2">Multi-energy vector management of operation</td></tr>
<tr><th colspan="3">ecoMicrogrid</th></tr>
<tr><th>UC</th><th>Description</th><th>Association with SGAM analysis</th></tr>
<tr><td>MG_1UC1</td><td>Microgrid monitoring</td><td>✓</td></tr>
<tr><td>MG_2UC1.1</td><td colspan="2">Real time microgrid monitoring and data acquisition</td></tr>
<tr><td>MG_2UC1.2</td><td colspan="2">RES production estimation</td></tr>
</table>

MG_2UC1.3	Data concentration, storage and management	
MG_1UC2	**Microgrid optimal management of operation**	✓
MG_2UC2.1	Effective communication with controllable assets	
MG_2UC2.2	Multi objective microgrid management - Optimization of Energy Production, Storage and Purchase	
MG_2UC2.3	Multi-energy vector microgrid management of operation	
ecoPlanning		
UC	**Description**	**Association with SGAM analysis**
PN_1UC1	**7-Year Energy Planning**	✓
PN_2UC1.1	Data collection and storage	
PN_2UC1.2	Electrical models & demand peak models design, RES & Load estimation	
PN_2UC1.3	Optimization algorithm for mid to long term horizon (1 to 7 years), for hourly Unit Commitment, maximizing RES penetration and securing normal operation	
PN_1UC2	**RES Hosting Capacity**	✓
PN_2UC2.1	Electrical models & demand peak models design, RES & Load estimation, RES units dimensions and thresholds	
PN_2UC2.2	Scenario simulation through optimization for 1 year per scenario run, for hourly Unit Commitment.	
PN_1UC3	**Multi-energy vector microgrid management of operation**	✓
PN_2UC3.1	Electrical models, demand peak models & interconnections design, RES & Load estimation	
PN_2UC3.2	Hourly Unit Commitment, through optimization algorithm for mid to long term horizon	
PN_1UC4	**Multi-energy vectors**	✓
PN_2UC4.1	Energy carriers identification, data collection and quantification of impact on total load (hourly)	
PN_2UC4.2	Electrical models & demand peak design, RES & Load estimation, energy carriers scenarios integration	
PN_2UC4.3	Optimal Unit Commitment for mid to long term horizon, based on multi energy carriers	
ecoDR		
UC	**Description**	**Association with SGAM analysis**
DR_1UC1	**Increased energy monitoring at demand side**	✓
DR_2UC1.1	Real time monitoring of energy consumption	
DR_2UC1.2	Dynamic pricing-based energy cost computation	
DR_1UC2	**Integration Interfaces for Load Management**	✓
DR_2UC2.1	Scheduling of loads	

DR_2UC2.2	Programmable Load shedding controller	
ecoPlatform		
UC	**Description**	**Association with SGAM analysis**
PT_1UC1	**Microgrid data acquisition**	
PT_2UC1.1	Data acquisition and monitoring	
PT_2UC1.2	Data cleansing to ensure consistency and visualization	
PT_1UC2	**Platform as a service for dependent tools integration**	✓
PT_2UC2.1	Facilitate data exchange between dependent tools	
PT_2UC2.2	Facilitate access to controllable assets for dependent tools	
PT_1UC3	**Data storage and cloud server**	
PT_2UC3.1	Data cloud storage	
PT_2UC3.2	Facilitate archived data access for dependent tools using API	
ecoMonitor		
UC	**Description**	**Association with SGAM analysis**
MN_1UC1	**Drinking water quality surveillance**	
MN_2UC1.1	Acquisition and monitoring of water quality	
MN_2UC1.2	Data processing and evaluation	
ecoCommunity		
UC	**Description**	**Association with SGAM analysis**
CM_1UC1	**Dynamic pricing of electricity**	✓
CM_2UC1.1	Displaying the dynamic pricing based on shape of energy profile	
CM_2UC1.2	Billing and payments	
CM_2UC1.3	Data security and privacy	
CM_1UC2	**Scheduling and Coordination**	
CM_2UC2.1	Facilitating(display) of the scheduling and shifting of non-critical and flexible loads	
CM_2UC2.2	Coordination of communal/shared loads	
CM_1UC3	**Outreach forum**	
CM_2UC3.1	Feedback and suggestions from users about the tools	
CM_2UC3.2	Reporting of problems	

CM_2UC3.3	Forum to share experiences	
CM_1UC4	**Guidance and Training**	
CM_2UC4.1	Training material (troubleshooting)	
CM_2UC4.2	Easy-to-use multimedia material and step-by-step guides (walkthroughs)	
ecoResilience		
UC	**Description**	**Association with SGAM analysis**
RS_1UC1	**Optimal passive resilient support structure for solar photovoltaic system**	
RS_2UC1.1	Optimal selection of parameters	
RS_2UC1.2	Computational fluid dynamics (CFD) and structural analysis (CSA) of support structures	
RS_2UC1.3	Experimental validation of the designed structure through wind tunnel testing	
RS_2UC1.4	Design of resilient foundation for solar photovoltaic system	
RS_1UC2	**Improved resilient tower and passive mechanism for wind turbine blades**	
RS_2UC2.1	Preliminary design of a tower truss structure and its optimization	
RS_2UC2.2	Design of a resilient mechanism to reduce wind loads on blades and its optimization	
RS_2UC2.3	Laboratory and field testing of the mechanism	
RS_2UC2.4	Resilient foundation for wind turbine tower structure	
RS_1UC3	**WT Local Manufacturing and Testing**	
RS_2UC3.1	Testing of Small Wind Turbines using Standards	
ecoVehicle		
UC	**Description**	**Association with SGAM analysis**
VH_1UC1	**Tailor-made Electric Vehicle (EV) charging facility**	
VH_2UC1.1	Effective control strategies for dc-bus voltage regulation	
VH_2UC1.2	State of charge and temperature estimation	
VH_2UC1.3	Temperature regulated charging strategies	
VH_1UC2	**Selection and customization of rickshaw**	
VH_2UC2.1	Sizing and Selection of the power train components	
VH_2UC2.2	Customization of the vehicle to the demo site requirements	
VH_1UC3	**Onboard energy management for e-Boat**	
VH_2UC3.1	PV Integration with e-Boat	
VH_2UC3.2	Optimal Energy management algorithms	

3 RE-EMPOWERED ecoTools SGAM modeling

The purpose of this section is to analyse the UCs related to the ecoTools defined in the deliverable of the task T2.1 [1] using a systematic approach based on the SGAM framework. The analysis follows the SGAM layers in the following order to help the reader understand better the modelling of the UCs:

- SGAM Component Layer
- SGAM Communication Layer
- SGAM Function Layer
- SGAM Information Layer

The purpose of the modelling of the ecoToolset UCs following the SGAM framework is mainly to provide a homogenized approach for the description of the UCs defined using the IEC 62559-2 [6] standard so for the subsequent development phase of the ecoToolset to have all the necessary information for the integration of the various systems and hardware components with the tools on each demo site.

To this end, three main remarks are highlighted:

- Although the analysis below is ecoTool-oriented, which means that the majority of the extracted diagrams are common for all demo-sites, there are specific UCs that needed to be considered separately for each demo-site.
- The business layer will not be considered at this stage of the analysis since it will be addressed in WP8 entitled: "Business models, impact assessment and replication". Moreover, as already mentioned the SGAM analysis describes interoperability between two or more devices/systems to exchange information and use that information for correct cooperation. As a result, only the UCs of Table 6 that include information exchange will be described through SGAM.
- The SGAM analysis performed in the following sections concerns the UCs which exchange information with each other. The same UCs might be applied to other Demo sites, but without exchanging information, thus there are not included in the present SGAM analysis.

3.1 EcoMicrogrid

3.1.1 MG_2UC1.1 Real time microgrid monitoring and data acquisition

3.1.1.1 Use Case Description

A variety of metering devices and sensors are necessary for the sufficient data acquisition concerning microgrid's operation. Those captured data and measurements it's highly important to reliably, securely, and effectively be transmitted to an access point, via which the data are further elaborated by the microgrid management system. Communication protocols are an important issue due to the necessity to integrate different vendors. The objective of this UC is to ensure the effective development and implementation of the on-line data transferring and near real-time monitoring system for the microgrid performance assessment and observation.

3.1.1.2 SGAM Component Layer

3.1.1.2.1 Kythnos Demo site

The Component Layer for MG_2UC1.1 implemented at Kythnos demo site describing the technology used for the interconnection between devices and the ecoTools, is depicted in the figure below.

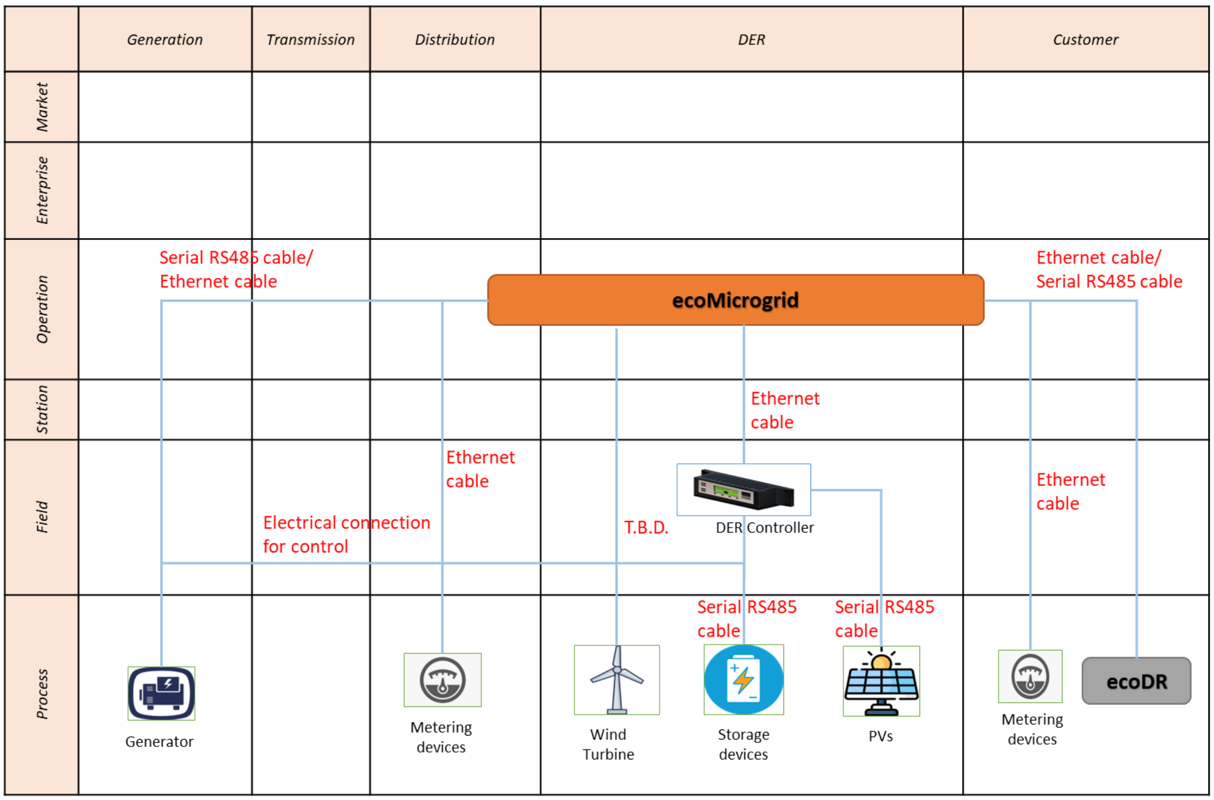


Figure 7 MG_2UC1.1 Component Layer for Kythnos demo-site

Table 7 List of Components MG_2UC1.1 for Kythnos demo-site

Component	Component Type
Generator	Device
Metering Devices	Device
Wind Turbine	Device
Storage Devices	Device
PVs	Device
DER Controller	Device

ecoDR	ecoTool Application
ecoMicrogrid	ecoTool Application

3.1.1.2.2 Keonjhar Demo Site

The Component Layer for MG_2UC1.1 implemented at Keonjhar describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 8.

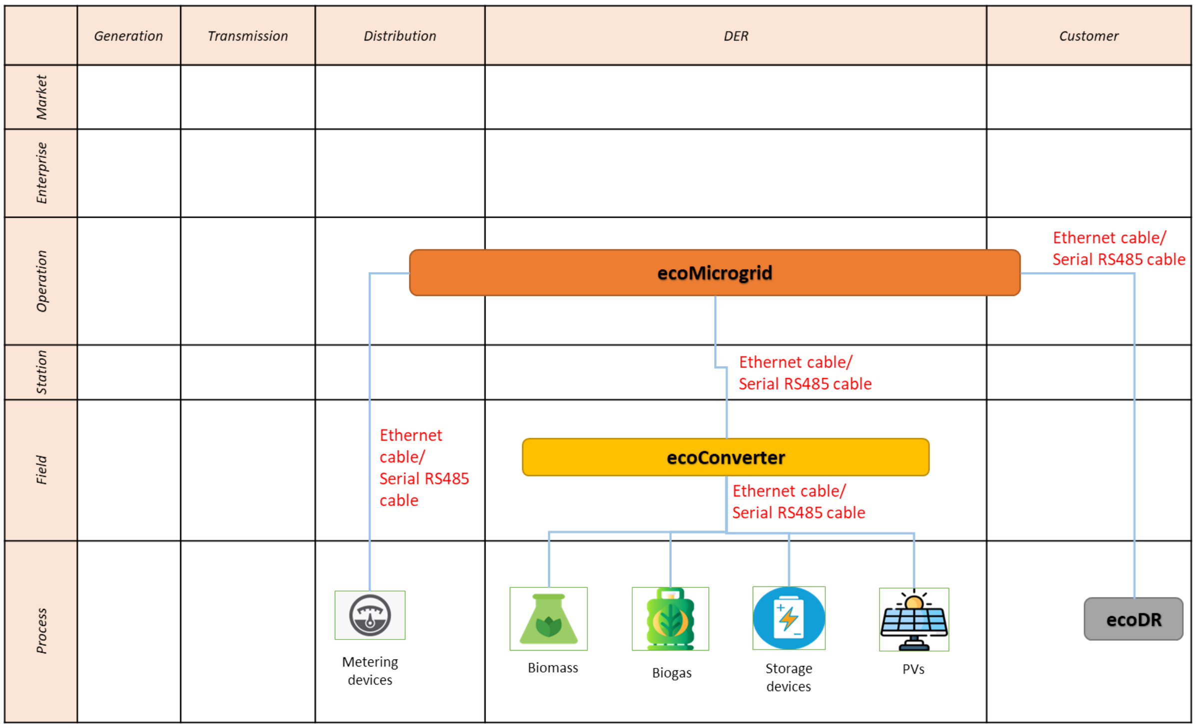


Figure 8 MG_2UC1.1 Component Layer for Keonjhar

Table 8 List of Components MG_2UC1.1 for Keonjhar

Component	Component Type
Biogas	Device
Metering Devices	Device
Biomass	Device
Storage Devices	Device
PVs	Device
ecoConverter	ecoTool Application
ecoMicrogrid	ecoTool Application
ecoDR	ecoTool Application

3.1.1.2.3 Ghoramara Demo Site

The Component Layer for MG_2UC1.1 implemented at Ghoramara island describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 9.

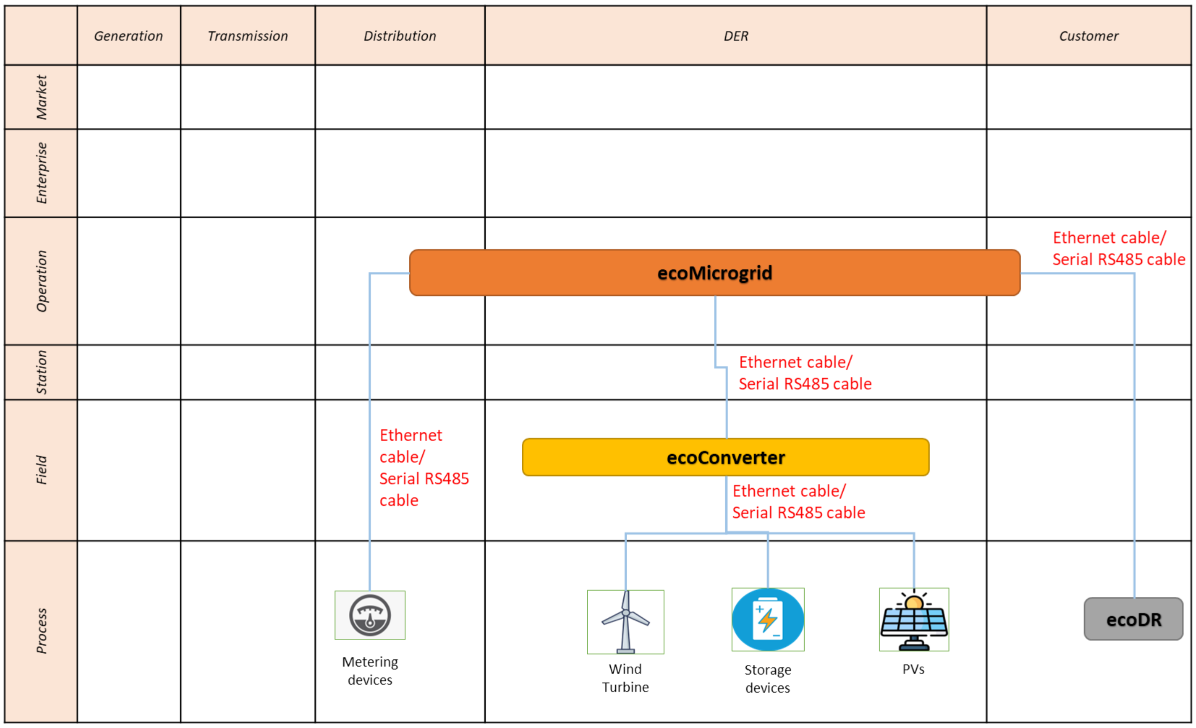


Figure 9 MG_2UC1.1 Component Layer for Ghoramara island

Table 9 List of Components MG_2UC1.1 for Ghoramara island

Component	Component Type
Wind Turbine	Device
Metering Devices	Device
Storage Devices	Device
PVs	Device
ecoDR	ecoTool Application
ecoMicrogrid	ecoTool Application
ecoConverter	ecoTool Application

3.1.1.3 SGAM Communication Layer

3.1.1.3.1 Kythnos Demo site

The Communication Layer for MG_2UC1.1 implemented at Kythnos demo-site describing the technology used for the communications between devices and the ecoTools, is depicted in the figure below.

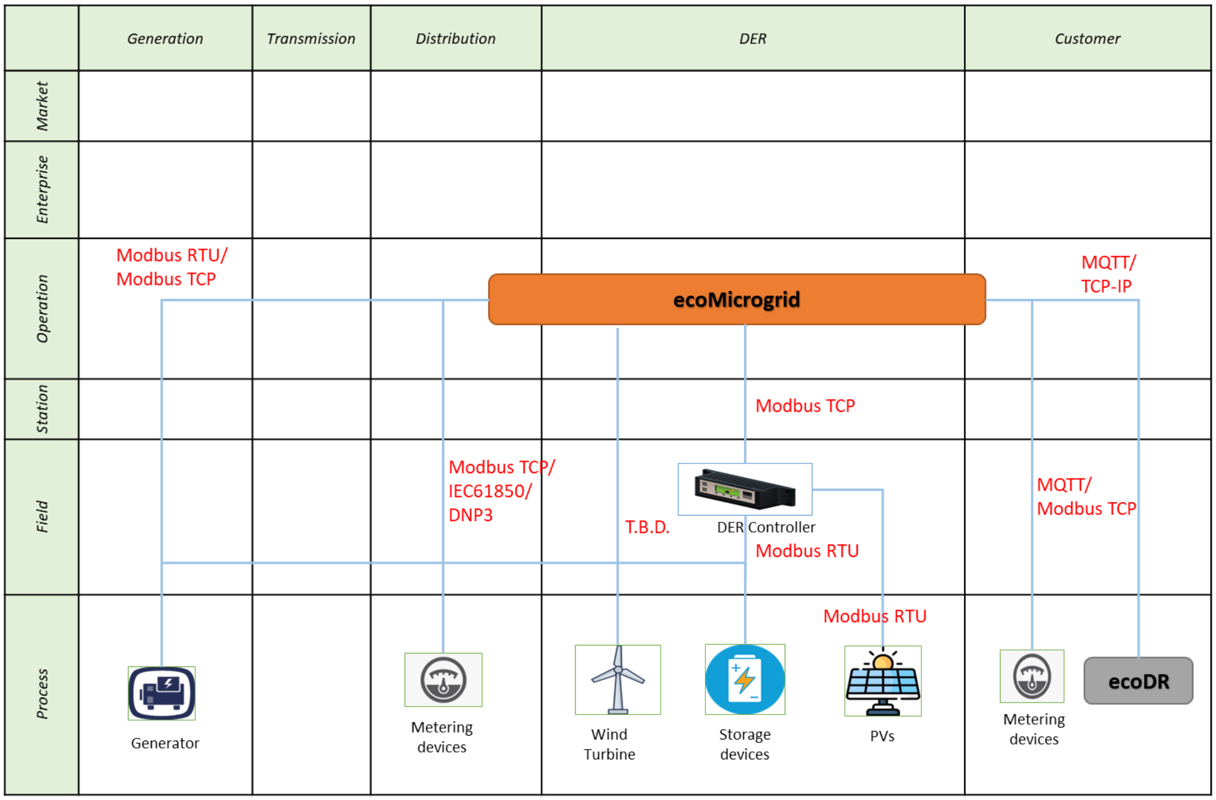


Figure 10 MG_2UC1.1 Communication Layer for Kythnos demo-site

Table 10 List of Communication technologies involved in MG_2UC1.1 for Kythnos demo-site

Component	Component Type
Modbus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols
Modbus RTU	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus RTU (Remote Terminal Unit) means that the Modbus protocol is used on top of a serial line with an RS-232, RS-485 or similar physical interface
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for

	connections where network bandwidth is limited and a lightweight messaging mechanism is required
IEC61850	IEC 61850 is an international standard defining communication protocols for intelligent electronic devices at electrical substations. It is a part of the International Electrotechnical Commission's (IEC) Technical Committee 57 reference architecture for electric power systems
DNP3	Distributed Network Protocol 3. Set of communication protocols used between components in process automation systems, especially in electric and water distribution. It is primarily used for communications between a SCADA control center and devices in the field (Remote Terminal Units and Intelligent Electronic Devices)
TCP-IP	Transmission Control Protocol/Internet Protocol. Conceptual model and set of communication protocols used on the Internet. They provide end-to-end data communication, specifying how data should be packetized, addressed, transmitted, routed, and received, through four abstraction layers (link, internet, transport, and application)

3.1.1.3.2 Keonjhar Demo Site

The communication Layer for MG_2UC1.1 implemented at Keonjhar describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 11.

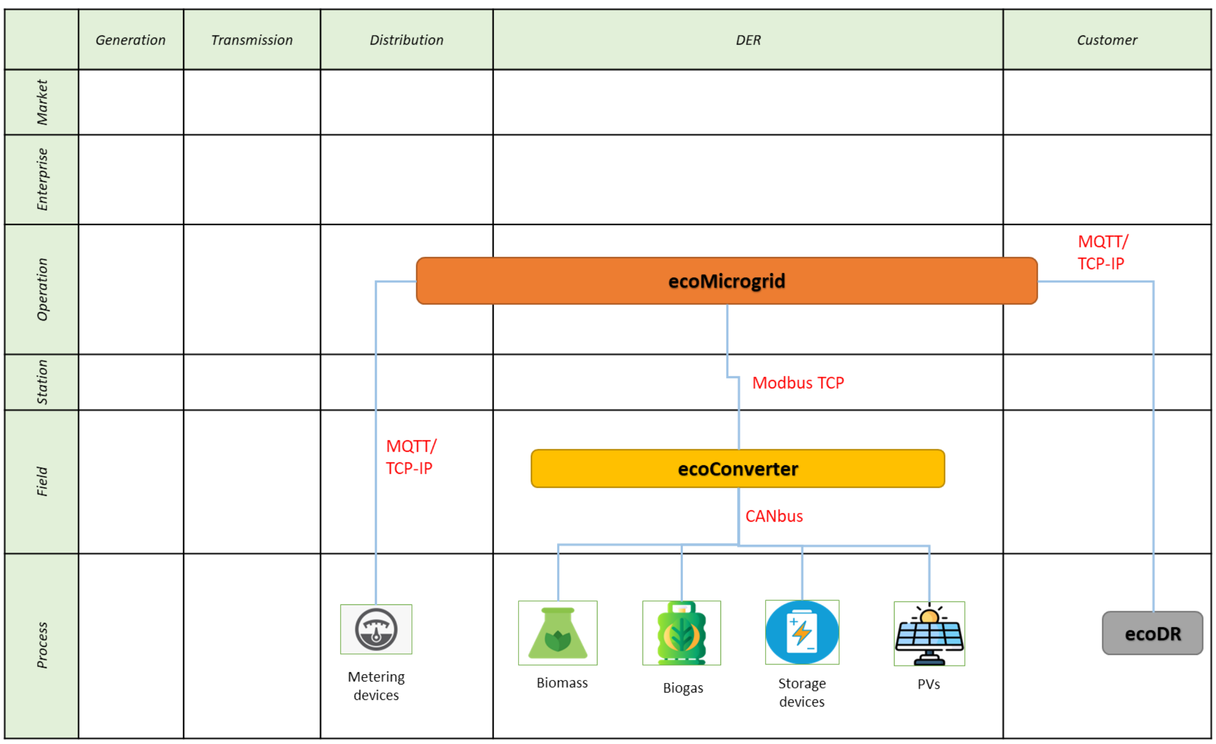


Figure 11 MG_2UC1.1 Communication Layer for Keonjhar

Table 11 List of Communication technologies involved in MG_2UC1.1 for Keonjhar

Component	Component Type
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
CAN bus	A Controller Area Network (CANbus) is a robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each other's applications without a host computer. It is a message-based protocol, designed originally for multiplex electrical wiring within automobiles to save on copper, but it can also be used in many other contexts
ModBus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols
TCP-IP	Transmission Control Protocol/Internet Protocol. Conceptual model and set of communication protocols used on the Internet. They provide end-to-end data communication, specifying how data should be packetized, addressed, transmitted, routed, and received, through four abstraction layers (link, internet, transport, and application)

3.1.1.3.3 Ghoramara Demo Site

The Communication Layer for MG_2UC1.1 implemented at Ghoramara island describing the technology used for the communication between devices and the ecoTools, is depicted in Figure 12.

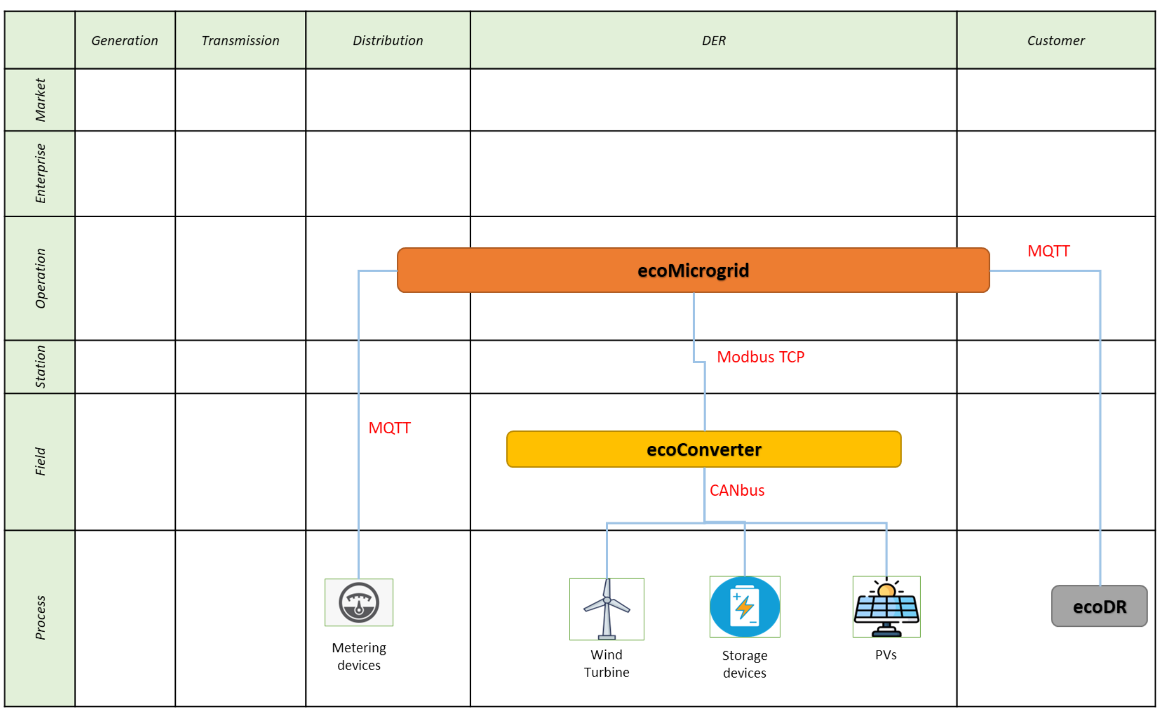


Figure 12 MG_2UC1.1 Communication Layer for Ghoramara island

Table 12 List of Communication technologies involved in MG_2UC1.1 for Ghoramara island

Component	Component Type
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
CAN bus	A Controller Area Network (CANbus) is a robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each other's applications without a host computer. It is a message-based protocol, designed originally for multiplex electrical wiring within automobiles to save on copper, but it can also be used in many other contexts
ModBus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols

3.1.1.4 SGAM Function Layer

3.1.1.4.1 Kythnos Demo site

The functional layer of MG_2UC1.1 implemented at Kythnos demo-site is presented in the graph below highlighting the key actors of the use case.

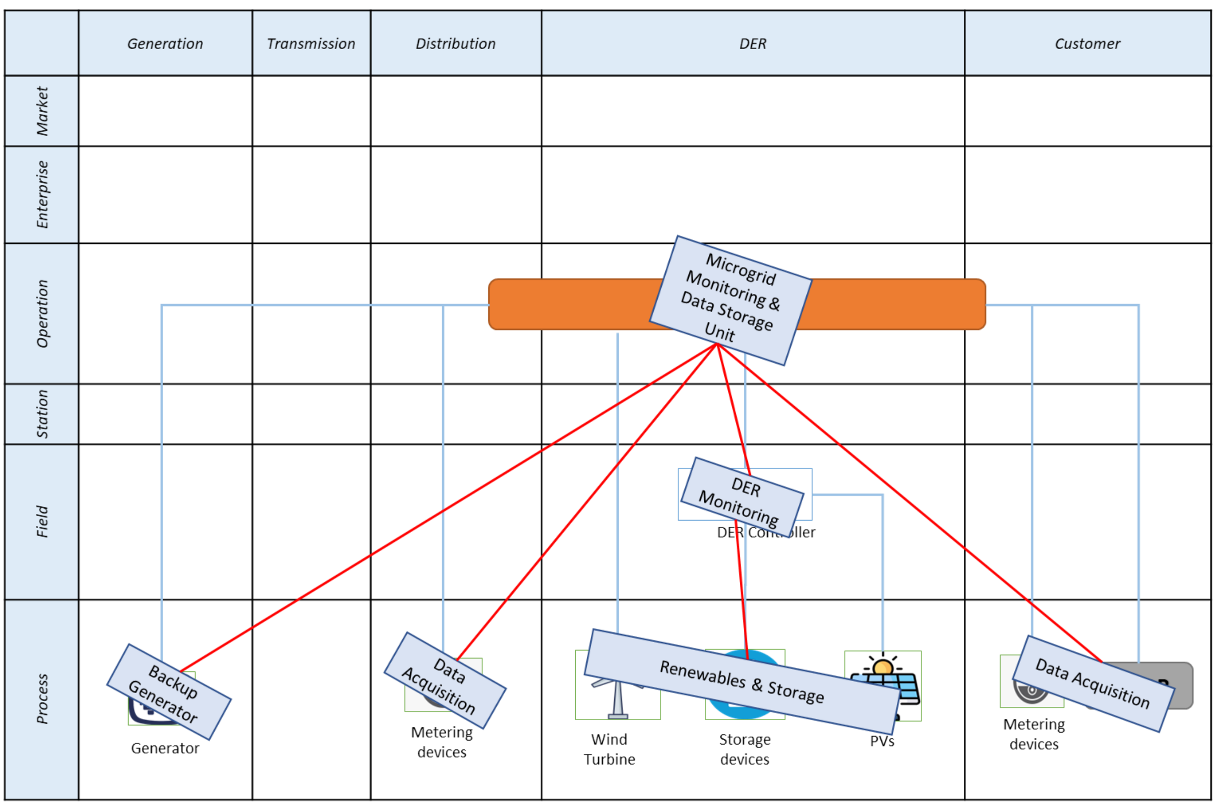


Figure 13 MG_2UC1.1 Function Layer for Kythnos demo-site

3.1.1.4.2 Keonjhar Demo Site

The functional layer of MG_2UC1.1 implemented at Keonjhar is presented in Figure 14, highlighting the key actors of the use case.

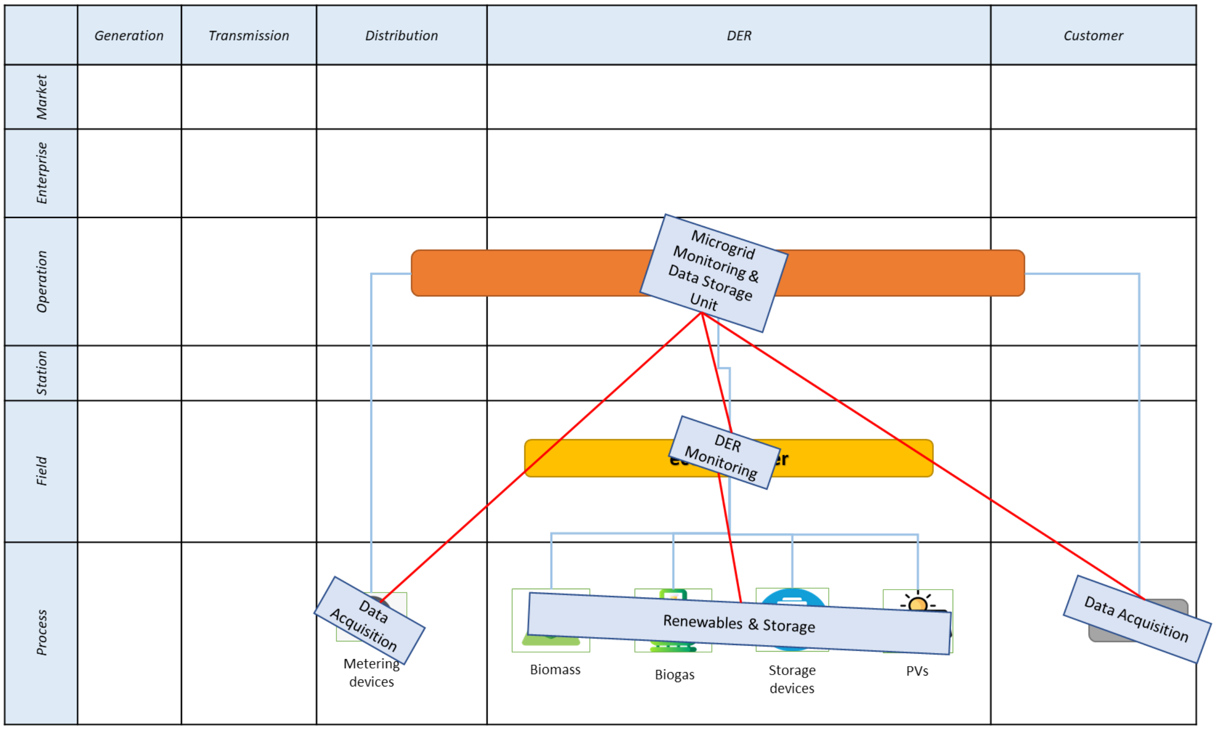


Figure 14 MG_2UC1.1 Function Layer for Keonjhar

3.1.1.4.3 Ghoramara Island

The functional layer of MG_2UC1.1 implemented at Keonjhar is presented in Figure 15, highlighting the key actors of the use case.

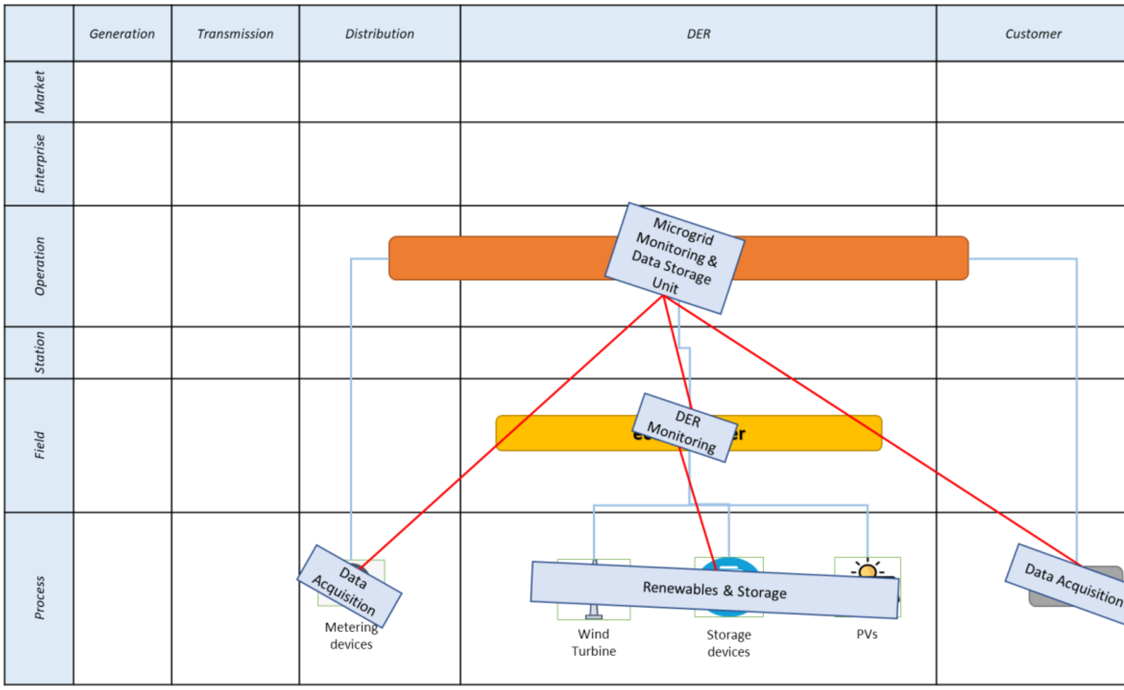


Figure 15 MG_2UC1.1 Function Layer for Ghoramara Island

3.1.1.5 SGAM Information Layer

3.1.1.5.1 Kythnos Demo site

Details about information layer of MG_2UC1.1 are presented in Figure 16, highlighting the key information objects.

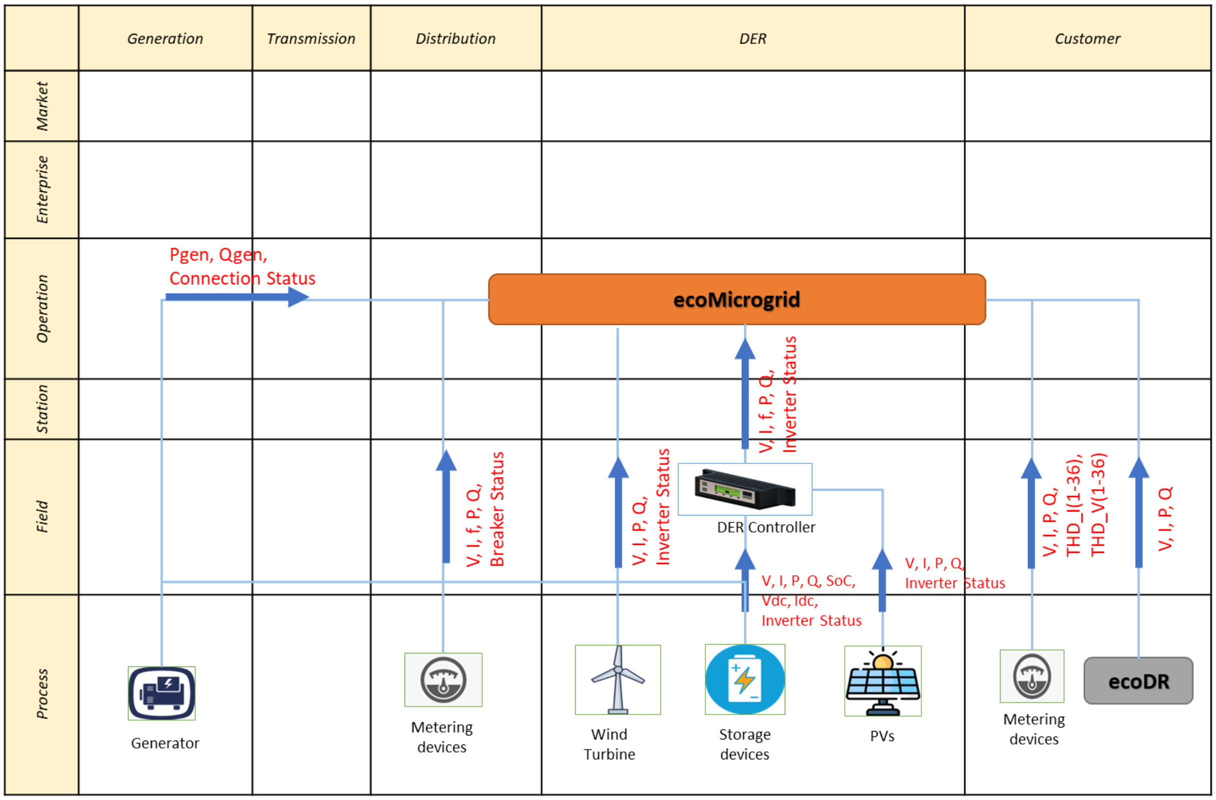


Figure 16 MG_2UC1.1 Information Layer for Kythnos demo-site

3.1.1.5.2 Keonjhar Demo Site

Details about information layer of MG_2UC1.1 are presented in Figure 17, highlighting the key information objects.

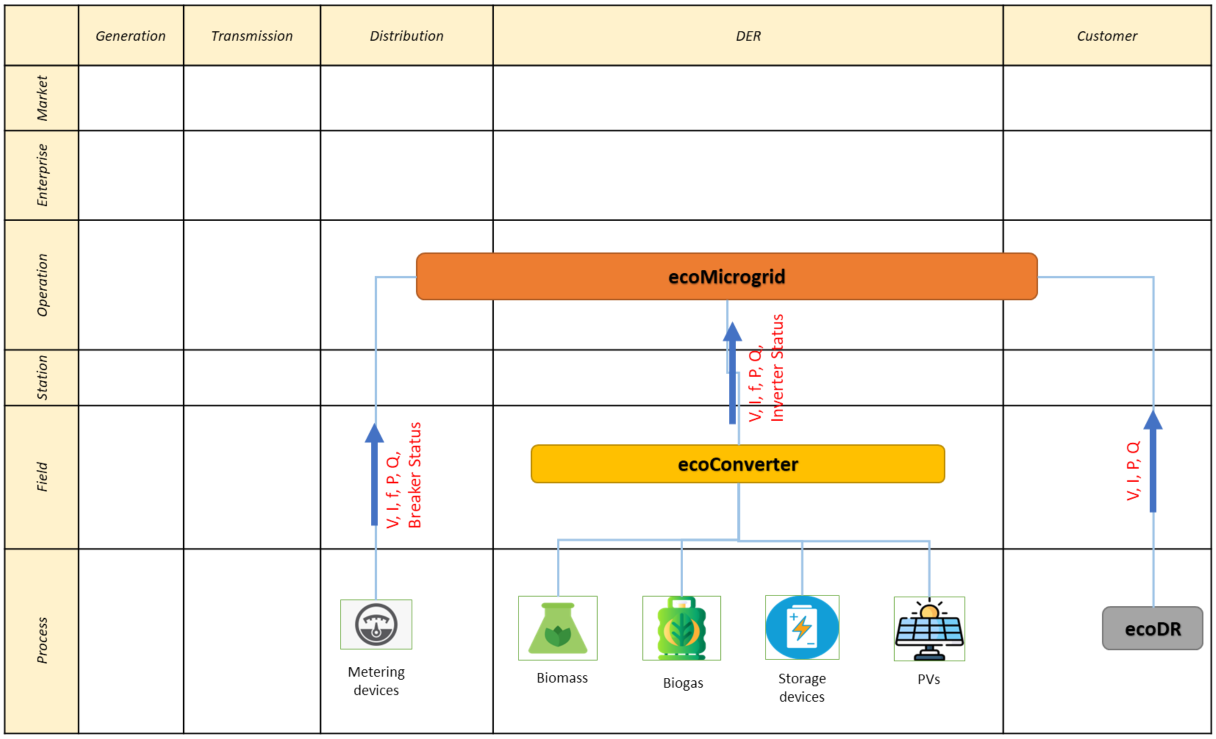


Figure 17 MG_2UC1.1 Information Layer for Keonjhar

3.1.1.5.3 Ghoramara Island

Details about information layer of MG_2UC1.1 are presented in Figure 18, highlighting the key information objects.

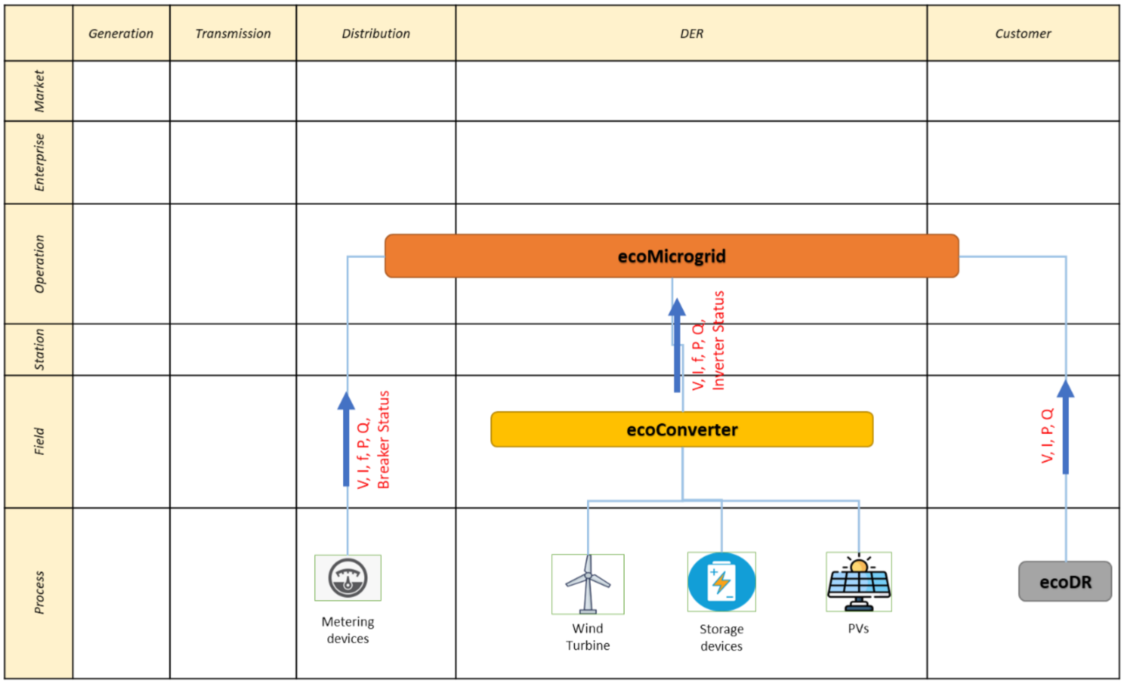


Figure 18 MG_2UC1.1 Information Layer for Ghoramara Island

3.1.2 MG_2UC1.2 RES production estimation

3.1.2.1 Use Case Description

Estimation of future behaviour of production is important for the optimal operation of a microgrid. This UC concerns the ecoMicrogrid functionality of RES forecast based on meteorological, historical, and real time data. By knowing the RES production for the entire day, the optimization module can account with greater certainty for the required number of units starts and stops as well as for keeping generation units near the most efficient operating point. Storage units, allow the optimization module to calculate the most cost-beneficial periods to charge and discharge.

3.1.2.2 SGAM Component Layer

3.1.2.2.1 Kythnos Demo Site

The Component Layer for MG_2UC1.2 describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 19.

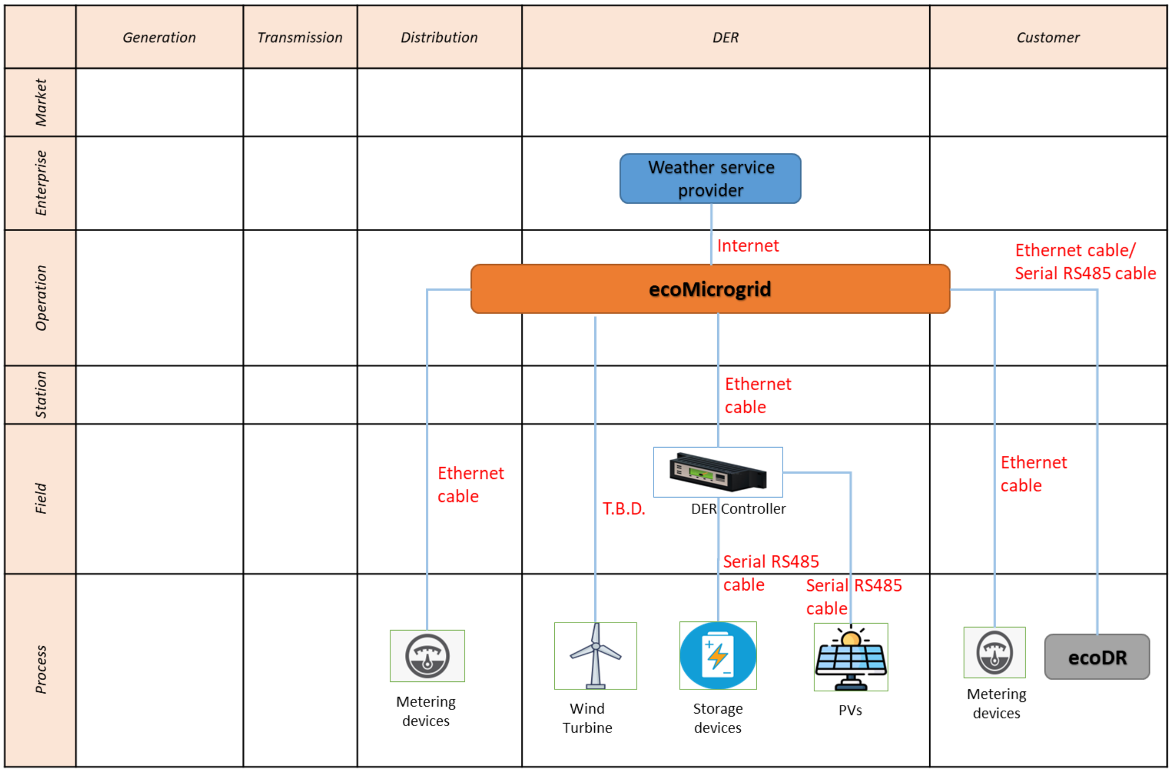


Figure 19 MG_2UC1.2 Component Layer

Table 13 List of Components MG_2UC1.2

Component	Component Type
Metering Devices	Device
Wind Turbine	Device
Storage Devices	Device
PVs	Device
DER Controller	Device
Weather Service Provider	Organization
ecoDR	ecoTool Application
ecoMicrogrid	ecoTool Application

3.1.2.3 SGAM Communication Layer

3.1.2.3.1 Kythnos Demo site

The Communication Layer for MG_2UC1.2 describing the technology used for the communication between devices and the ecoTools, is depicted in Figure 20.

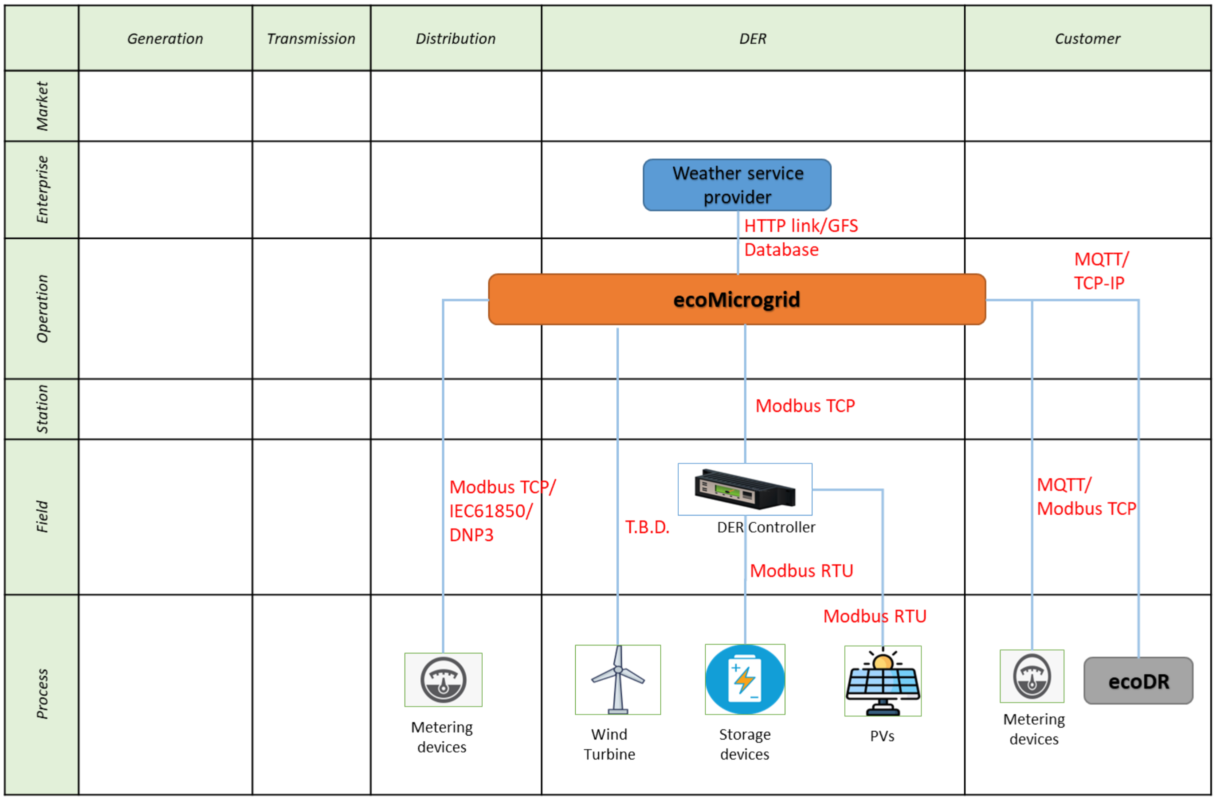


Figure 20 MG_2UC1.2 Communication Layer

Table 14 List of Communication technologies involved in MG_2UC1.2

Component	Component Type
Modbus RTU	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus RTU (Remote Terminal Unit) means that the Modbus protocol is used on top of a serial line with an RS-232, RS-485 or similar physical interface.
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
IEC61850	IEC 61850 is an international standard defining communication protocols for intelligent electronic devices at electrical substations. It is a part of the

	International Electrotechnical Commission's (IEC) Technical Committee 57 reference architecture for electric power systems.
DNP3	Distributed Network Protocol 3. Set of communication protocols used between components in process automation systems, especially in electric and water distribution. It is primarily used for communications between a SCADA control center and devices in the field (Remote Terminal Units and Intelligent Electronic Devices)
Modbus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols

3.1.2.4 SGAM Function Layer

3.1.2.4.1 Kythnos Demo site

The functional layer of MG_2UC1.2 is presented in Figure 21, highlighting the key actors of the use case.

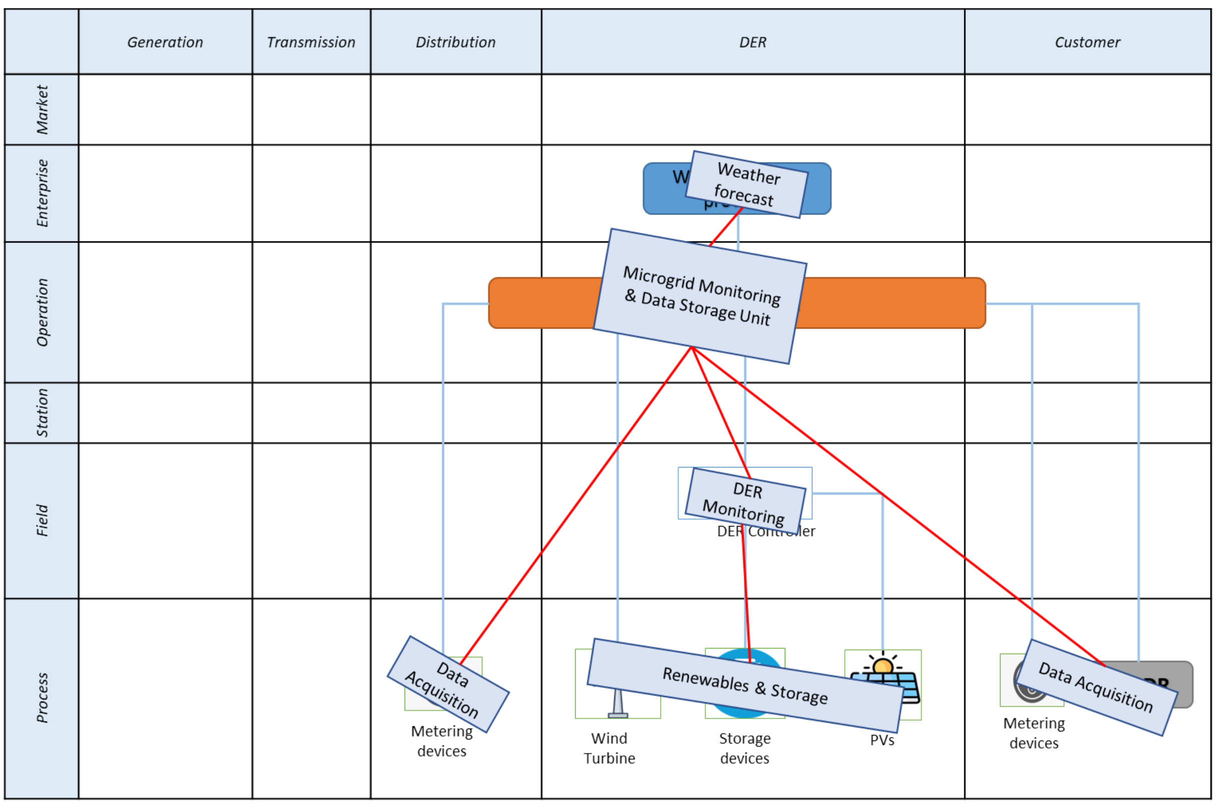


Figure 21 MG_2UC1.2 Function Layer

3.1.2.5 SGAM Information Layer

3.1.2.5.1 Kythnos Demo site

Details about information layer of MG_2UC1.2 are presented in Figure 22, highlighting the key information objects.

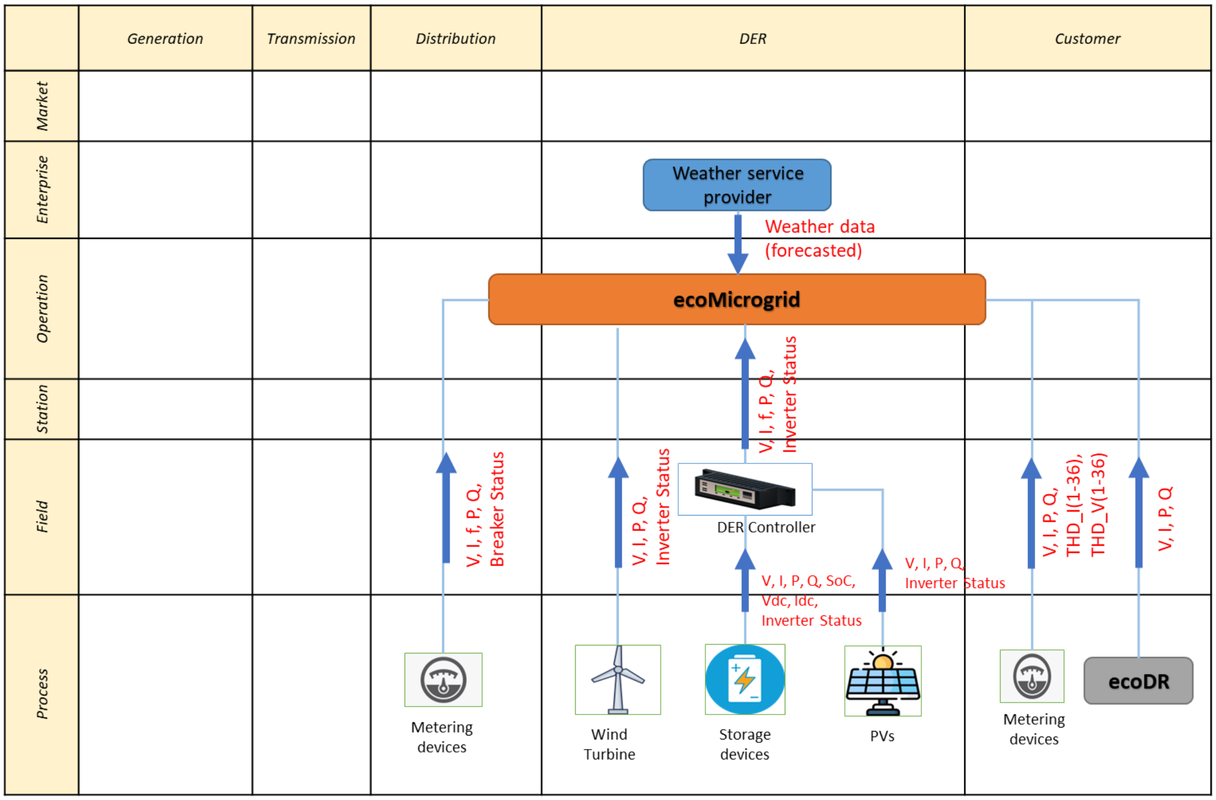


Figure 22 MG_2UC1.2 Information Layer

3.1.3 MG_2UC2.1 and MG_2UC2.2

3.1.3.1 Use Case Description

MG_2UC2.1: Effective communication with controllable assets

The objective of this UC is to ensure the effective communication and conveyance of commands to different controllable assets of a microgrid. The communication scheme, designed according to recommended/used protocols and standards for such applications (Modbus, DNP3, IEC 61850 series of standards), achieves interoperability between vendor-agnostic devices and enables secure and effective dispatch of commands to controllable assets.

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

Microgrid operation should exploit its assets in a way that financial and environmental objectives are met. This UC aims to evaluate, in real-time, the microgrid management functionality. Real-time measurements and estimation of future RES production/demand will be considered by a sophisticated algorithm to compute optimal commands for controllable loads, storage Units, RES Units and thermal generators. The functionality will be compared with existing microgrid operation policies to clarify its benefits in term of cost and RES exploitation.

3.1.3.2 SGAM Component Layer

3.1.3.2.1 Kythnos Demo site

The Component Layer for MG_2UC2.1 implemented at Kythnos demo-site describing the technology used for the interconnection between devices and the ecoTools, is depicted in the figure below.

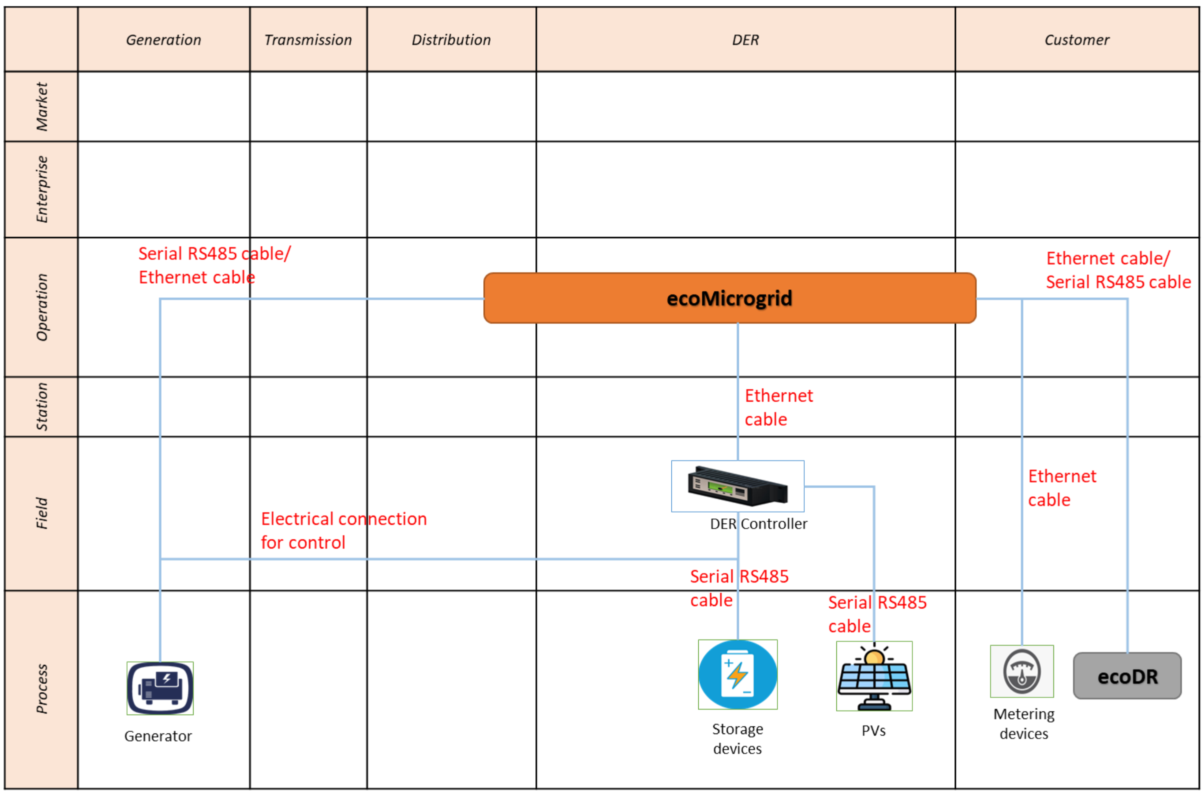


Figure 23 MG_2UC2.1 Component Layer for Kythnos demo-site

Table 15 List of Components MG_2UC2.1 for Kythnos demo-site

Component	Component Type
Generator	Device
Metering Devices	Device
Storage Devices	Device
PVs	Device
DER Controller	Device
ecoDR	ecoTool Application

ecoMicrogrid	ecoTool Application

3.1.3.2.2 Keonjhar Demo Site

The Component Layer for MG_2UC2.1 implemented at Keonjhar describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 24.

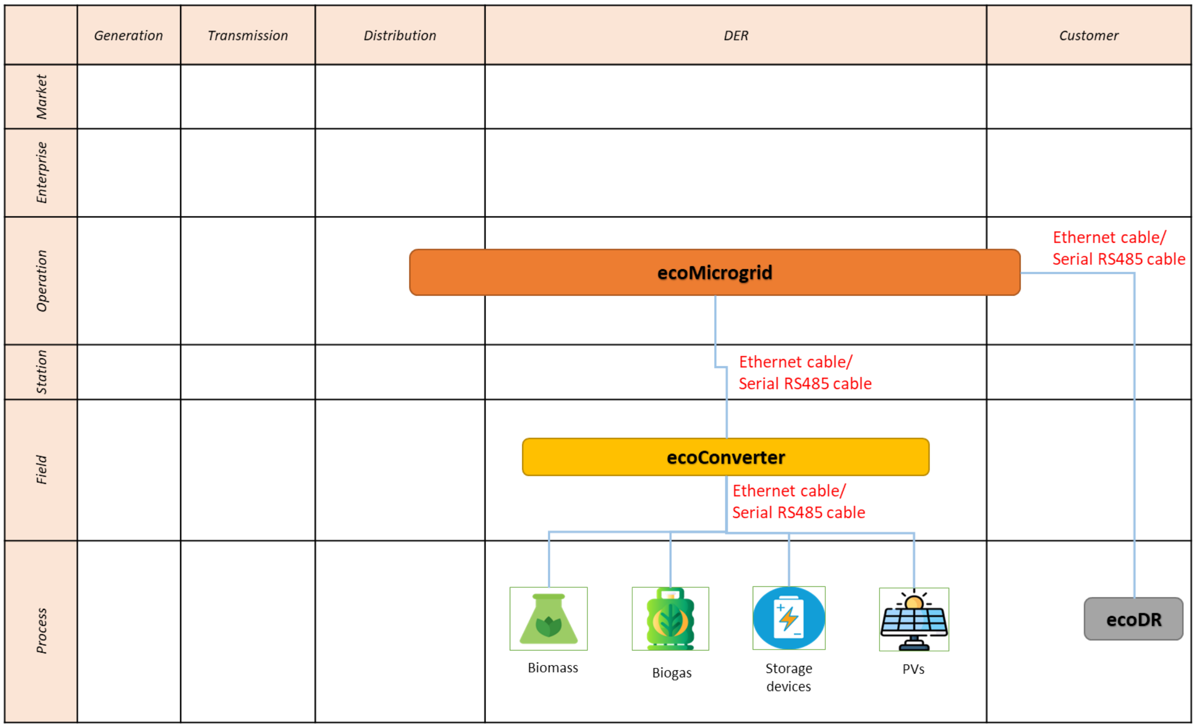


Figure 24 MG_2UC2.1 Component Layer for Keonjhar

Table 16 List of Components MG_2UC2.1 for Keonjhar

Component	Component Type
Biogas	Device
Biomass	Device
Storage Devices	Device
PVs	Device
ecoConverter	ecoTool Application
ecoMicrogrid	ecoTool Application
ecoDR	ecoTool Application

The same diagram is also applicable for the UC MG_2UC2.2.

3.1.3.2.3 Ghoramara Demo Site

The Component Layer for MG_2UC2.1 implemented at Ghoramara island describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 25.

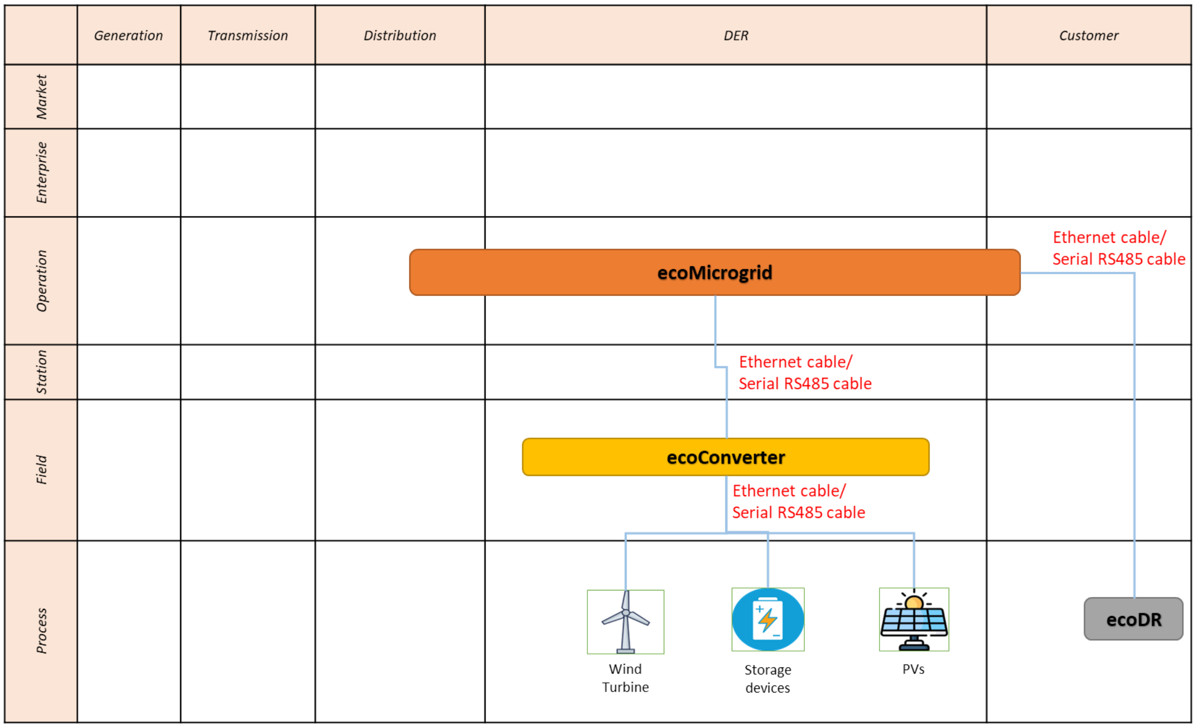


Figure 25 MG_2UC2.1 Component Layer for Ghoramara island

Table 17 List of Components MG_2UC2.1 for Ghoramara island

Component	Component Type
Wind Turbine	Device
Storage Devices	Device
PVs	Device
ecoDR	ecoTool Application
ecoMicrogrid	ecoTool Application
ecoConverter	ecoTool Application

The same diagram is also applicable for the UC MG_2UC2.2.

3.1.3.3 SGAM Communication Layer

3.1.3.3.1 Kythnos Demo site

The Communication Layer for MG_2UC2.1 implemented at Kythnos demo-site describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 26.

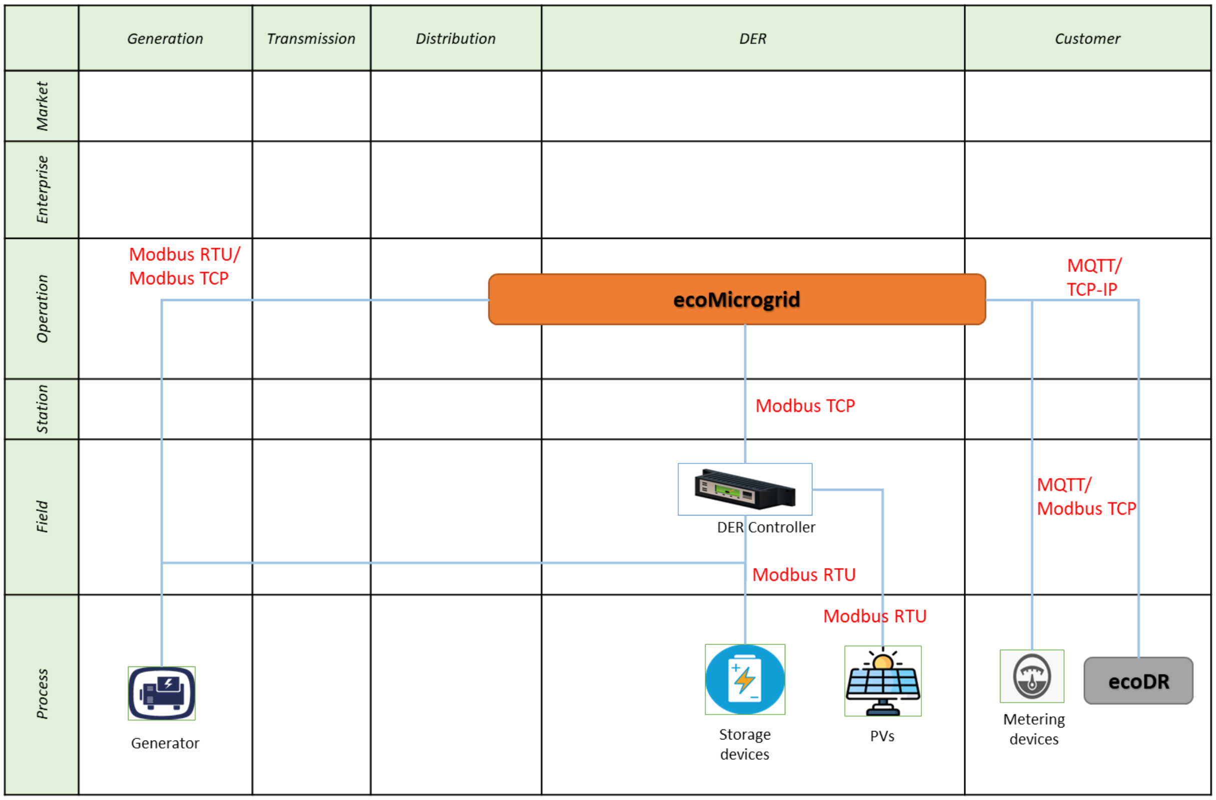


Figure 26 MG_2UC2.1 Communication Layer for Kythnos demo-site

Table 18 List of Communication technologies involved in MG_2UC2.1 for Kythnos demo-site

Component	Component Type
Modbus RTU/	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus RTU (Remote Terminal Unit) means that the Modbus protocol is used on top of a serial line with an RS-232, RS-485 or similar physical interface
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
TCP-IP	Transmission Control Protocol/Internet Protocol. Conceptual model and set of communication protocols used on the Internet. They provide end-to-end data communication, specifying how data should be packetized, addressed,

	transmitted, routed, and received, through four abstraction layers (link, internet, transport, and application)
Modbus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols

3.1.3.3.2 Keonjhar Demo Site

The communication Layer for MG_2UC2.1 implemented at Keonjhar describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 27.

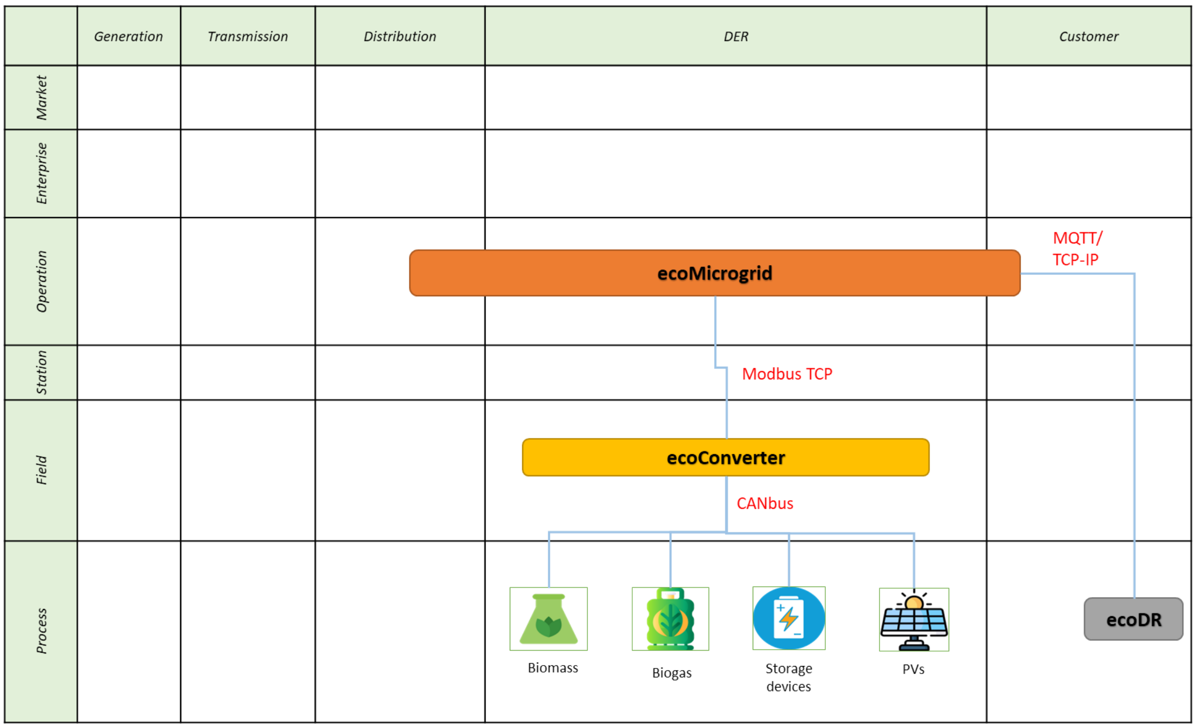


Figure 27 MG_2UC2.1 Communication Layer for Keonjhar

Table 19 List of Communication technologies involved in MG_2UC1.1 for Keonjhar

Component	Component Type
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
CAN bus	A Controller Area Network (CANbus) is a robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each other's applications without a host computer. It is a message-based protocol, designed originally for multiplex electrical wiring within automobiles to save on copper, but it can also be used in many other contexts

ModBus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols
TCP-IP	Transmission Control Protocol/Internet Protocol. Conceptual model and set of communication protocols used on the Internet. They provide end-to-end data communication, specifying how data should be packetized, addressed, transmitted, routed, and received, through four abstraction layers (link, internet, transport, and application)

The same diagram is also applicable for the UC MG_2UC2.2.

3.1.3.3.3 Ghoramara Demo Site

The Communication Layer for MG_2UC2.1 implemented at Ghoramara island describing the technology used for the communication between devices and the ecoTools, is depicted in Figure 28.

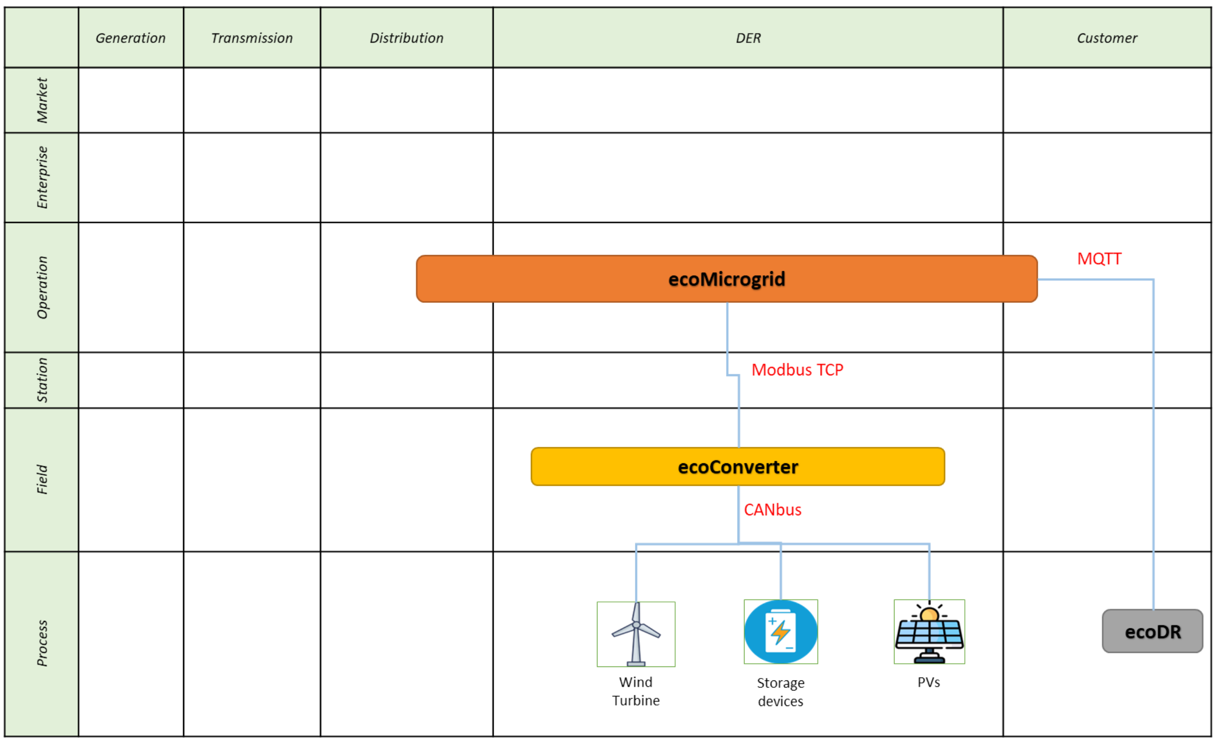


Figure 28 MG_2UC2.1 Communication Layer for Ghoramara island

Table 20 List of Communication technologies involved in MG_2UC2.1 for Ghoramara island

Component	Component Type
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required

CAN bus	A Controller Area Network (CANbus) is a robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each other's applications without a host computer. It is a message-based protocol, designed originally for multiplex electrical wiring within automobiles to save on copper, but it can also be used in many other contexts
ModBus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols

The same diagram is also applicable for the UC MG_2UC2.2.

3.1.3.4 SGAM Function Layer

3.1.3.4.1 Kythnos Demo site

The functional layer of MG_2UC2.1 implemented at Kythnos demo-site is presented in the graph below highlighting the key actors of the use case.

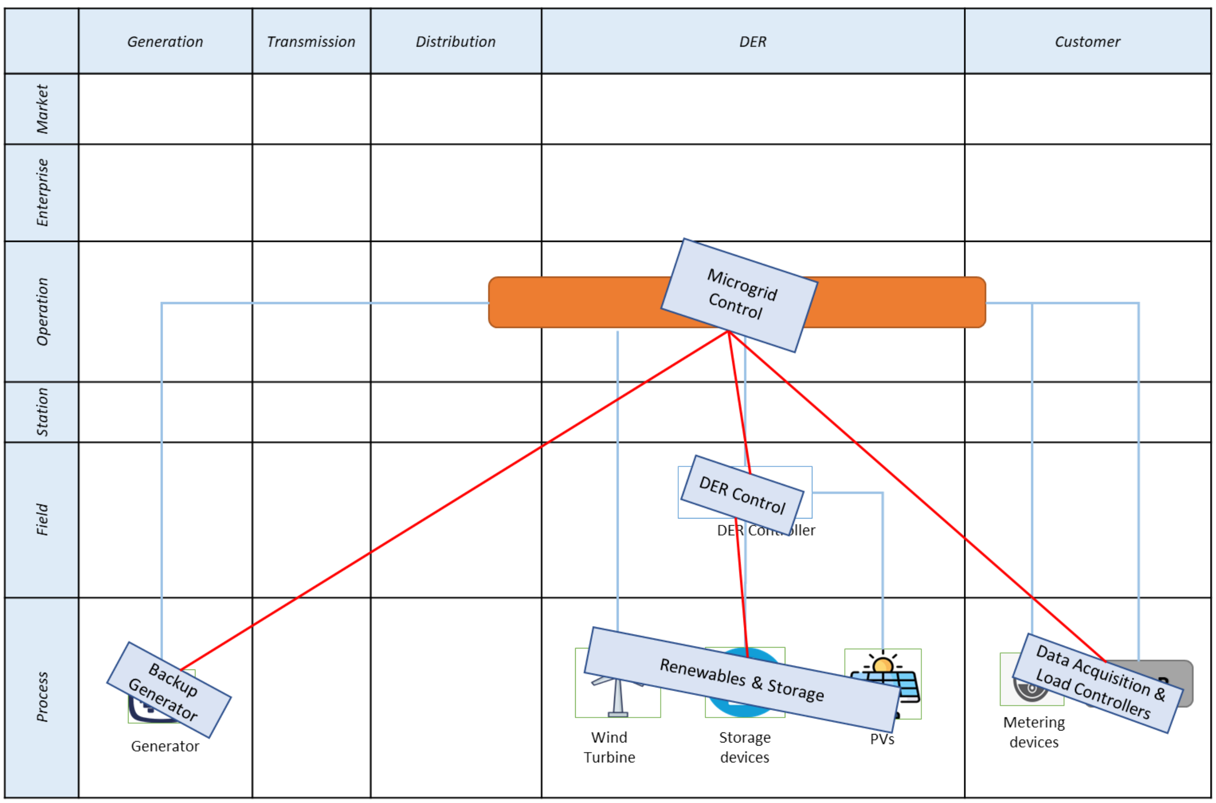


Figure 29 MG_2UC2.1 Function Layer for Kythnos demo-site

3.1.3.4.2 Keonjhar Demo Site

The functional layer of MG_2UC2.1 implemented at Keonjhar is presented in Figure 30, highlighting the key actors of the use case.

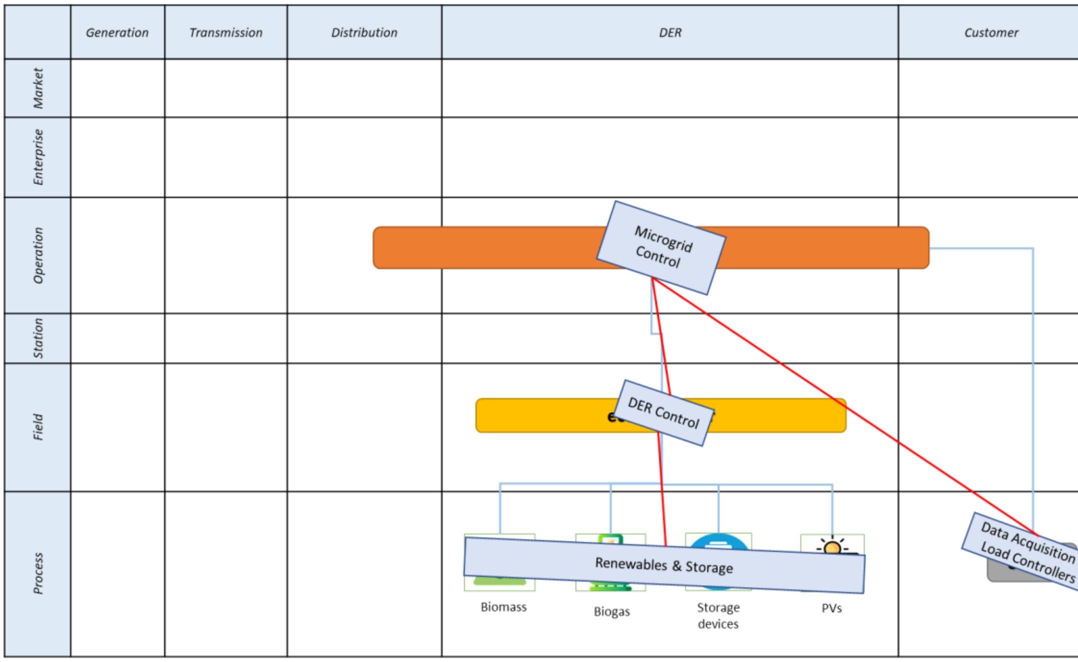


Figure 30 MG_2UC2.1 Function Layer for Keonjhar

The same diagram is also applicable for the UC MG_2UC2.2.

3.1.3.4.3 Ghoramara Island

The functional layer of MG_2UC2.1 implemented at Keonjhar is presented in Figure 31, highlighting the key actors of the use case.

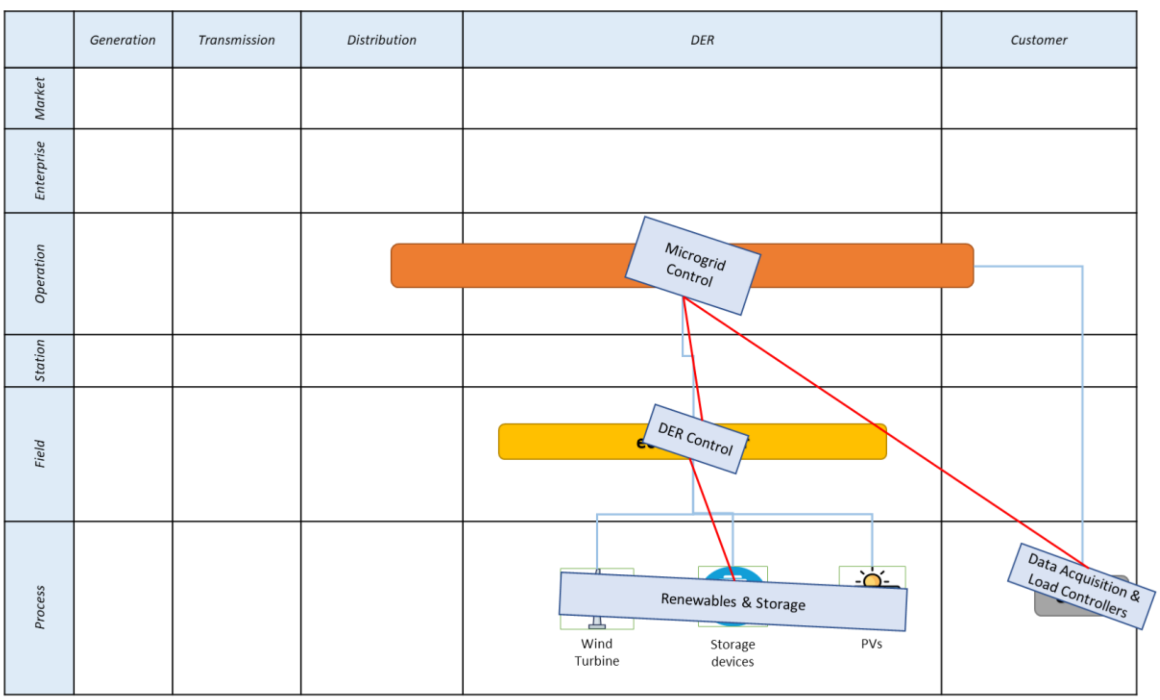


Figure 31 MG_2UC2.1 Function Layer for Ghoramara Island

The same diagram is also applicable for the UC MG_2UC2.2.

3.1.3.5 SGAM Information Layer

3.1.3.5.1 Kythnos Demo site

Details about information layer of MG_2UC2.1 are presented in Figure 32, highlighting the key information objects.

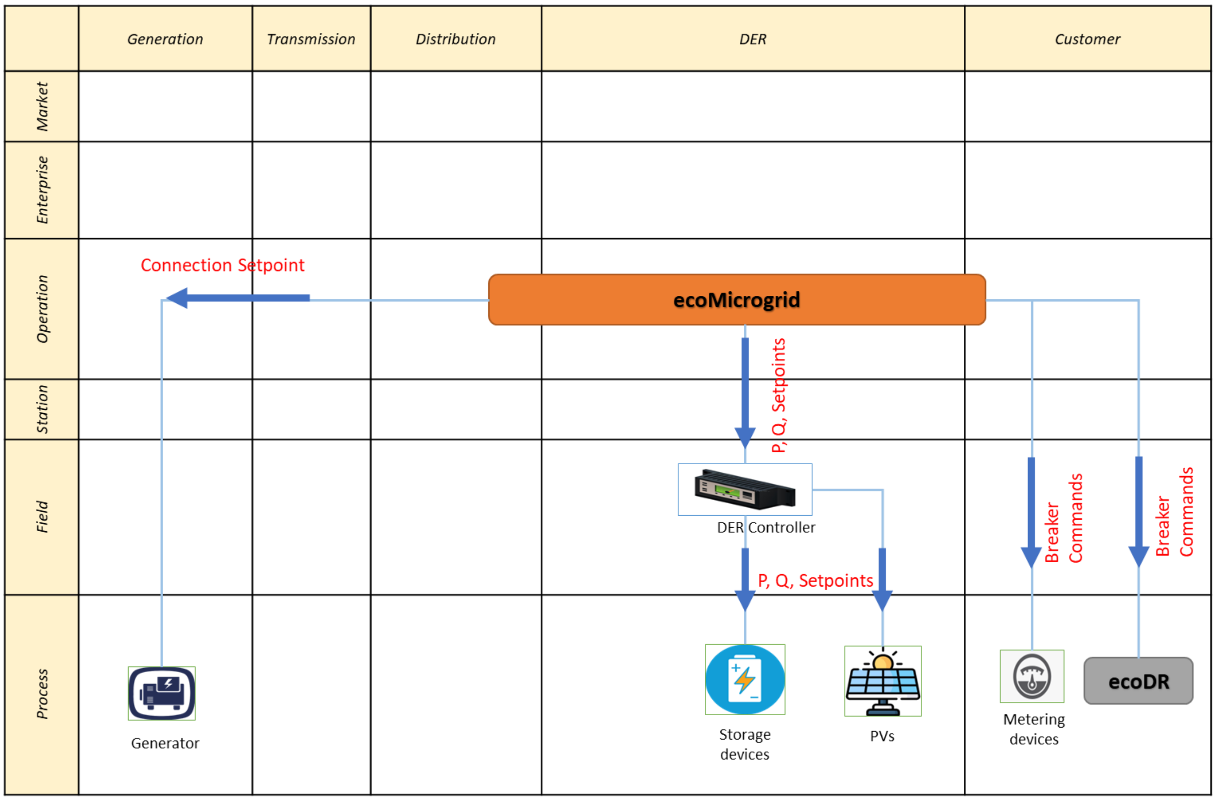


Figure 32 MG_2UC2.1 Information Layer for Kythnos demo-site

3.1.3.5.2 Keonjhar Demo Site

Details about information layer of MG_2UC2.1 are presented in Figure 33, highlighting the key information objects.

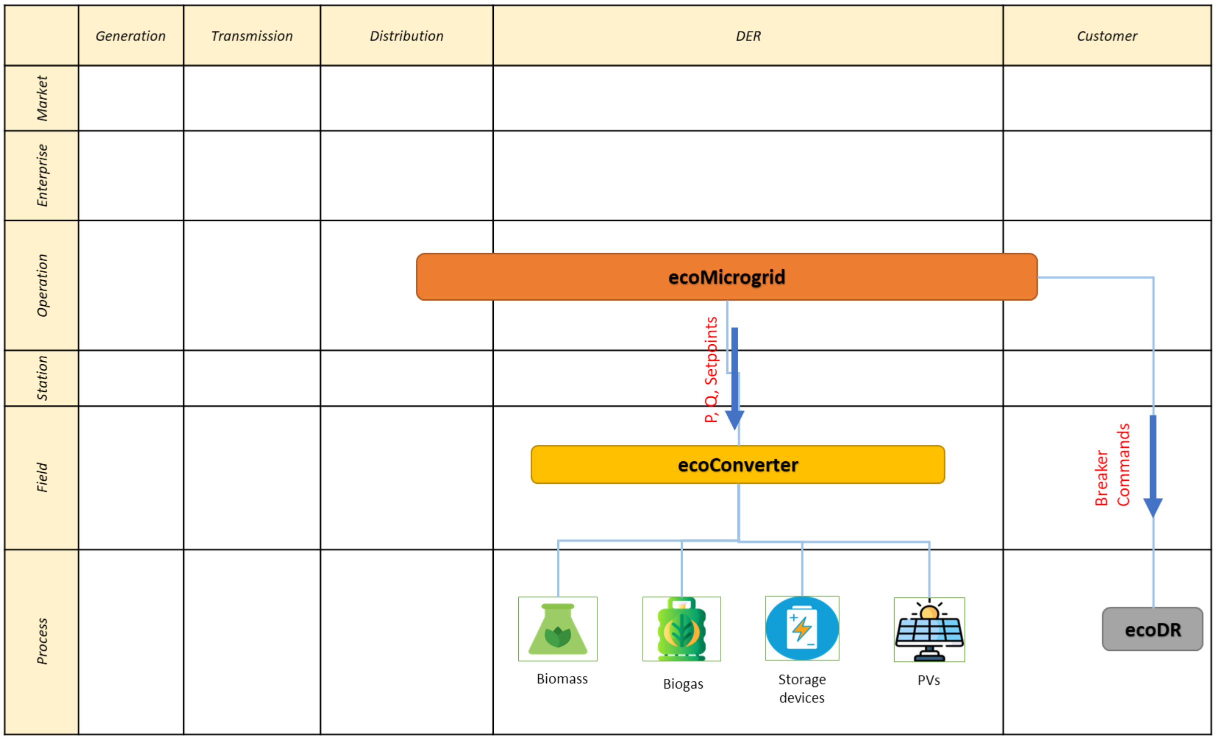


Figure 33 MG_2UC2.1 Information Layer for Keonjhar

The same diagram is also applicable for the UC MG_2UC2.2.

3.1.3.5.3 Ghoramara Island

Details about information layer of MG_2UC1.1 are presented in Figure 18, highlighting the key information objects.

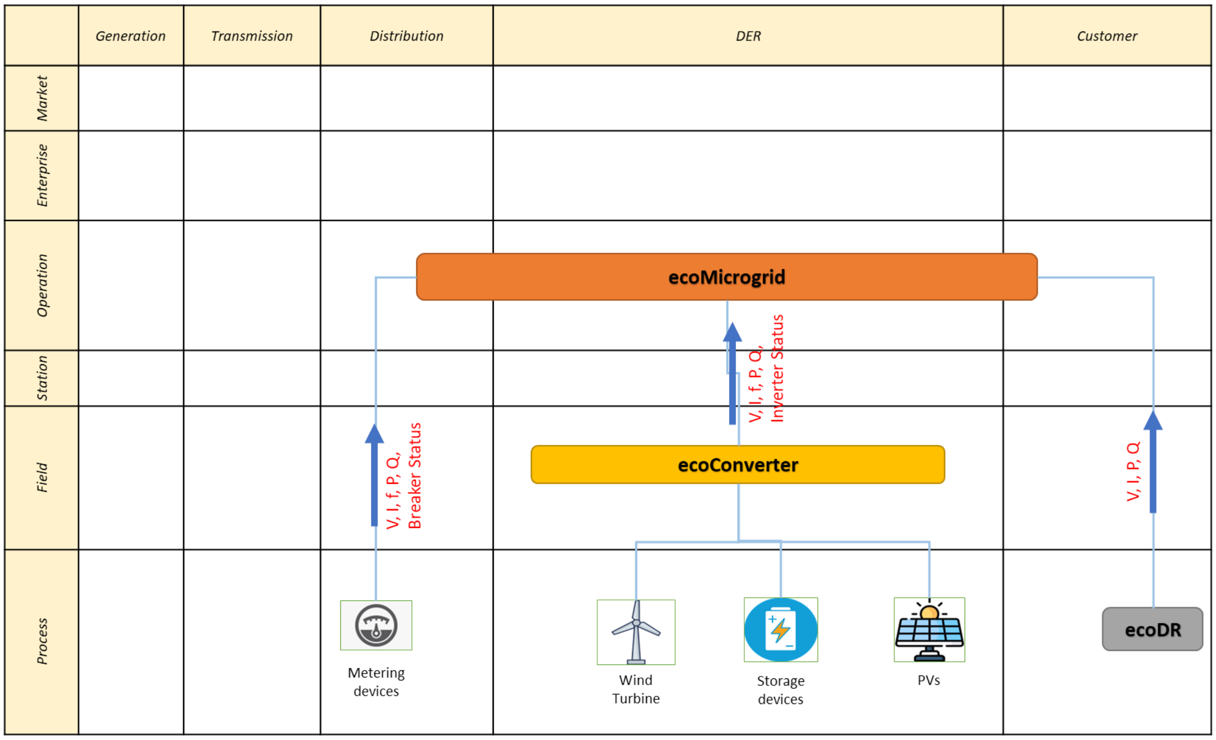


Figure 34 MG_2UC1.1 Information Layer for Ghoramara Island

The same diagram is also applicable for the UC MG_2UC2.2.

3.2 ecoEMS

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

3.2.1.1 Use Case Description

A variety of measurements are necessary for the sufficient data acquisition concerning EMS operation, as well as static technical data for each asset. It is highly important for the measurements and to be reliably, securely, and effectively transmitted from the SCADA to the database (preferably a MSSQL database), via which the data are used by the Energy Management System. Static data also need to be reliable and cross-checked and should not be altered if any actual change does not take place. Communication protocols are an important issue due to the necessity to integrate different vendors. The objective of this UC is to ensure the effective development and implementation of the on-line data transferring and near real-time monitoring system for the EMS performance overview.

3.2.1.2 SGAM Component Layer

3.2.1.2.1 Kythnos island

The Component Layer for EMS_2UC1.1 implemented at Kythnos demo-site describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 35.

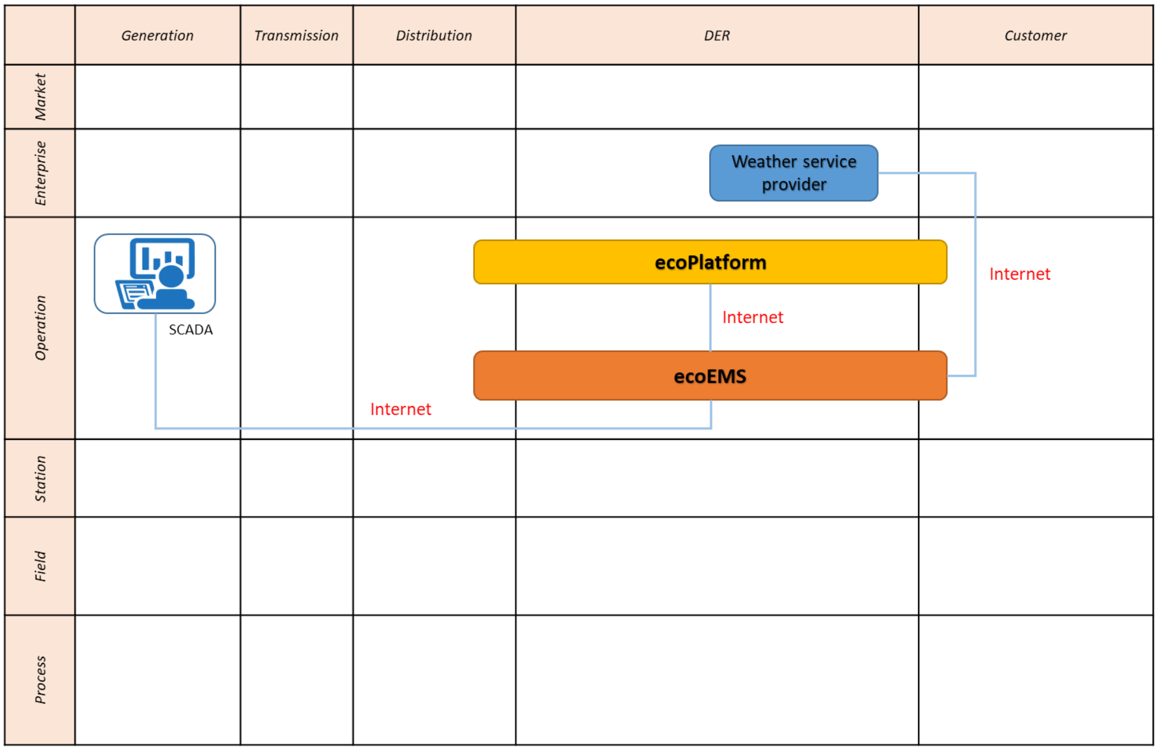


Figure 35 EMS_2UC1.1 Component Layer for Kythnos demo-site

Table 21 List of Components EMS_2UC1.1 for Kythnos demo-site

Component	Component Type
SCADA	Device
Weather service provider	Organization
ecoPlatform	ecoTool Application
ecoEMS	ecoTool Application

3.2.1.2.2 Bornholm island

The Component Layer for EMS_2UC1.1 implemented at Bornholm island describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 36.

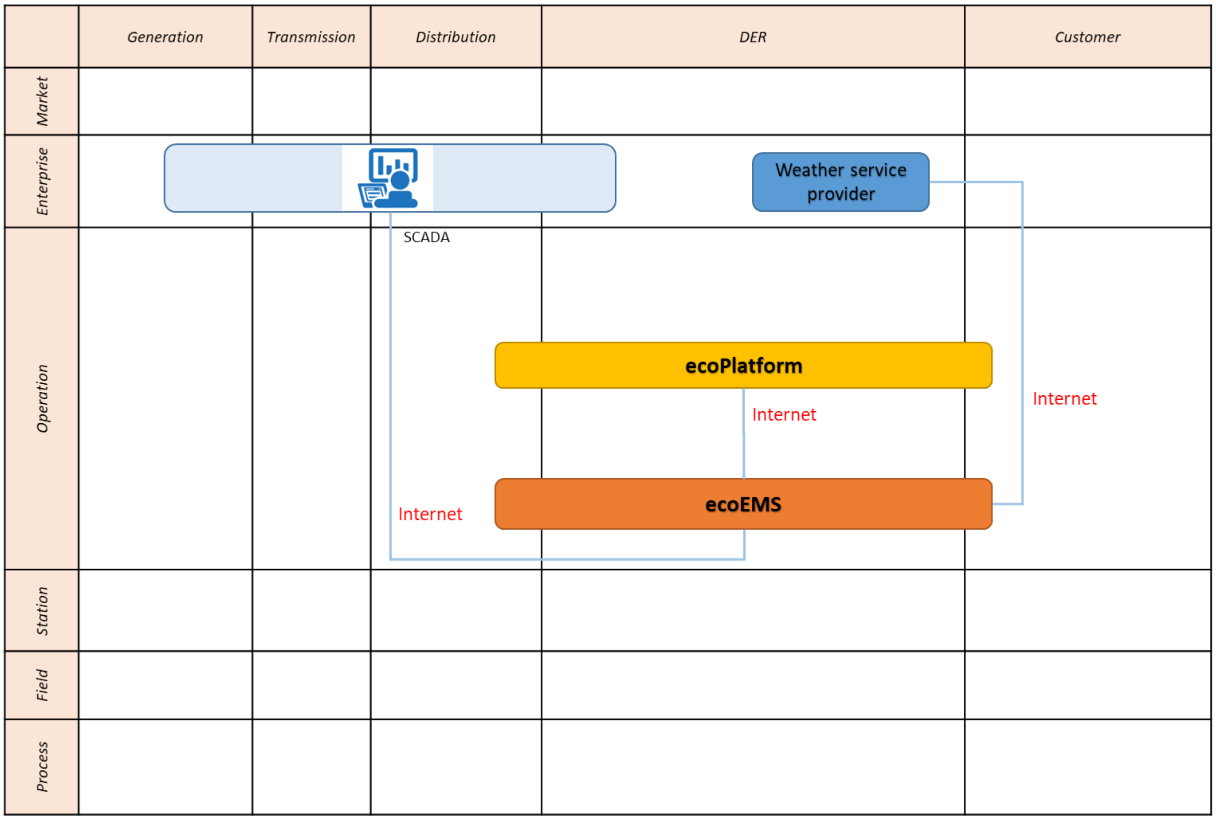


Figure 36 EMS_2UC1.1 Component Layer for Bornholm island

Table 22 List of Components EMS_2UC1.1 for Bornholm island

Component	Component Type
SCADA	Device
Weather service provider	Organization
ecoPlatform	ecoTool Application
ecoEMS	ecoTool Application

3.2.1.3 SGAM Communication Layer

3.2.1.3.1 Kythnos Demo Site

The communication Layer for EMS_2UC1.1 implemented at Kythnos demo-site describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 37.

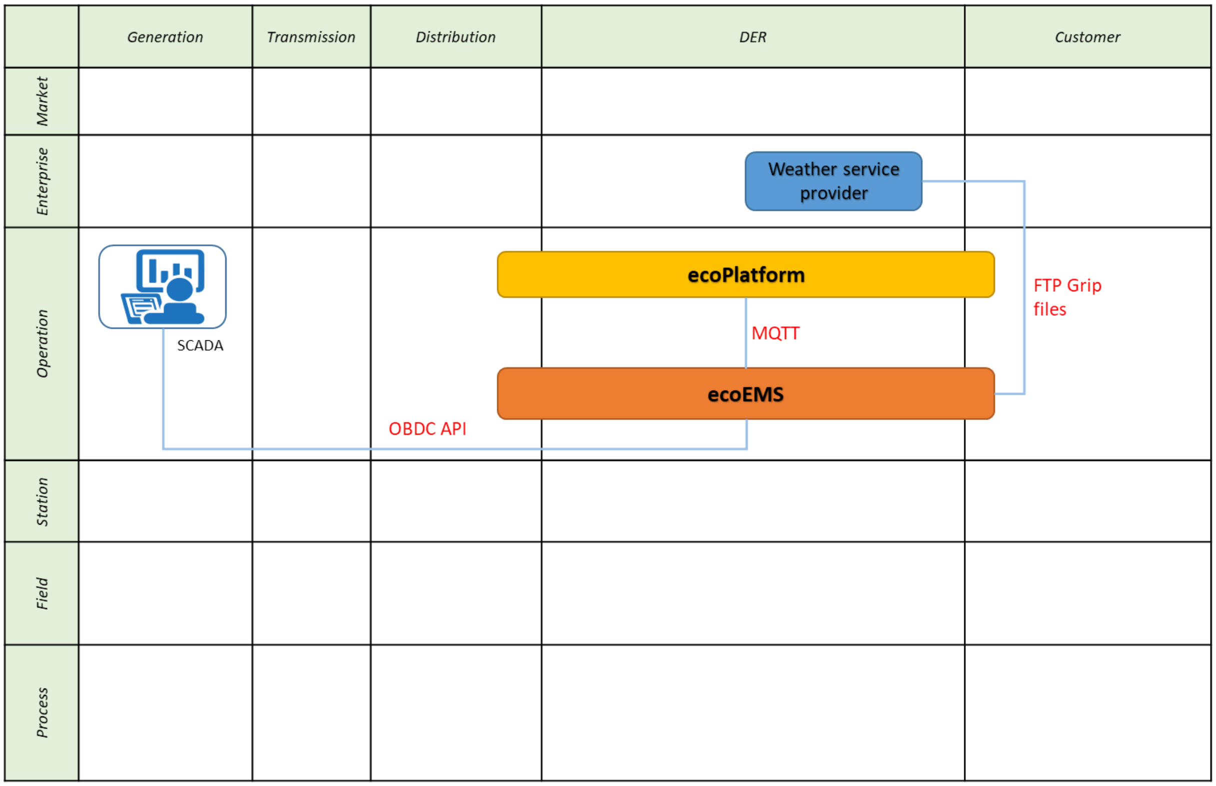


Figure 37 EMS_2UC1.1 Communication Layer for Kythnos demo-site

Table 23 List of Communication technologies involved in EMS_2UC1.1 for Kythnos demo-site

Component	Component Type
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
ODBC API	Open Database Connectivity (ODBC) is an open standard Application Programming Interface (API) for accessing a database.
FTP Grip files	The File Transfer Protocol (FTP) is a standard communication protocol used for the transfer of computer files from a server to a client on a computer network. FTP is built on a client–server model architecture using separate control and data connections between the client and the server.

3.2.1.3.2 Bornholm Demo site

The communication Layer for EMS_2UC1.1 implemented at Bornholm island describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 38.

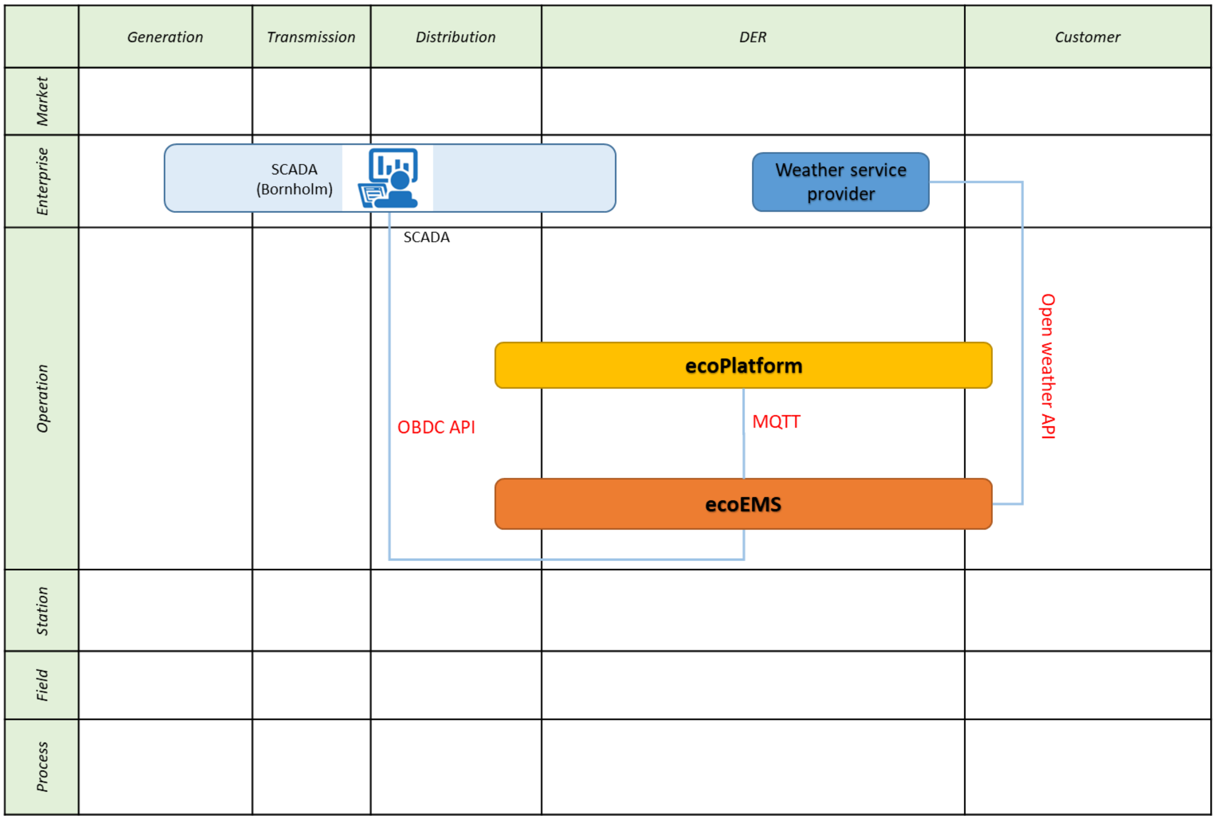


Figure 38 EMS_2UC1.1 Communication Layer for Bornholm island

Table 24 List of Communication technologies involved in EMS_2UC1.1 for Bornholm island

Component	Component Type
Open Weather API	OpenWeatherMap is an online service, that provides global weather data via API, including current weather data, forecasts, nowcasts and historical weather data for any geographical location. It provides a minute-by-minute hyperlocal precipitation forecast for any location
OBDC API	Open Database Connectivity (ODBC) is an open standard Application Programming Interface (API) for accessing a database
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required

3.2.1.4 SGAM Function Layer

3.2.1.4.1 Kythnos Demo site

The functional layer of EMS_2UC1.1 implemented at Kythnos demo-site is presented in the graph below highlighting the key actors of the use case.

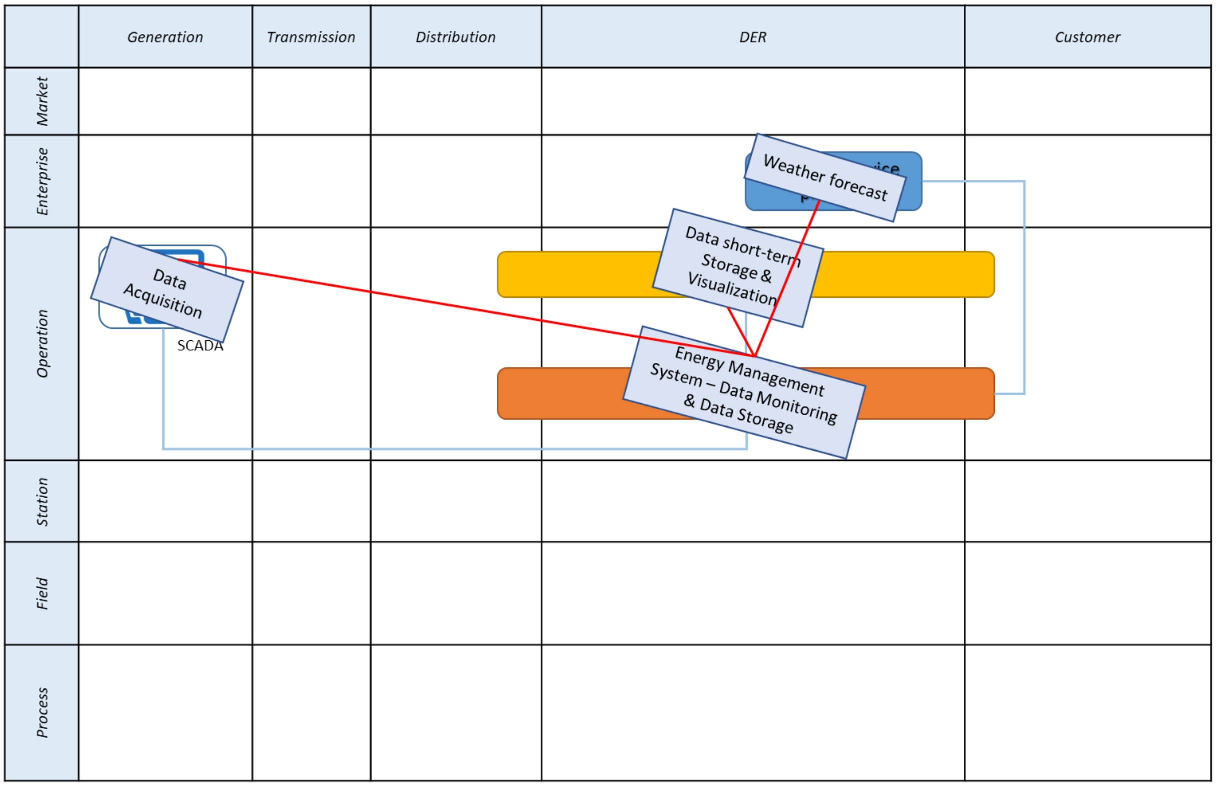


Figure 39 EMS_2UC1.1 Function Layer for Kythnos demo-site

3.2.1.4.2 Borhnolm Demo Site

The functional layer of EMS_2UC1.1 implemented at Bornholm island is presented in Figure 40, highlighting the key actors of the use case.

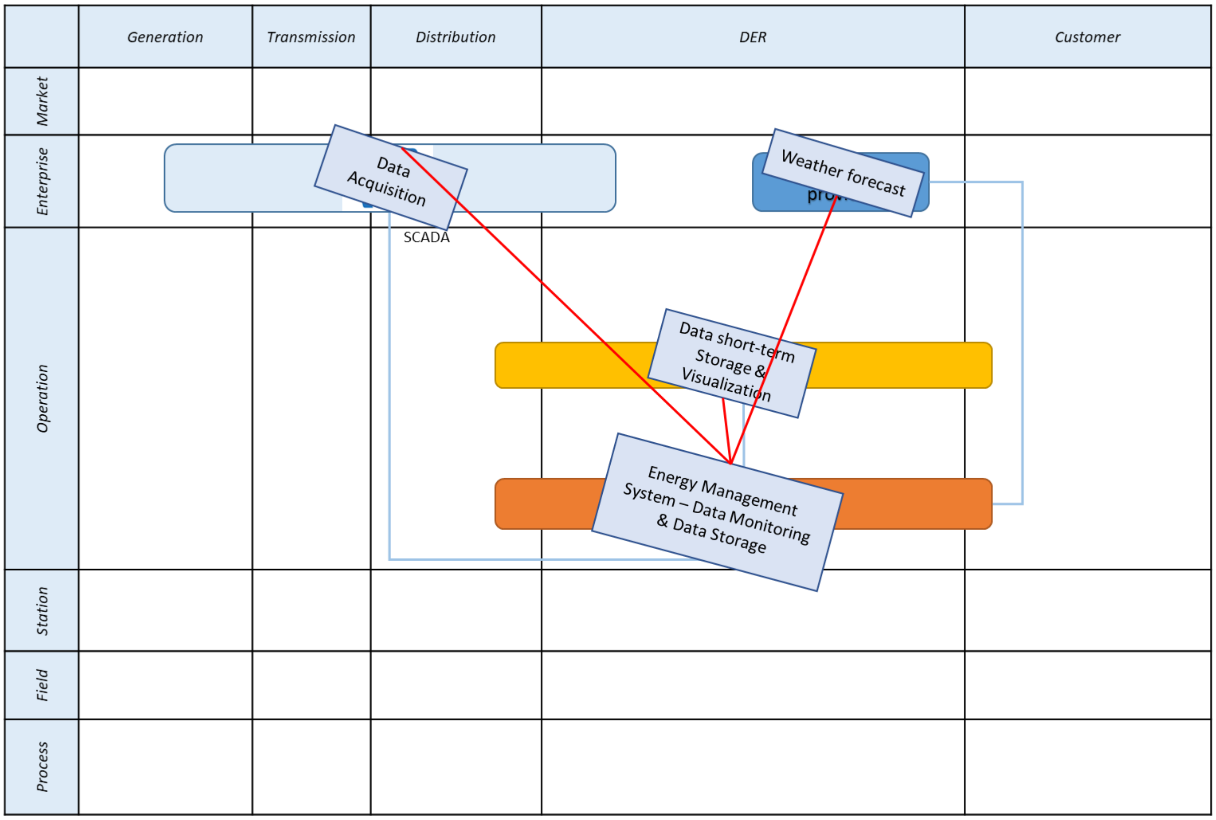


Figure 40 EMS_2UC1.1 Function Layer for Bornholm Island

3.2.1.5 SGAM Information Layer

3.2.1.5.1 Kythnos Demo site

Details about information layer of EMS_2UC1.1 are presented in Figure 41, highlighting the key information objects.

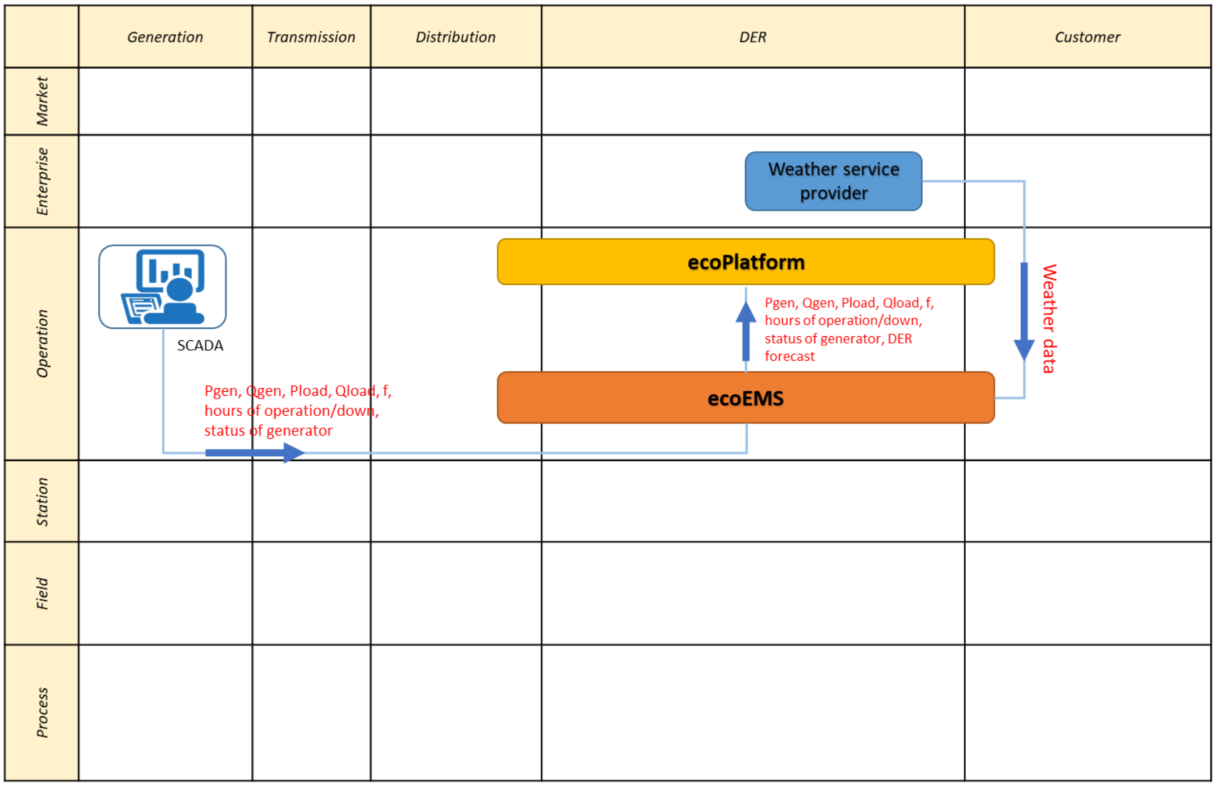


Figure 41 EMS_2UC1.1 Information Layer for Kythnos demo-site

3.2.1.5.2 Bornholm Demo Site

Details about information layer of EMS_2UC1.1 are presented in Figure 42, highlighting the key information objects.

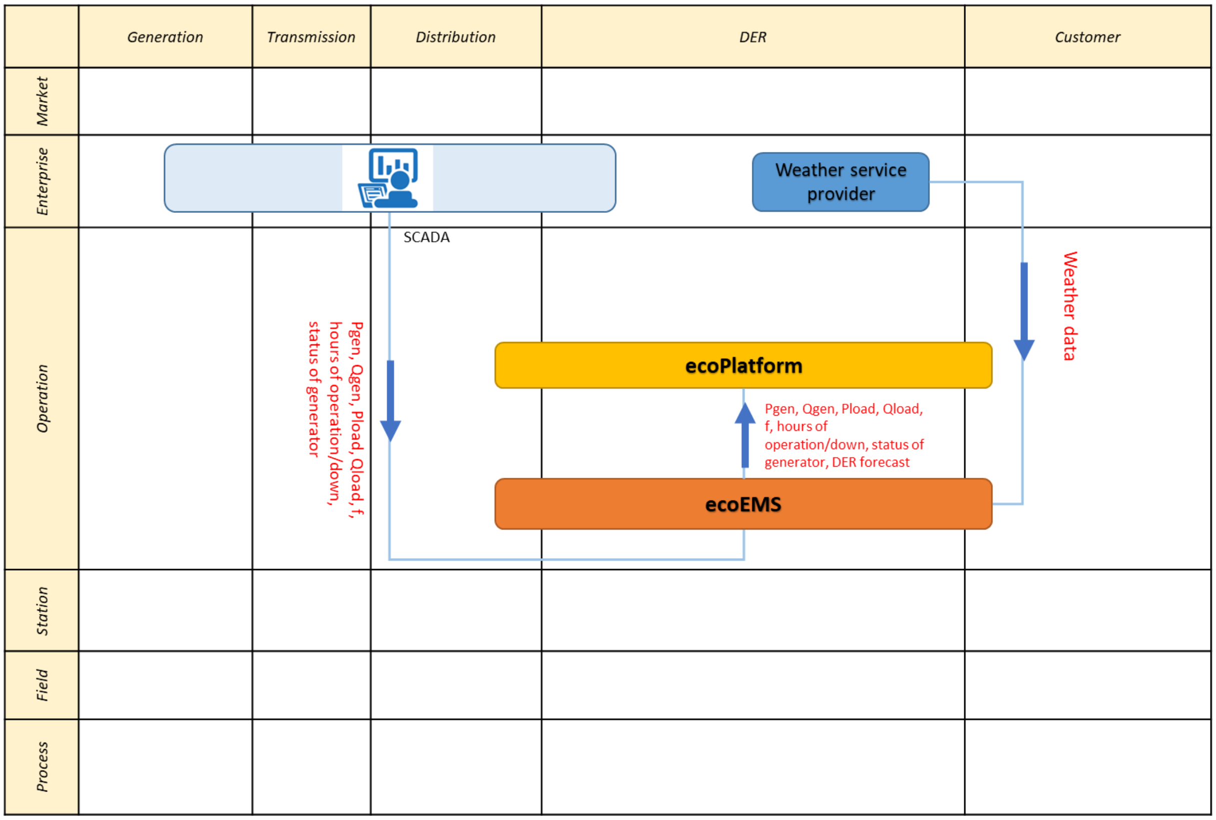


Figure 42 EMS_2UC1.1 Information Layer for Bornholm Island

3.2.2 EMS_2UC2.3 Unit Commitment and Economic Dispatch algorithms

3.2.2.1 Use Case Description

This UC addresses resources management, e.g. dispatchable loads, storage Units, RES Units, thermal generators, are being committed to primarily satisfy the energy balance constraint, based on the load forecast, aiming to achieve various goals such us the cost minimization, increased RES utilization, etc. To this end, the ecoEMS module should be able to run simulations under hyper-parameter definition, after communicating with other services, such as RES and Load forecast services, and then execute the optimization algorithm to calculate the optimal unit commitment. Those dispatch orders are sent to the various system assets. Economic Dispatch algorithm, is following the Unit Commitment, executed time-closer to the dispatch hour, with larger time granularity, quarter hour time step, producing redispatch orders.

3.2.2.2 SGAM Component Layer

3.2.2.2.1 Kythnos Island

The Component Layer for EMS_2UC2.3 implemented at Kythnos demo-site describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 43.

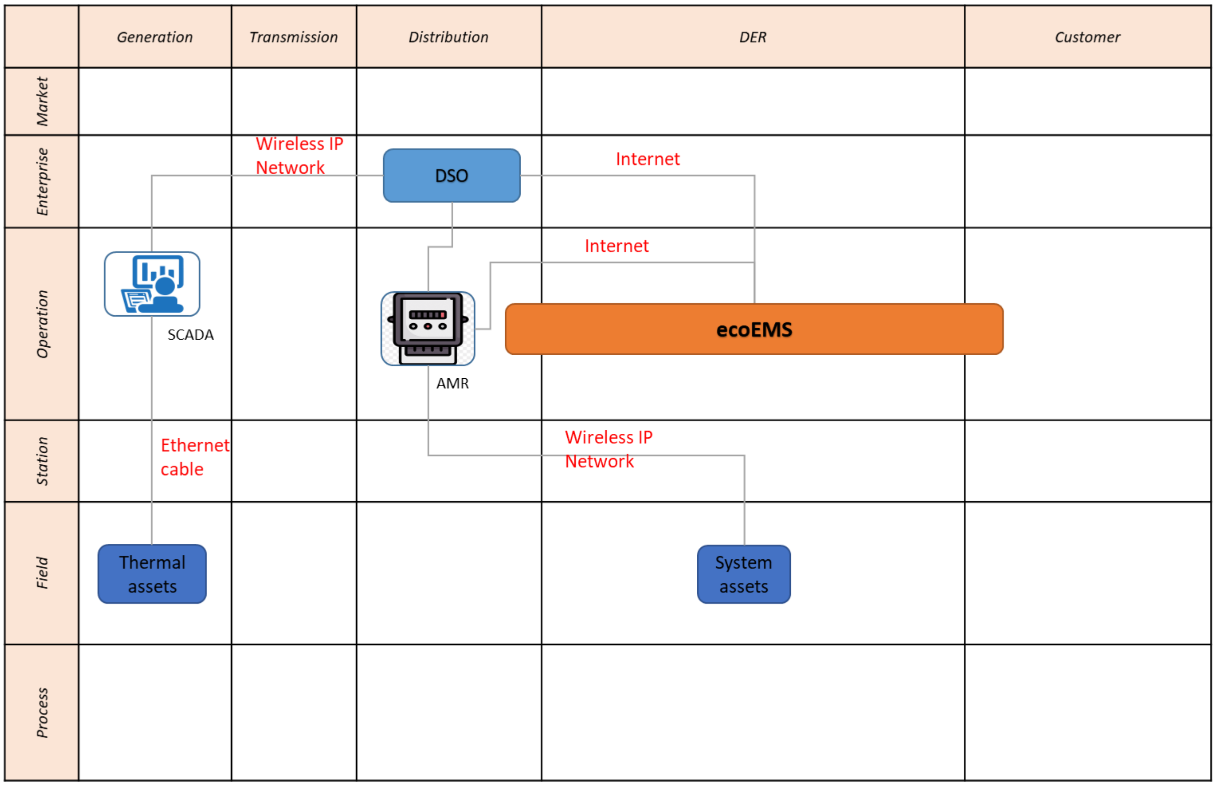


Figure 43 EMS_2UC2.3 Component Layer for Kythnos demo-site

Table 25 List of Components EMS_2UC2.3 for Kythnos island

Component	Component Type
SCADA	Device
System Assets	Device
DSO	Organization
ecoEMS	ecoTool Application
AMR	Device
Thermal Assets	Device

3.2.2.2.2 Bornholm island

The Component Layer for EMS_2UC2.3 implemented at Bornholm island describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 44.

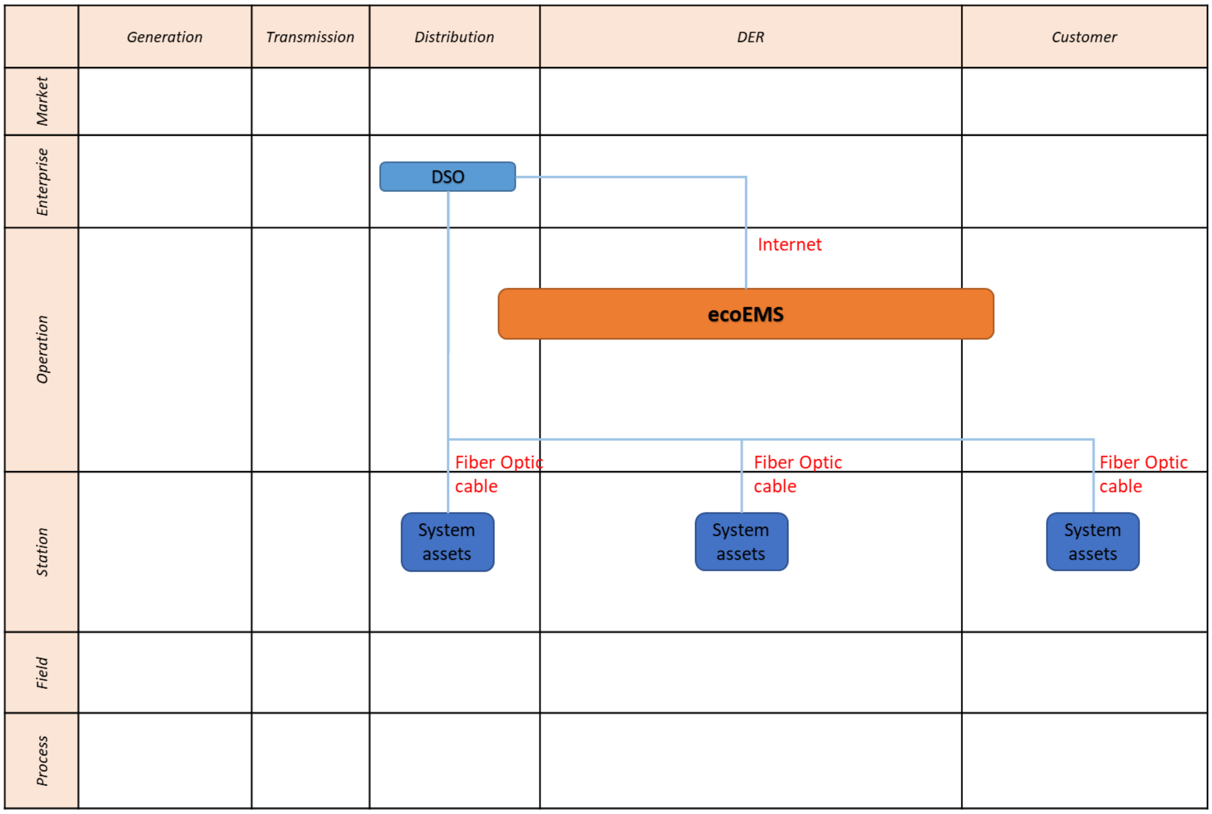


Figure 44 EMS_2UC2.3 Component Layer for Bornholm island

Table 26 List of Components EMS_2UC2.3 for Bornholm island

Component	Component Type
DSO	Organization
System Assets	Device
ecoEMS	ecoTool Application

3.2.2.3 SGAM Communication Layer

3.2.2.3.1 Kythnos Demo Site

The communication Layer for EMS_2UC2.3 implemented at Kythnos demo-site describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 45.

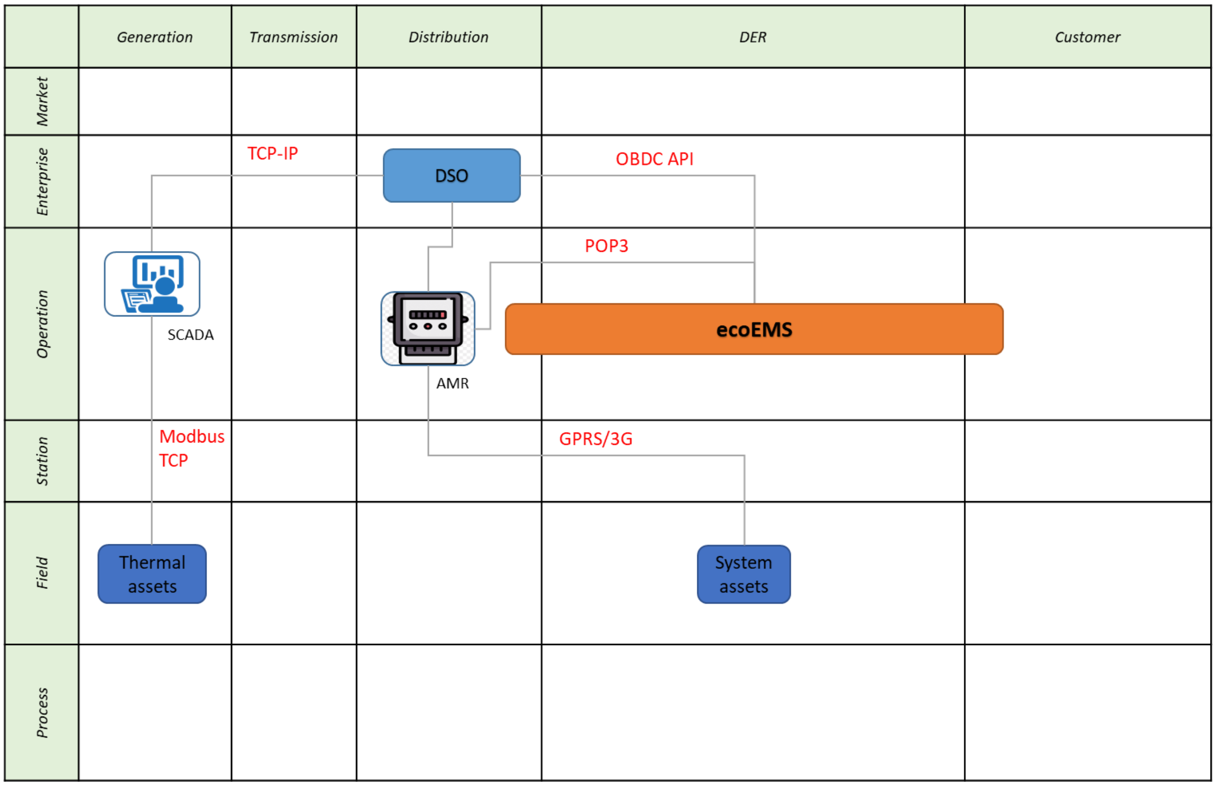


Figure 45 EMS_2UC2.3 Communication Layer for Kythnos demo-site

Table 27 List of Communication technologies involved in EMS_2UC2.3 for Kythnos demo-site

Component	Component Type
Modbus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols
TCP/IP	Transmission Control Protocol/Internet Protocol. Conceptual model and set of communication protocols used on the Internet. They provide end-to-end data communication, specifying how data should be packetized, addressed, transmitted, routed, and received, through four abstraction layers (link, internet, transport, and application)
ODBC API	Open Database Connectivity (ODBC) is an open standard Application Programming Interface (API) for accessing a database

GPRS/3G	General Packet Radio Service (GPRS) is a packet oriented mobile data standard on the 2G and 3G cellular communication network's global system for mobile communications (GSM)
POP3	Post Office Protocol version 3. An application-layer Internet standard protocol used by e-mail clients to retrieve e-mail from a mail server

3.2.2.3.2 Bornholm Demo site

The communication Layer for EMS_2UC2.3 implemented at Bornholm island describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 46.

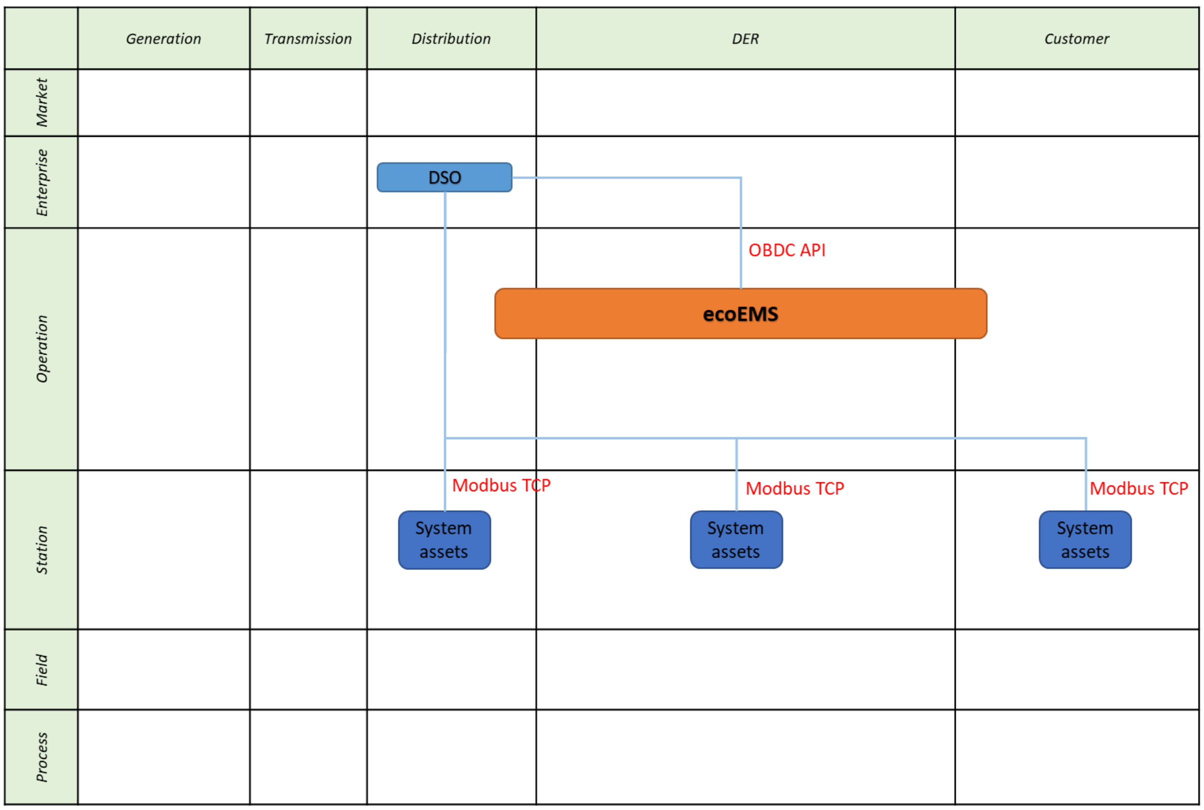


Figure 46 EMS_2UC2.3 Communication Layer for Bornholm island

Table 28 List of Communication technologies involved in EMS_2UC2.3 for Bornholm island

Component	Component Type
Modbus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols
OBDC API	Open Database Connectivity (ODBC) is an open standard Application Programming Interface (API) for accessing a database

3.2.2.4 SGAM Function Layer

3.2.2.4.1 Kythnos Demo site

The functional layer of EMS_2UC2.3 implemented at Kythnos demo-site is presented in the graph below highlighting the key actors of the use case.

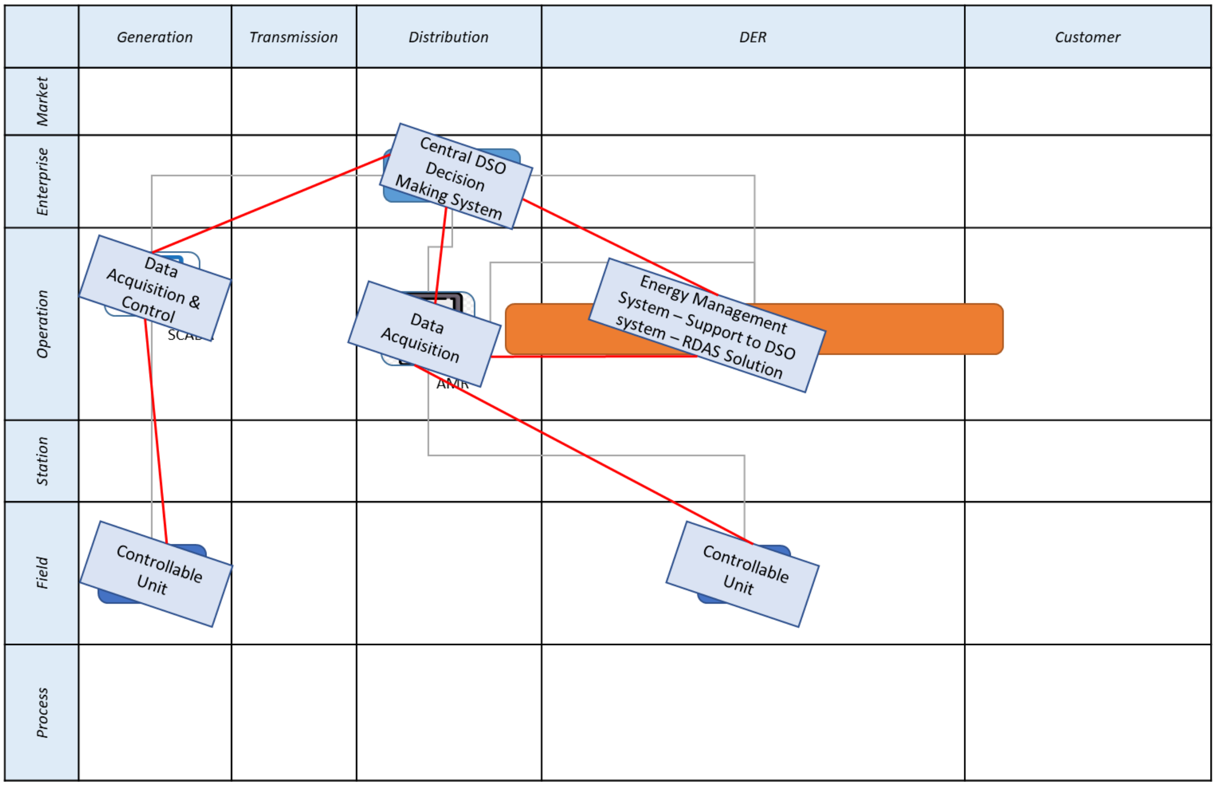


Figure 47 EMS_2UC2.3 Function Layer for Kythnos demo-site

3.2.2.4.2 Borhnolm Demo Site

The functional layer of EMS_2UC2.3 implemented at Bornholm island is presented in Figure 48, highlighting the key actors of the use case.

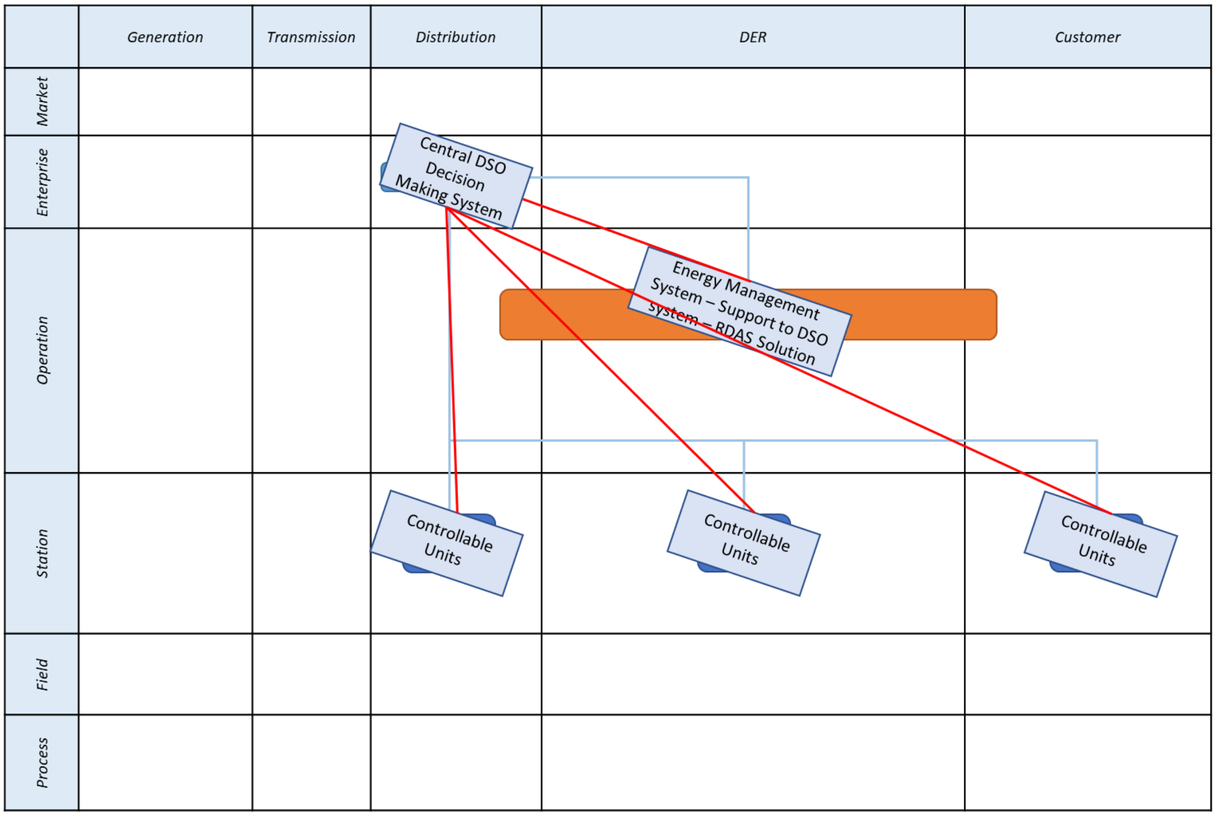


Figure 48 EMS_2UC2.3 Function Layer for Bornholm Island

3.2.2.5 SGAM Information Layer

3.2.2.5.1 Kythnos Demo site

Details about information layer of EMS_2UC2.3 are presented in Figure 49, highlighting the key information objects.

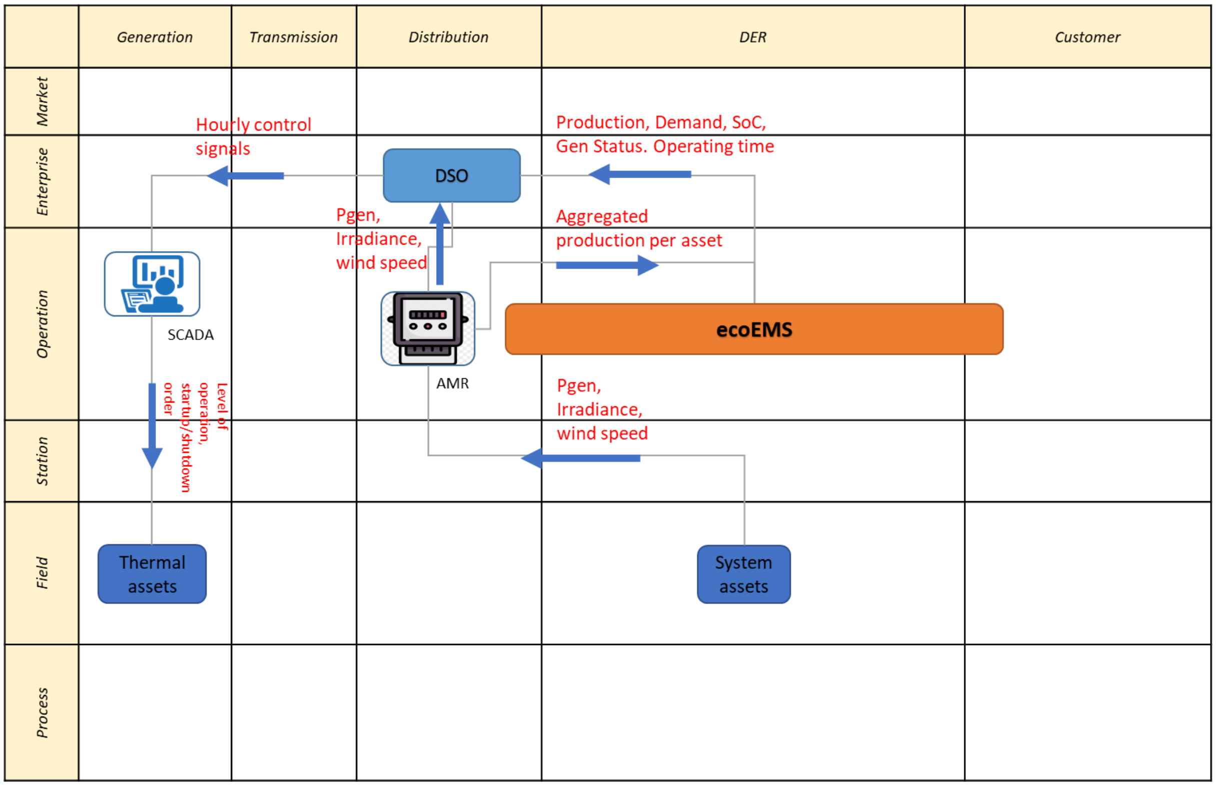


Figure 49 EMS_2UC2.3 Information Layer for Kythnos demo-site

3.2.2.5.2 Bornholm Demo Site

Details about information layer of EMS_2UC2.3 are presented in Figure 50, highlighting the key information objects.

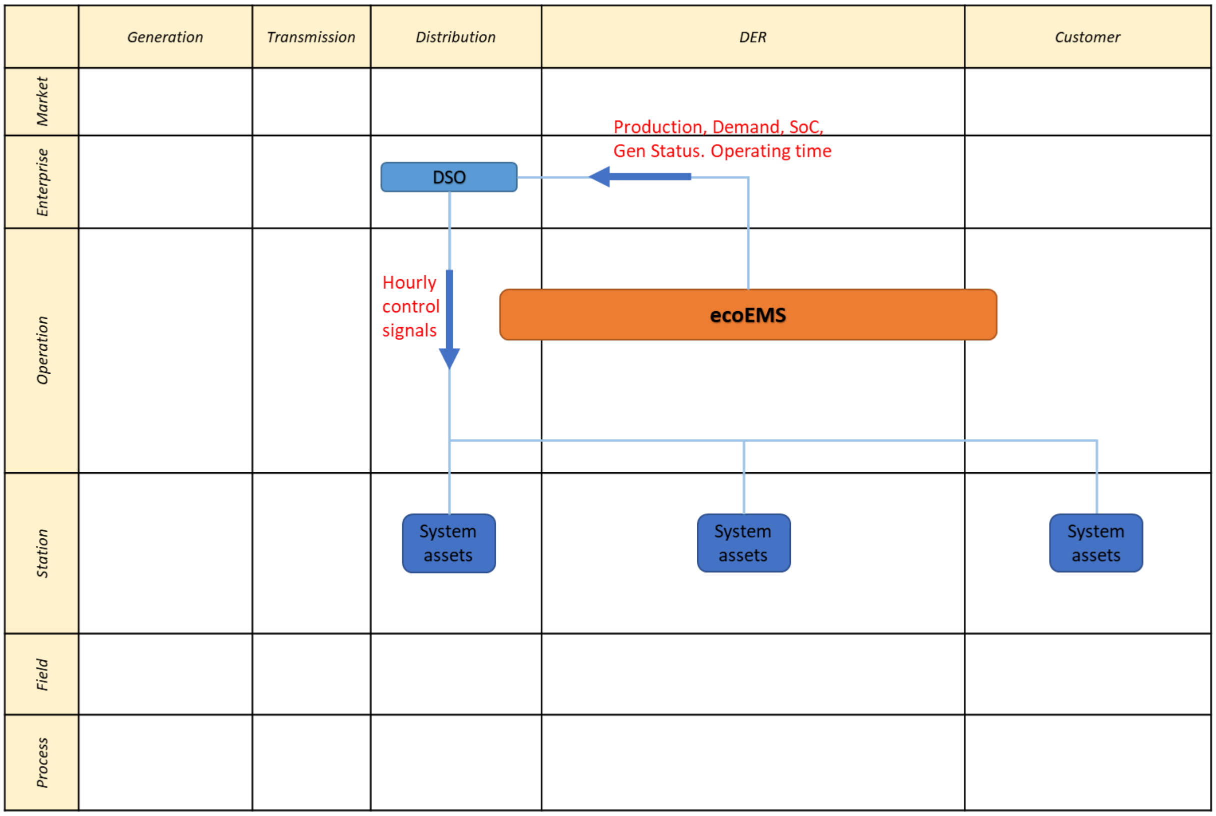


Figure 50 EMS_2UC2.3 Information Layer for Bornholm Island

3.3 ecoPlanning

3.3.1 PN_2UC1.2, PN_2UC2.1, PN_2UC3.1 & PN_2UC4.2

3.3.1.1 Use Case Description

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

In this UC, firstly a forecast/estimation must be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC1.2, and any new designed generation units and general system parameters, an Electrical System model is designed. Afterwards, with a selected load curve, and past system data concerning the peak and demand, an estimation is made through a series of statistical processes for the peak and demand of the next 7 years, and the selected load curve is appropriately adjusted, and saved as a Demand/Peak model. Both models are stored in a .json format in the database.

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

In this 2UC, firstly a forecast/estimation must be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC2.1, and any new designed generation units and general system parameters, an Electrical System model is designed. Afterwards, with a selected load curve, and past system data concerning the peak and demand, an estimation is made through a series of statistical processes for the peak and demand of the next 7 years, and the selected load curve is appropriately adjusted, and saved as a Demand/Peak model. Both models are stored in a .json format in the database.

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

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

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

In this 2UC, firstly a forecast/estimation must be made concerning the WFs and PVs generation in a normalized format. Combining these RES forecasts, along with the data stored in 2UC4.1, and any new designed generation units and general system parameters, an Electrical System model is designed. The impact of energy carriers (DSM, cooling, etc) is being quantified in MWh and incorporated in the electrical system load. Afterwards, with the adjusted load curve, past system data concerning the peak and demand, an estimation can be made through a series of statistical processes for the peak and demand of the next 7 years, and saved as a Demand/Peak model, or with the direct use of the adjusted system load timeseries. Both models are stored in a .json format in the database.

For all the above-mentioned UCs, the same SGAM Layer diagrams are applicable.

3.3.1.2 SGAM Component Layer

3.3.1.2.1 Kythnos Demo site

The Component Layer for PN_2UC tools describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 51.

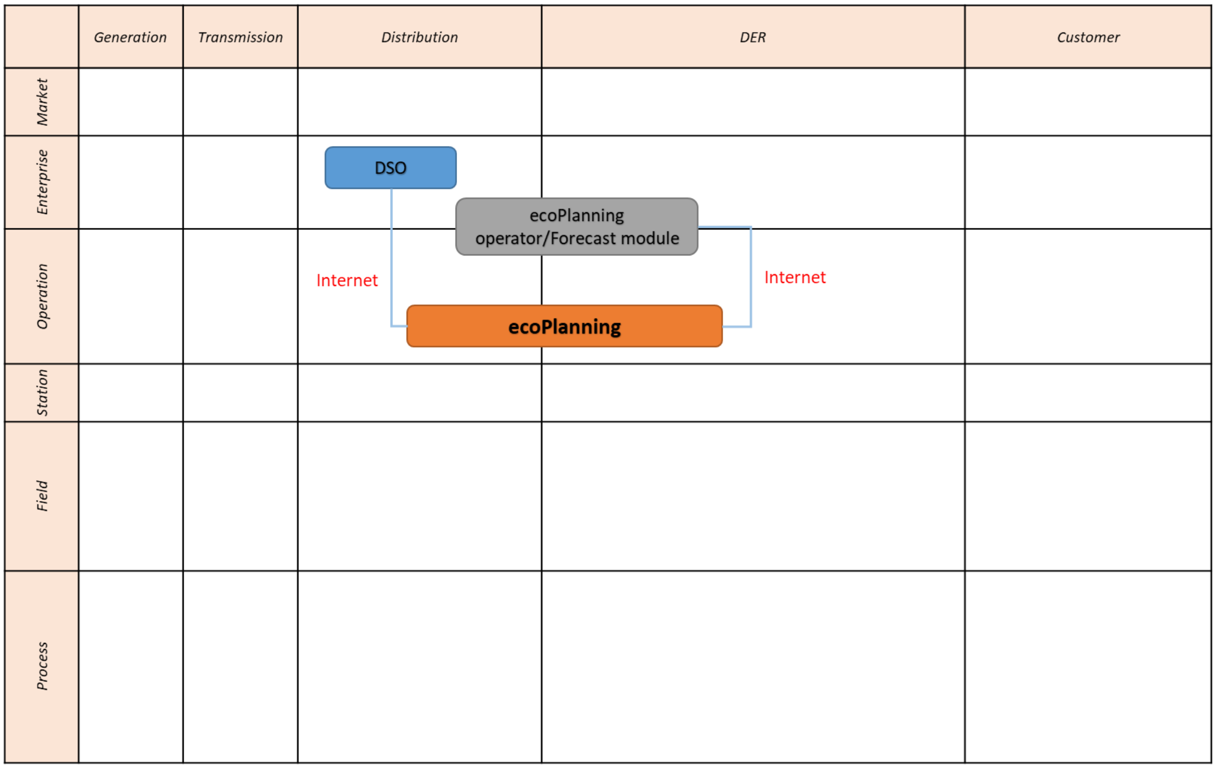


Figure 51 PN_2UC Component Layer

Table 29 List of Components PN_2UC

Component	Component Type
ecoPlanning operator/Forecast module	Application
DSO	Organization
ecoPlanning	ecoTool Application

3.3.1.3 SGAM Communication Layer

3.3.1.3.1 Kythnos Demo site

The communication Layer for PN_2UC describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 52.

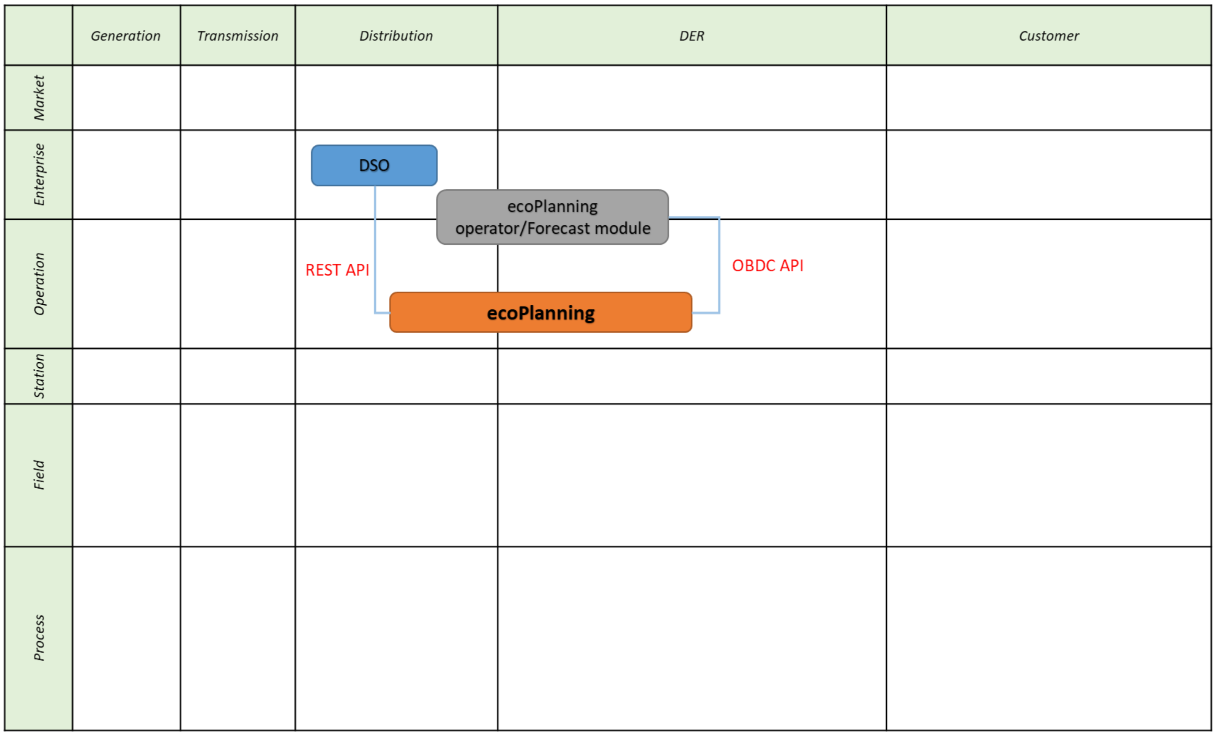


Figure 52 PN_2UC Communication Layer for

Table 30 List of Communication technologies involved in PN_2UC

Component	Component Type
REST API	A REST API is an application programming interface (API or web API) that conforms to the constraints of REST architectural style and allows for interaction with RESTful web services
ODBC API	Open Database Connectivity (ODBC) is an open standard Application Programming Interface (API) for accessing a database

3.3.1.4 SGAM Function Layer

3.3.1.4.1 Kythnos Demo site

The functional layer of PN_2UC is presented in the graph below highlighting the key actors of the use case.

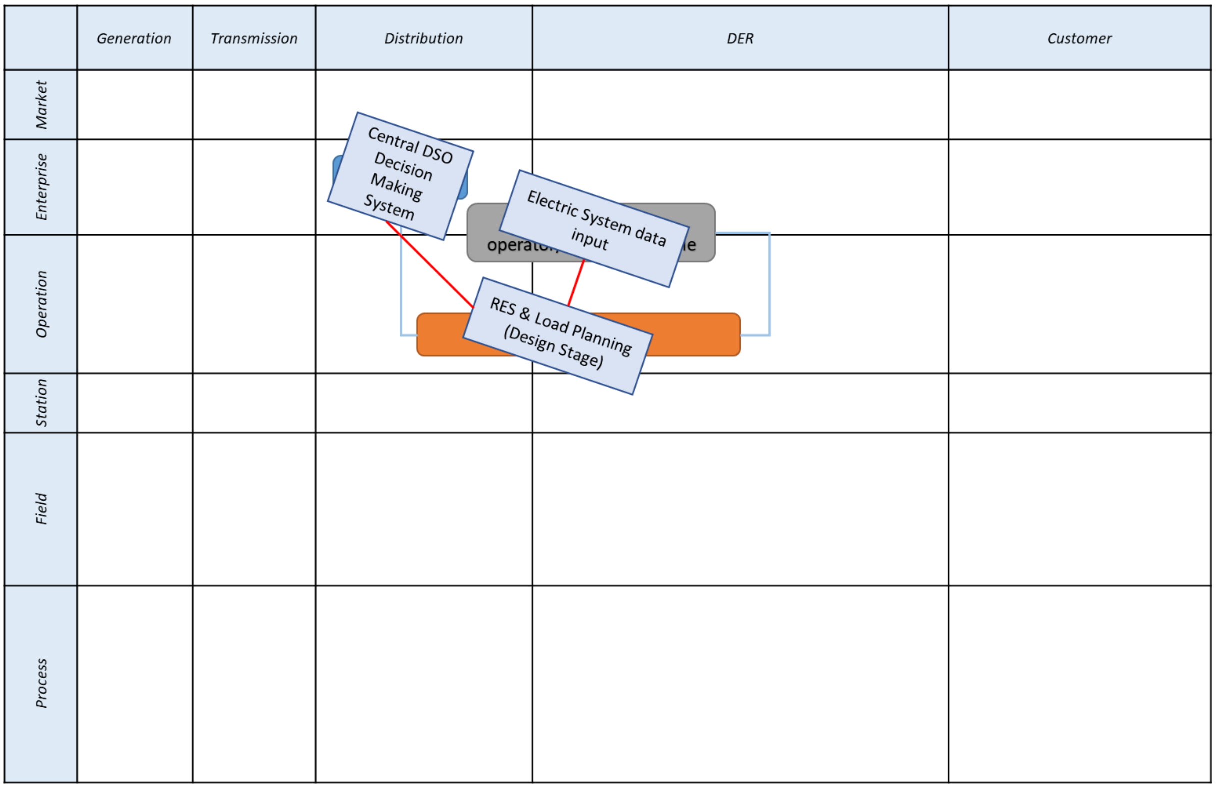


Figure 53 PN_2UC Function Layer

3.3.1.5 SGAM Information Layer

3.3.1.5.1 Kythnos Demo site

Details about information layer of PN_2UC are presented in Figure 54, highlighting the key information objects.

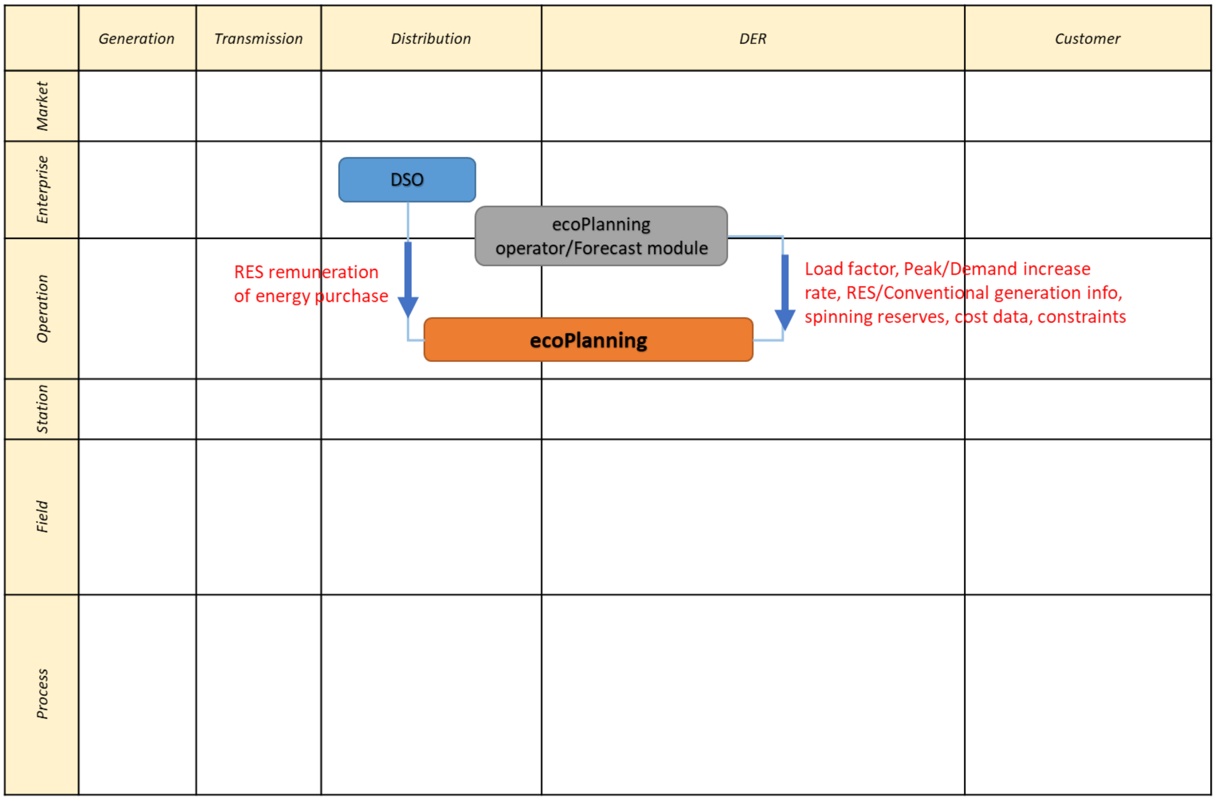


Figure 54 PN_2UC Information Layer

3.4 ecoPlatform

3.4.1 PF_2UC2.1 Facilitate data exchange between dependent tools

3.4.1.1 Use Case Description

EcoPlatform will serve as a platform for data transfer between the dependent tools. The provision of data transfer in near-real-time with low latency and slower archived data will be available. The transfer access will be authenticated and authorized by the ecoPlatform.

3.4.1.2 SGAM component Layer

3.4.1.2.1 Kythnos and Indian demo sites

The Component Layer for PF_2UC2.1 describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 55.

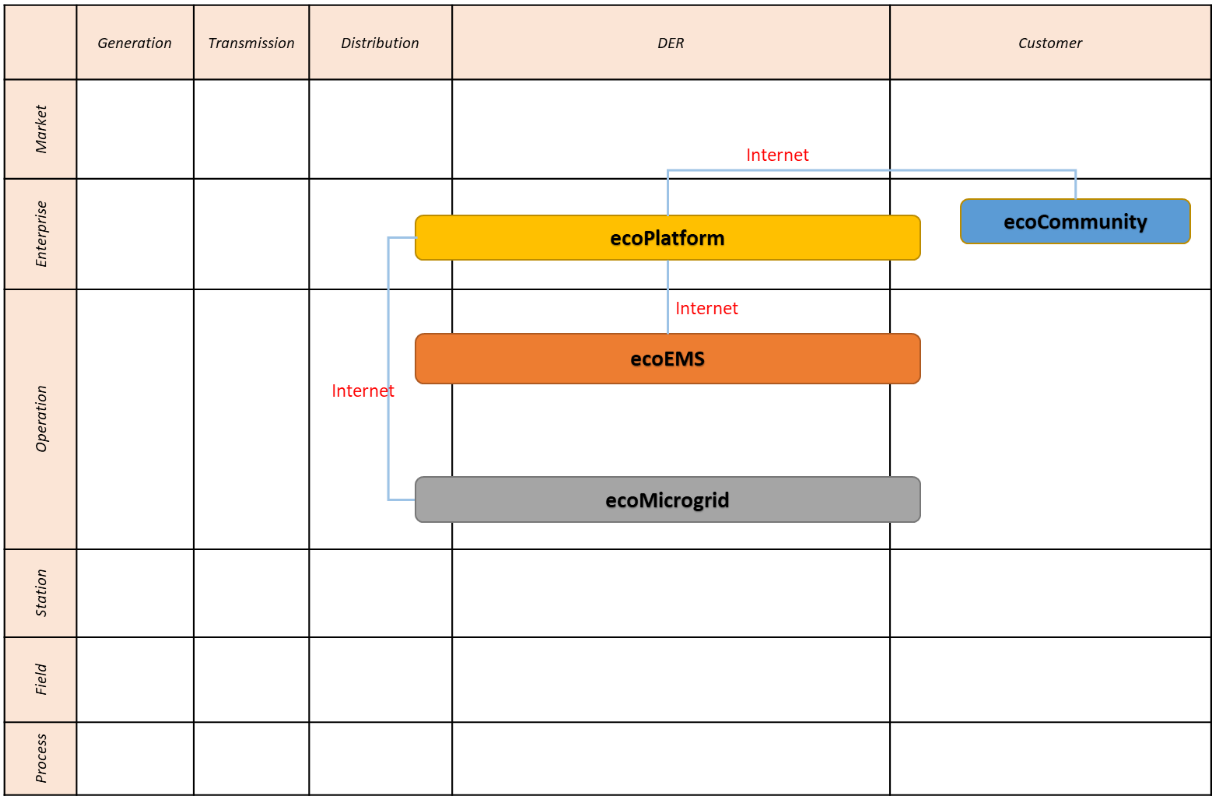


Figure 55 PF_2UC2.1 Component Layer

Table 31 List of Components of FT_2UC2.1

Component	Component Type
ecoMicrogrid	ecoTool Application
ecoEMS	ecoTool Application
ecoPlatform	ecoTool Application
ecoCommunity	ecoTool Application

3.4.1.3 SGAM Communication Layer

3.4.1.3.1 Kythnos and Indian demo sites

The communication Layer for PF_2UC2.1 describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 56.

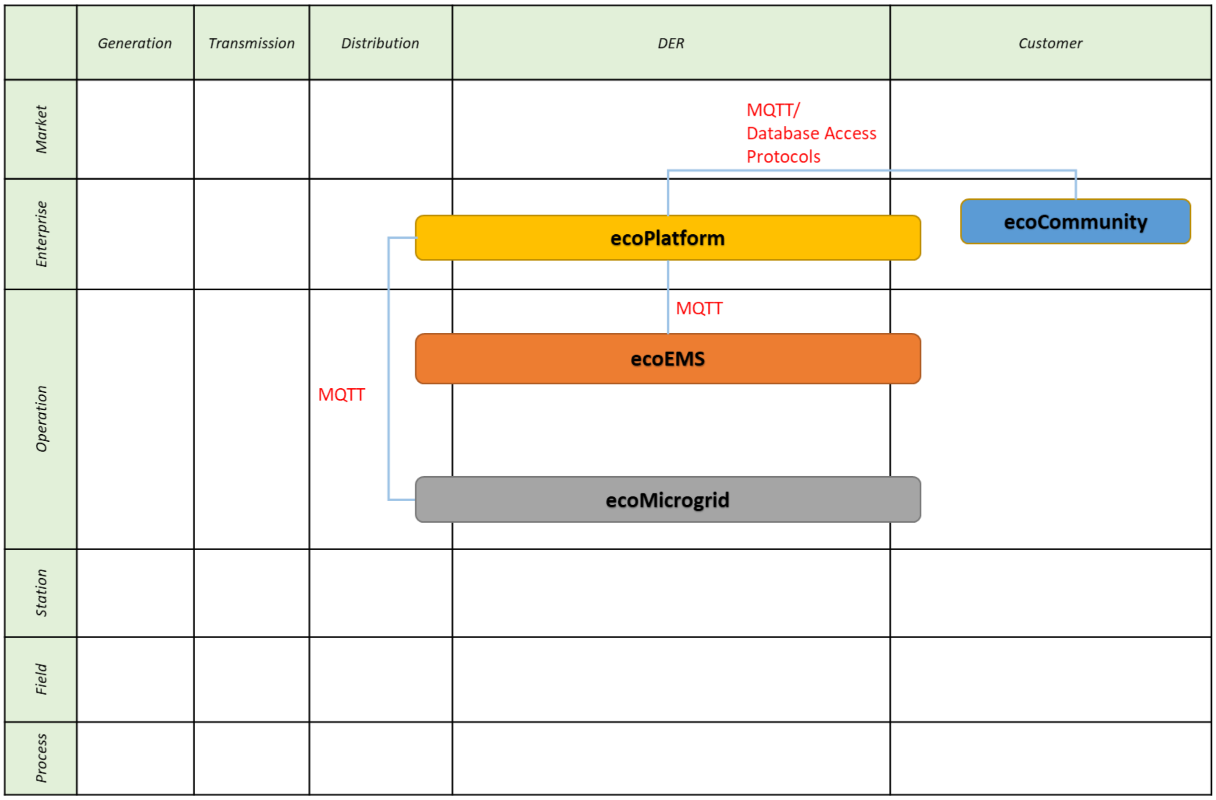


Figure 56 PF_2UC2.1 Communication Layer

Table 32 List of Communication technologies involved in PF_2UC2.1

Component	Component Type
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
Database Access Protocols	The DAP is aprotocol for access to data organized as name-datatype-value tuples. It is particularly suited to accesses by a client computer to data stored on remote (server) computers which are networked to the client computer

3.4.1.4 SGAM Function Layer

3.4.1.4.1 Kythnos and Indian demo sites

The functional layer of PF_2UC2.1 is presented in the graph below highlighting the key actors of the use case.

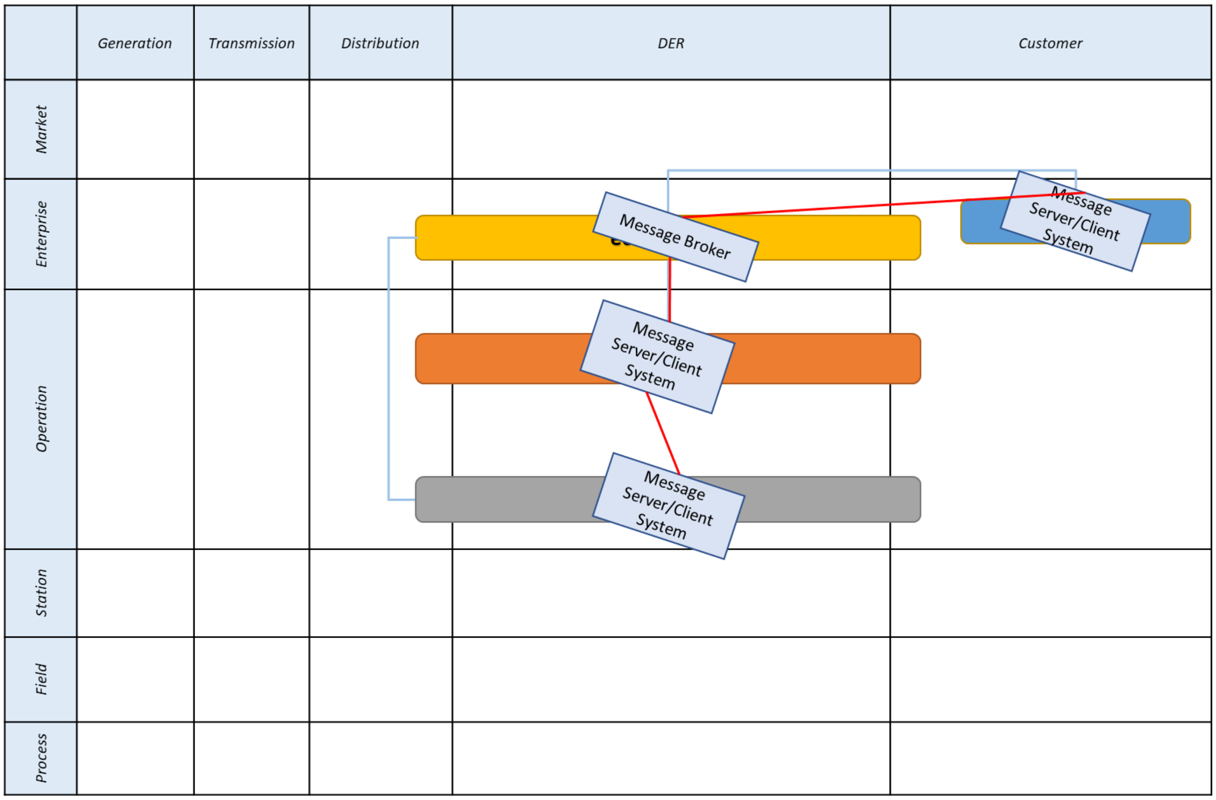


Figure 57 PF_2UC2.1 Function Layer

3.4.1.5 SGAM Information Layer

3.4.1.5.1 Kythnos and Indian demo sites

Details about information layer of PF_2UC2.1 are presented in Figure 58, highlighting the key information objects.

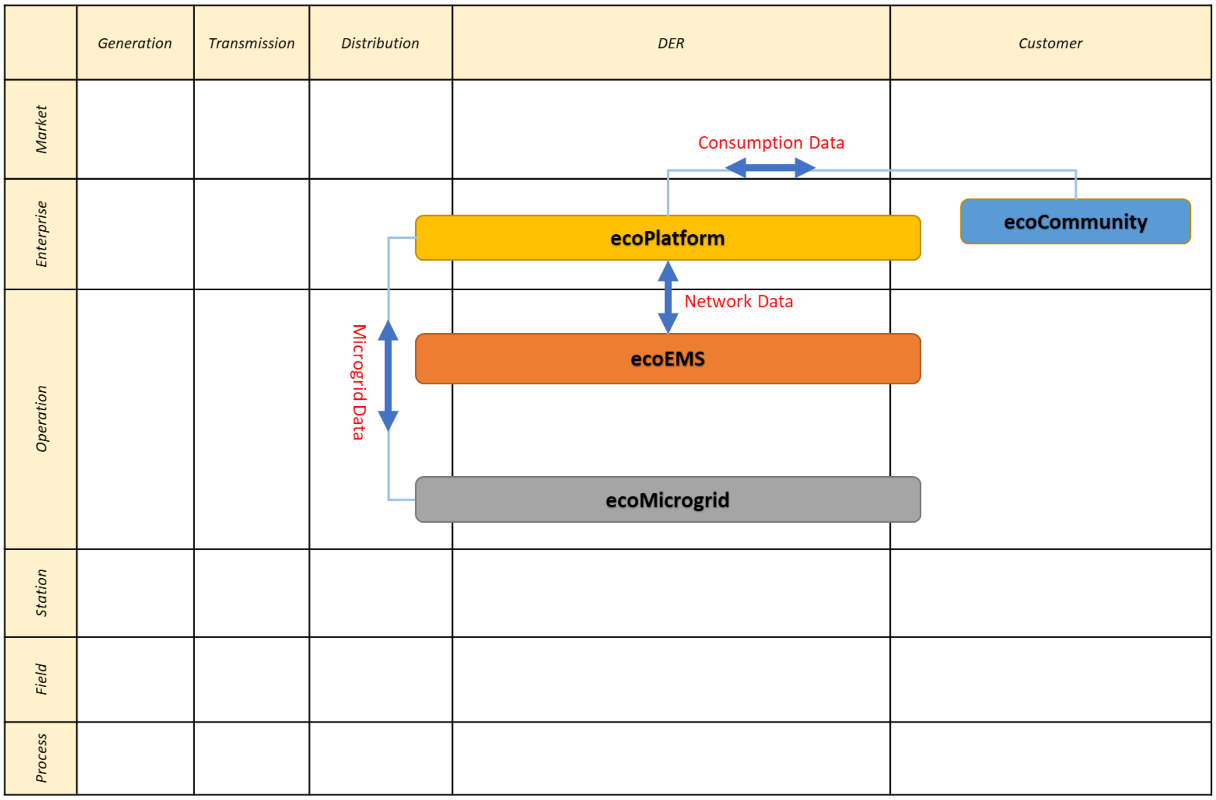


Figure 58 PF_2UC2.1 Information Layer

3.5 ecoDR

3.5.1 DR_2UC1.2 and DR_2UC2.1

3.5.1.1 Use Case Description

DR_2UC1.2 Dynamic pricing based energy cost computation

Better alignment of the cost of electricity supply with demand, using dynamic pricing tariffs, can potentially yield multiple benefits. Real Time Pricing allows end users to make better choices - benefitting both energy provider and end users. This UC describes the process of real time pricing of energy cost based on received dynamic pricing data.

DR_2UC2.1 Scheduling of loads

This UC deals with the scheduling of non-critical and flexible loads. The proposed scheme attempts to coordinate the available flexibility to increase the operational effectiveness of the network. The ecoDR receives the information regarding the load schedule and is responsible to implement it. This UC will also deal with the design of supporting hardware and software to implement the scheduler shared by ecoCommunty tool. This UC will also ensure manual override.

3.5.1.2 SGAM Component Layer

3.5.1.2.1 Kythnos and Indian demo sites

The Component Layer for DR_2UC1.2 describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 59. The same diagram is also applicable for DR_2UC2.1.

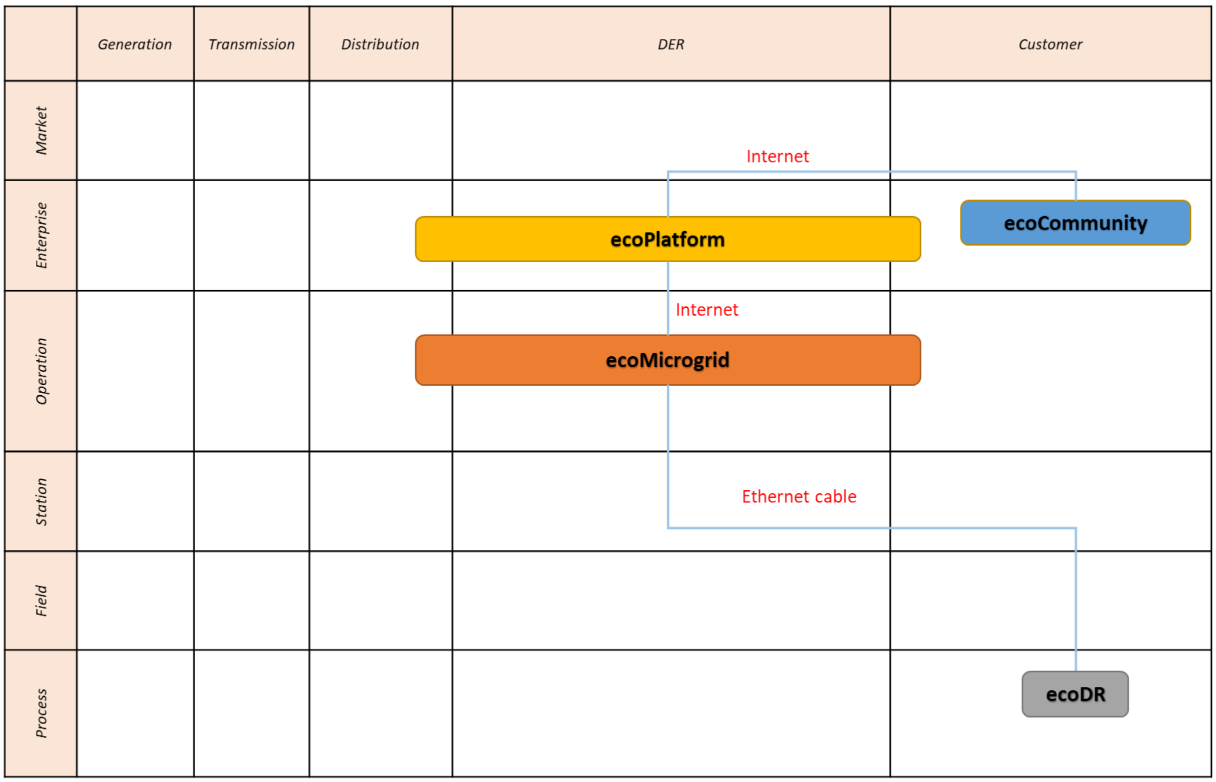


Figure 59 DR_2UC1.2 Component Layer

Table 33 List of Components of DR_2UC1.2

Component	Component Type
ecoMicrogrid	ecoTool Application
ecoDR	ecoTool Application
ecoPlatform	ecoTool Application
ecoCommunity	ecoTool Application

3.5.1.3 SGAM Communication Layer

3.5.1.3.1 Kythnos and Indian demo sites

The communication Layer for DR_2UC1.2 describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 60. The same diagram is also applicable for DR_2UC2.1.

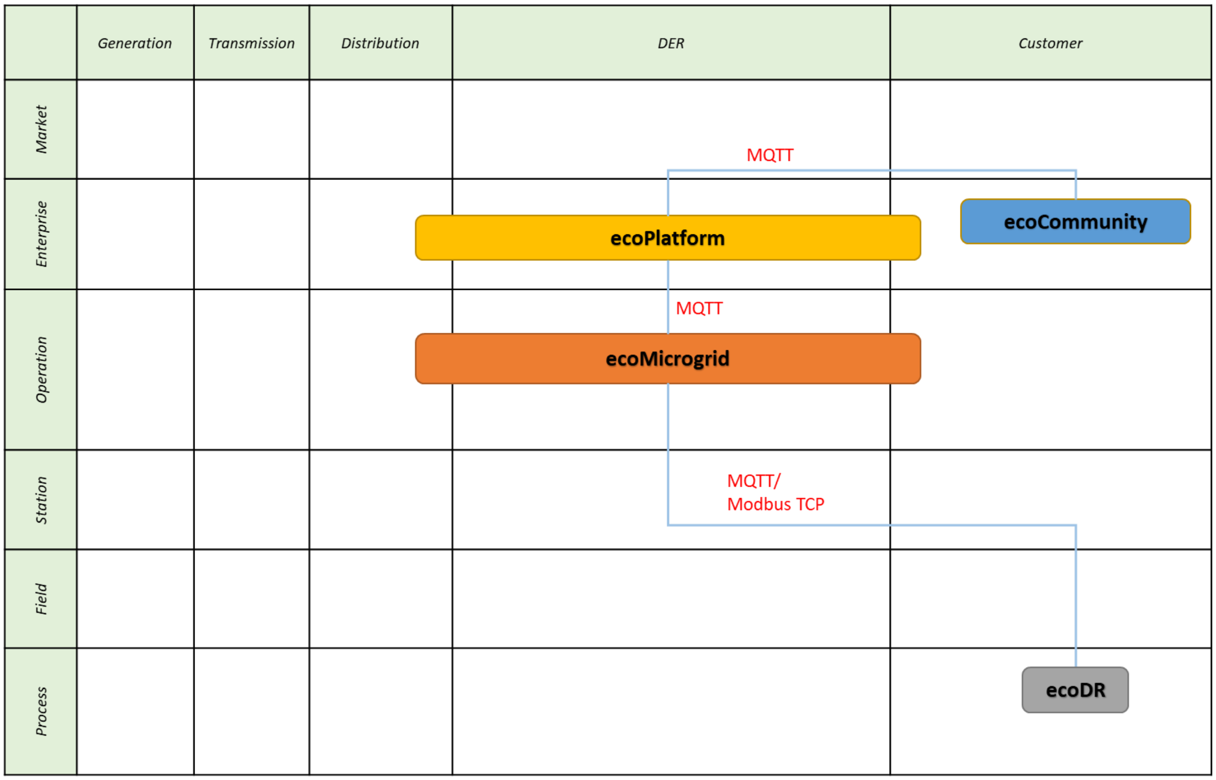


Figure 60 DR_2UC1.2 Communication Layer

Table 34 List of Communication technologies involved in DR_2UC

Component	Component Type
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
Modbus TCP	Communication protocol for programmable logic controllers (PLCs). It is openly published, easy to deploy and maintain, and does not present many restrictions on integration with different vendors. Modbus TCP covers the use of Modbus messaging in an 'Intranet' or 'Internet' environment using the TCP/IP protocols

3.5.1.4 SGAM Function Layer

3.5.1.4.1 Kythnos and Indian demo sites

The functional layer of DR_2UC1.2 and DR2_2UC2.1 is presented in the graph below highlighting the key actors of the use case.

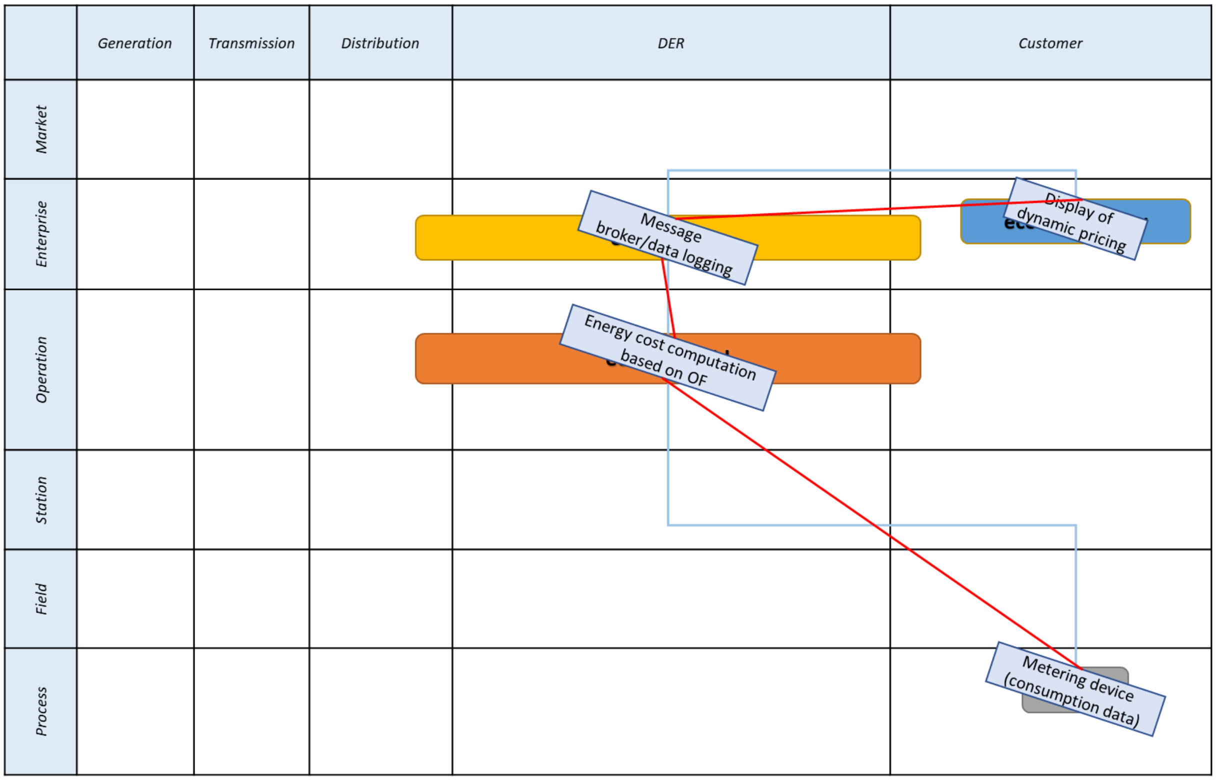
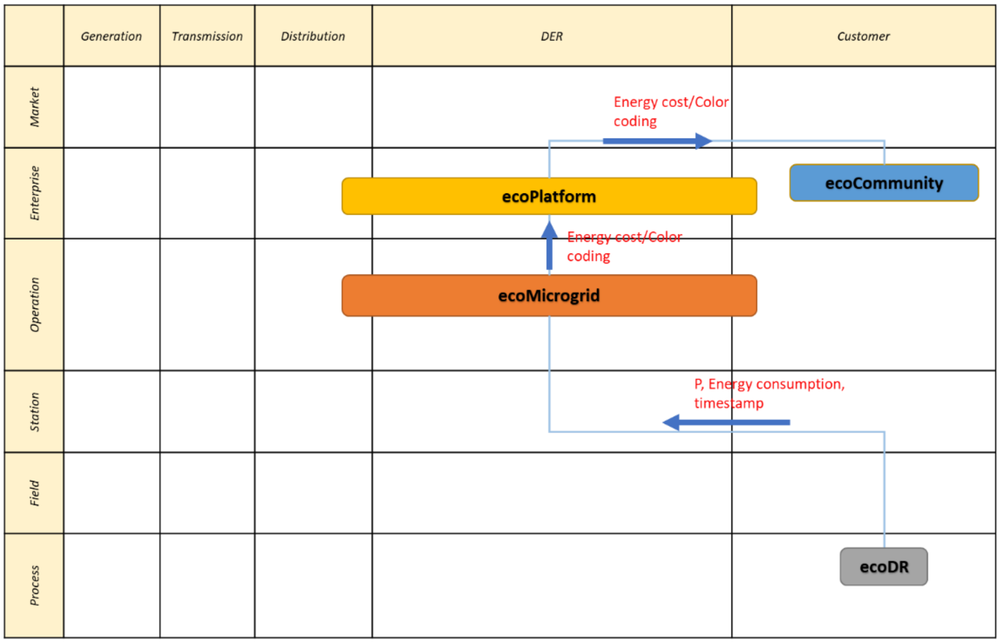


Figure 61 DR_2UC1.2 Function Layer

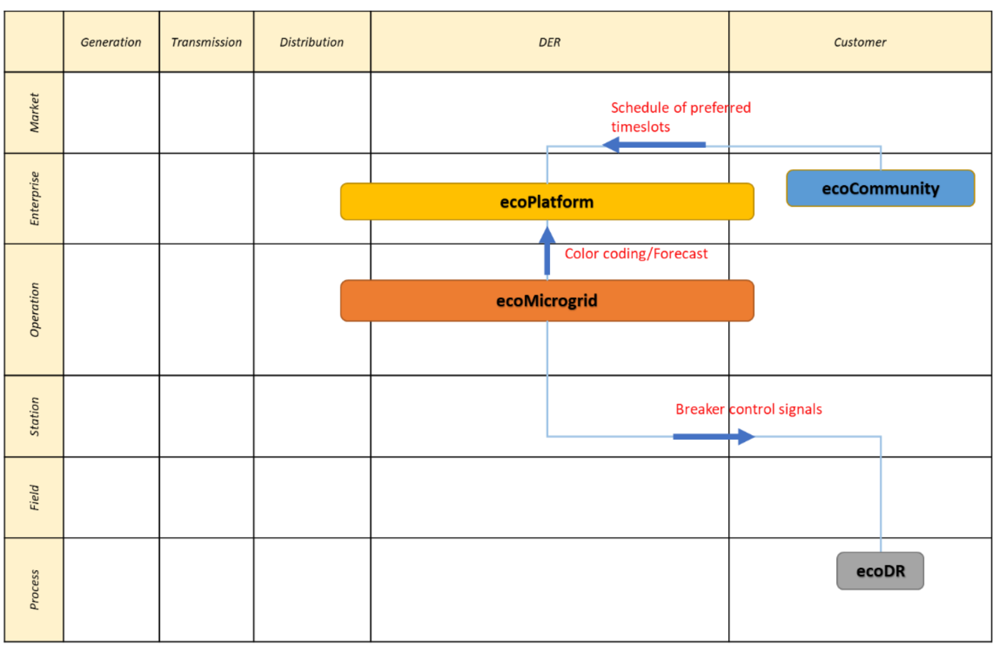
3.5.1.5 SGAM Information Layer

3.5.1.5.1 Indian demo sites

Details about information layer of DR_2UC1.2 and DR_2UC2.1 are presented in Figure 62a and Figure 62b respectively, highlighting the key information objects.



(a)



(b)

Figure 62 a) DR_2UC1.2 Information Layer

b) DR_2UC2.1 Information Layer

3.6 ecoCommunity

3.6.1 CM_2UC1.1 and CM_2UC1.2

3.6.1.1 Use Cases Description

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

This UC is about displaying the dynamic pricing of electricity based on shape of energy profile. The information about the shape of energy profile will be obtained from the DSM mechanism implemented in Task 3.2. Varying price signals with colour coding and time slots will be displayed to the consumers through this platform. This increases the flexibility potential of consumers.

CM_2UC1.2 Billing and payments

This 2UC1.2 addresses the billing and payments. The electricity consumption based on the dynamic pricing will be calculated and the billing information will be displayed to the consumers. A secured payment gateway will be present which allows the customers to pay the bills seamlessly

The same SGAM Layer diagrams are applicable to the above mentioned UCs, as described in the following sections.

3.6.1.2 SGAM Component Layer

3.6.1.2.1 Kythnos and Keonjhar[1] demo sites

The Component Layer for CM_2UC describing the technology used for the interconnection between devices and the ecoTools, is depicted in Figure 63.

[1] Depending on the installations

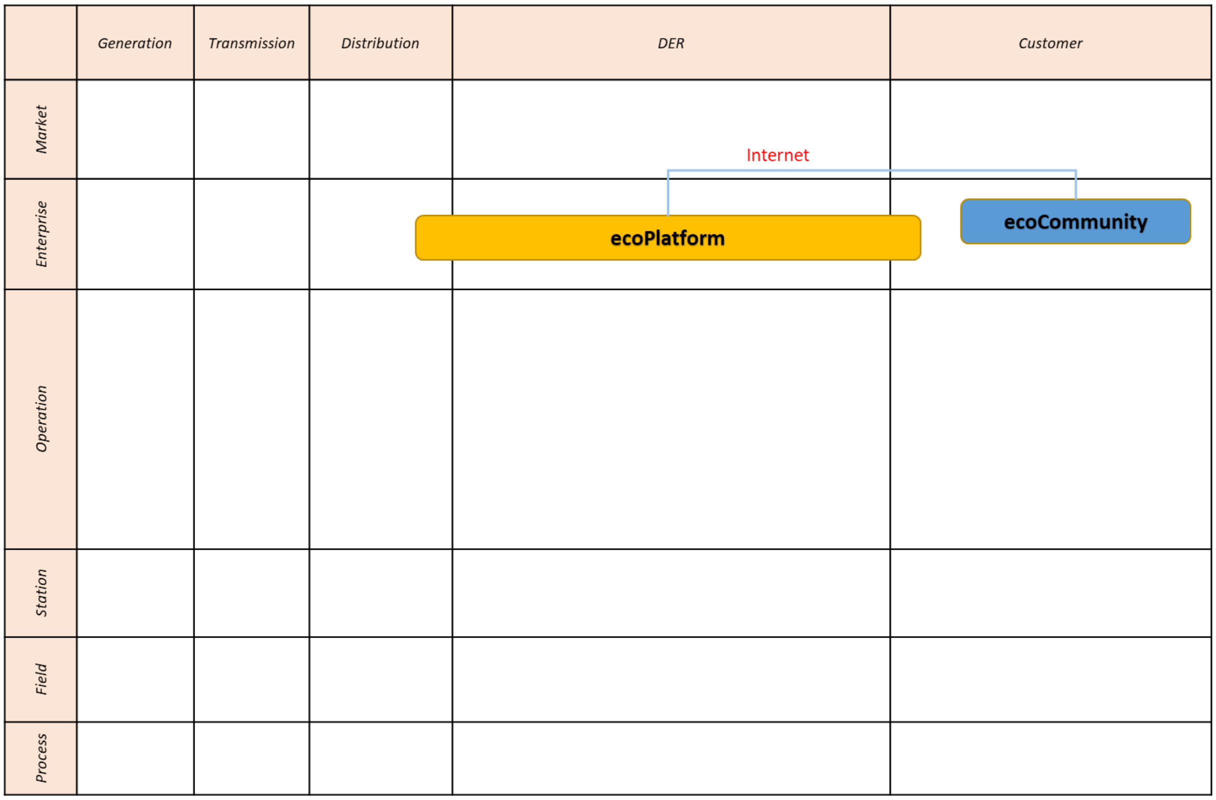


Figure 63 CM_2UC Component Layer

Table 35 List of Components of CM_2UC

Component	Component Type
ecoPlatform	ecoTool Application
ecoCommunity	ecoTool Application

3.6.1.3 SGAM Communication Layer

3.6.1.3.1 Kythnos and Keonjhar[2] demo sites

The communication Layer for CM_2UC describing the technology used for the communications between devices and the ecoTools, is depicted in Figure 64.

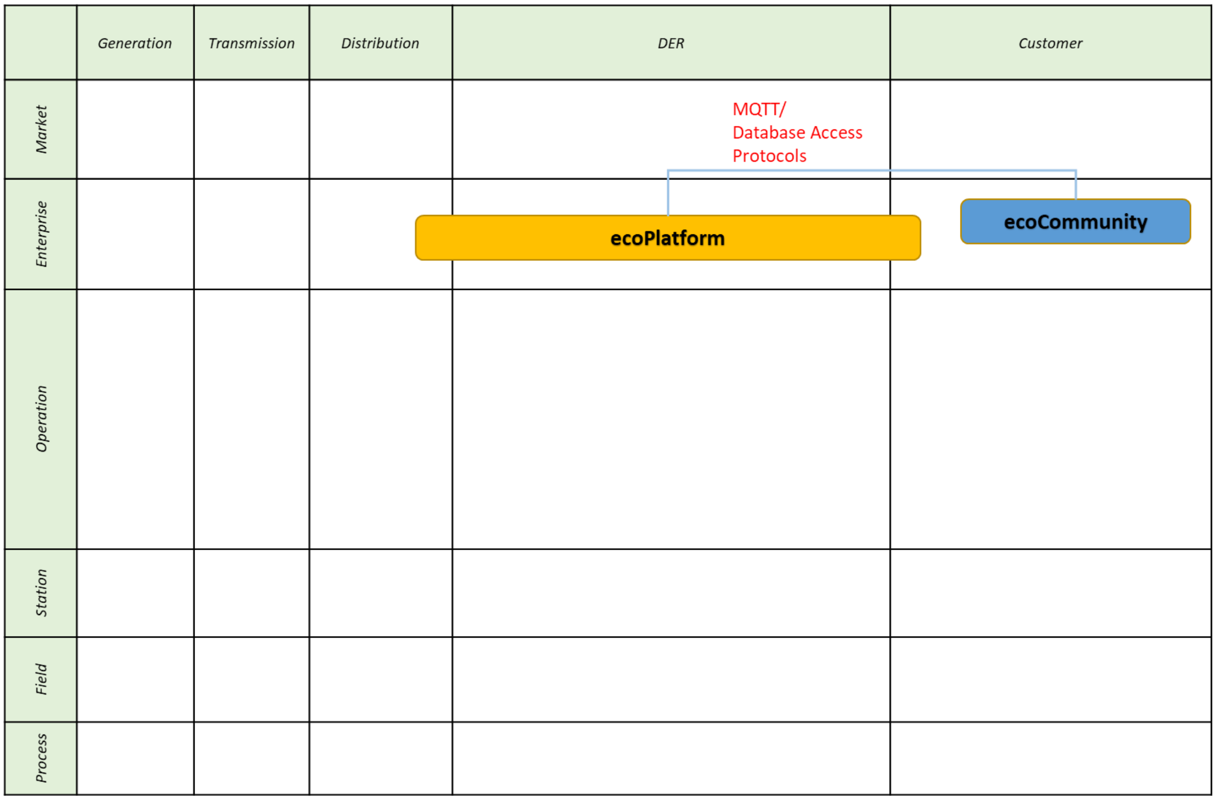


Figure 64 CM_2UC Communication Layer

Table 36 List of Communication technologies involved in CM_2UC

Component	Component Type
MQTT	Message Queuing Telemetry Transport. Publish-subscribe message protocol over TCP/IP defined in ISO/IEC PRF 20922 standard. It is designed for connections where network bandwidth is limited and a lightweight messaging mechanism is required
Database Access Protocols	The DAP is a protocol for access to data organized as name-datatype-value tuples. It is particularly suited to accesses by a client computer to data stored on remote (server) computers which are networked to the client computer.

[2] Depending on the installations

3.6.1.4 SGAM Function Layer

3.6.1.4.1 Kythnos and Keonjhar[3] demo sites

The functional layer of CM_2UC is presented in the graph below highlighting the key actors of the use case.

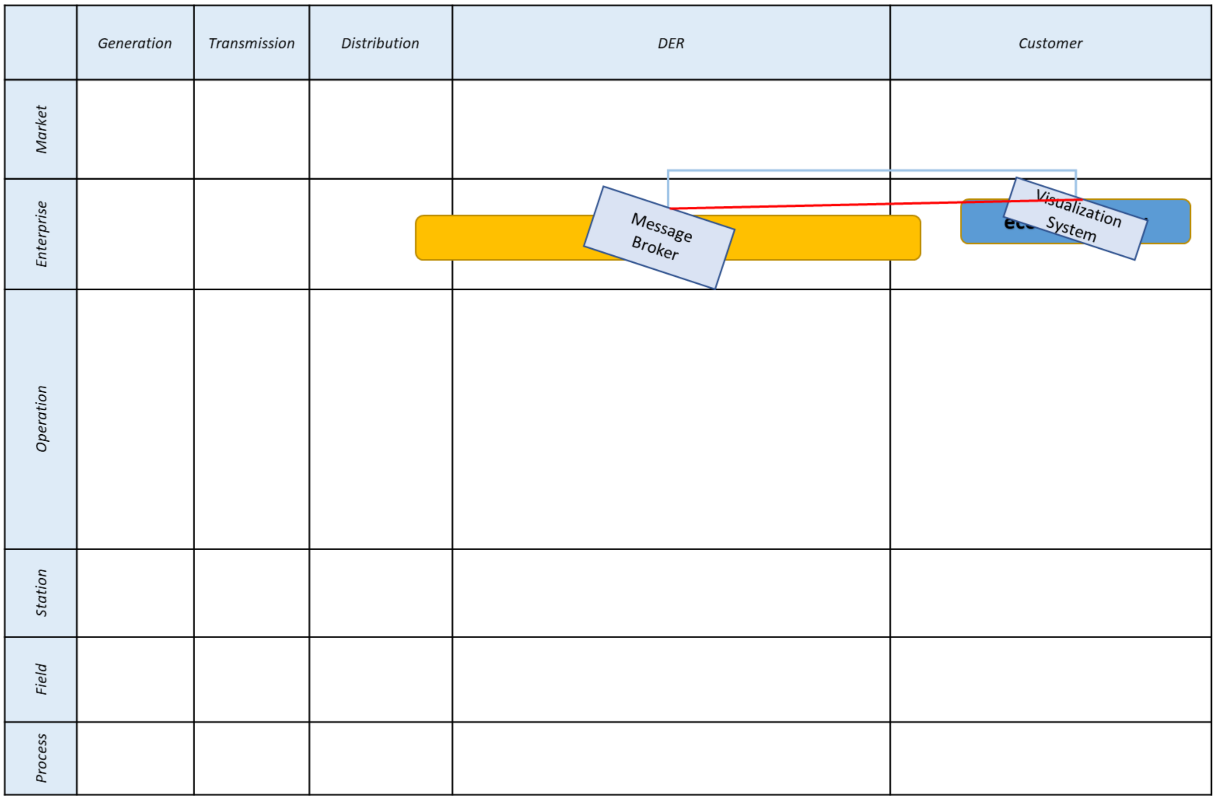


Figure 65 CM_2UC Function Layer

[3] Depending on the installations

3.6.1.5 SGAM Information Layer

3.6.1.5.1 Kythnos and Keonjhar[4] demo sites

Details about information layer of CM_2UC are presented in Figure 66, highlighting the key information objects.

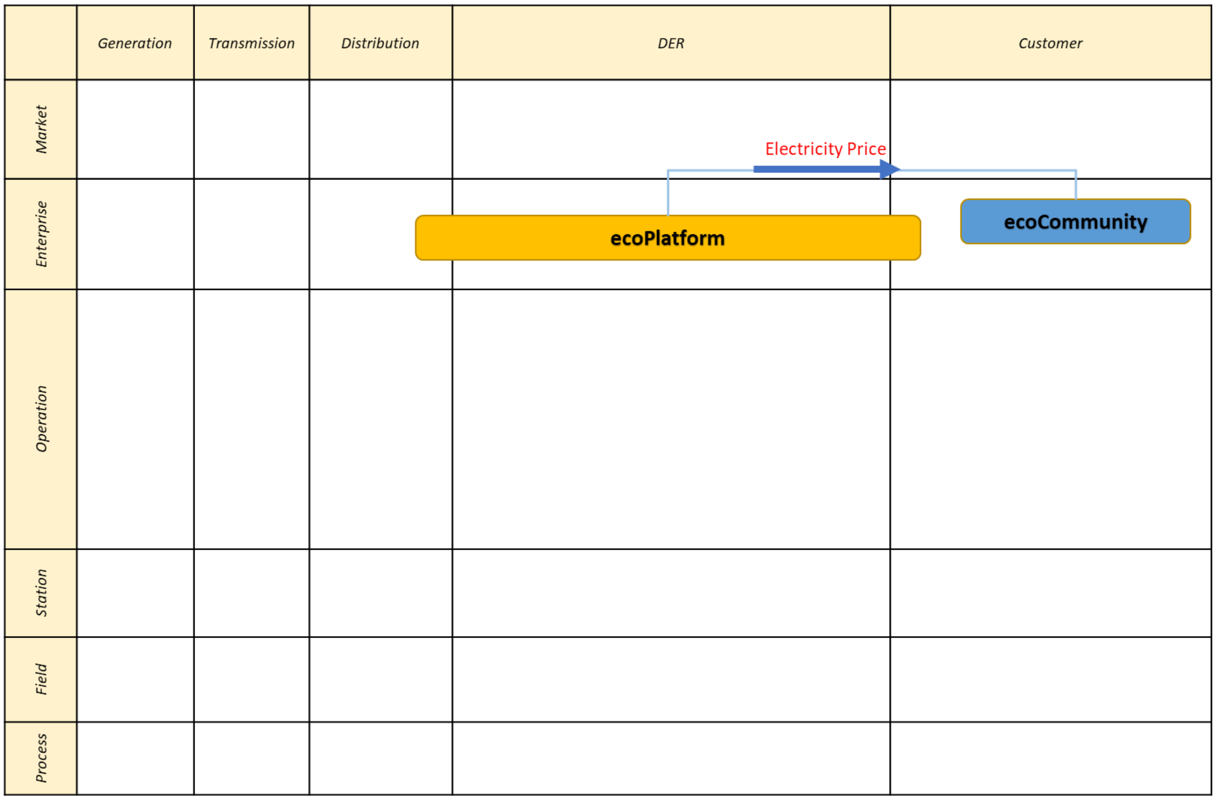


Figure 66 CM_2UC Information Layer

[4] Depending on the installations

4 Functional Specifications of ecoTools

In this section, the functional specifications of each ecoTools will be presented. Although in Deliverable D2.1 [1] a first list of the functionalities was presented, in this section an updated analysis of these functionalities has been performed, taking into consideration the progress of the project and the discussions among the ecoTools and Demo sites leaders. Thus, a presentation of the specifications of each tool is included in the following subsections. Moreover, an analytical structure for the ecoTools that are in a most mature stage is also depicted in a graphical form.

4.1 ecoMicrogrid

The functional specifications of ecoMicrogrid are presented in Table 37, while its structure is depicted in Figure 67.

Table 37 Functional specifications of ecoMicrogrid

No	Main Features	Description
1	Forecasting	Via the accurate forecasting of RES production for the entire day, the optimization module can account with greater certainty for the required number of units starts and stops as well as for keeping generation units near the most efficient operating point
2	Optimized algorithm for controllable loads, storage Units, RES Units and thermal generators	Real-time measurements and estimation of future RES production/demand will be considered by a sophisticated algorithm to compute optimal commands for controllable loads, storage Units, RES Units and thermal generators
3	Management of multi energy vectors for economical operation	Microgrid management of operation should utilize the flexibility of multi energy vectors aiming at most economical operation

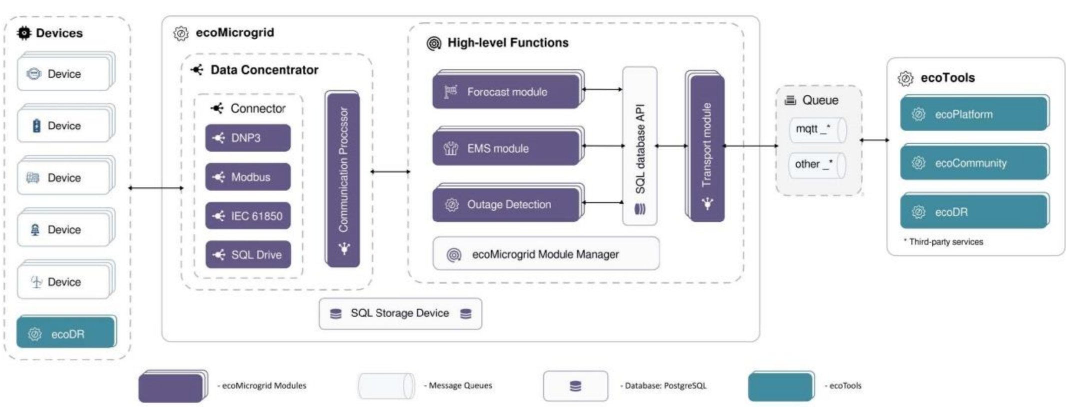


Figure 67 ecoMicrogrid structure

4.2 ecoEMS

The functional specifications of ecoEMS are presented in Table 38.

Table 38 Functional specifications of ecoEMS

No	Main Features	Description
1	Forecasting	Mid-term and short-term RES and load forecasting will be performed, specifically a 24/48h ahead horizon and a 4h ahead horizon. Moreover, the forecast algorithms will be produced from a combination of three different forecasting training models
2	Unit Commitment and Economic Dispatch algorithms	The ecoEMS module should be able to run simulations under hyper-parameter definition, after communicating with other services, such as RES and Load forecast services, and then execute the optimization algorithm to calculate the optimal unit commitment
3	Management of multi energy vectors for economical operation	Management of operation should utilize the flexibility of multi energy vectors aiming at most economical operation., such as the incorporation of the load demand of EV's chargers

4.3 ecoPlanning

The functional specifications of ecoPlanning are shown in Table 39.

Table 39 Functional specifications of ecoPlanning

No	Main Features	Description
1	Energy Planning	Optimization algorithm for mid to long term horizon (1 to 7 years), for hourly Unit Commitment, maximizing RES penetration and securing normal operation. This feature aims to quantify the generation capacity needs of the system over the examined horizon
2	RES hosting capacity	This feature aims to locate the energy mix with the lowest cost and as much RES capacity as possible, among the different RES technologies
3	Interconnection	The goal of this study is to examine the operational status and cost in a scenario of interconnecting the island with the mainland system or with other autonomous power systems

4.4 ecoDR

The functional specifications of ecoDR are shown inTable 40, while its structure is depicted in Figure 68.

Table 40 Functional specifications of ecoDR

No	Main Features	Description
1	Real time monitoring	EcoDR will provide access to real-time data to boost new service and functionalities, providing energy consumption data and other electrical parameters like active power, power factor etc
2	Load scheduling	The proposed scheme attempts to coordinate the available flexibility to increase the operational effectiveness of the network. The ecoDR receives the information regarding the load schedule and is responsible to implement it
3	Programmable Load shedding controller	Enables the operator (energy supplier) to restrict the maximum load (in Watt) per household. Once the energy consumption/load connection goes beyond the maximum load the meter will shed the load locally by disconnecting power from output terminal of meter

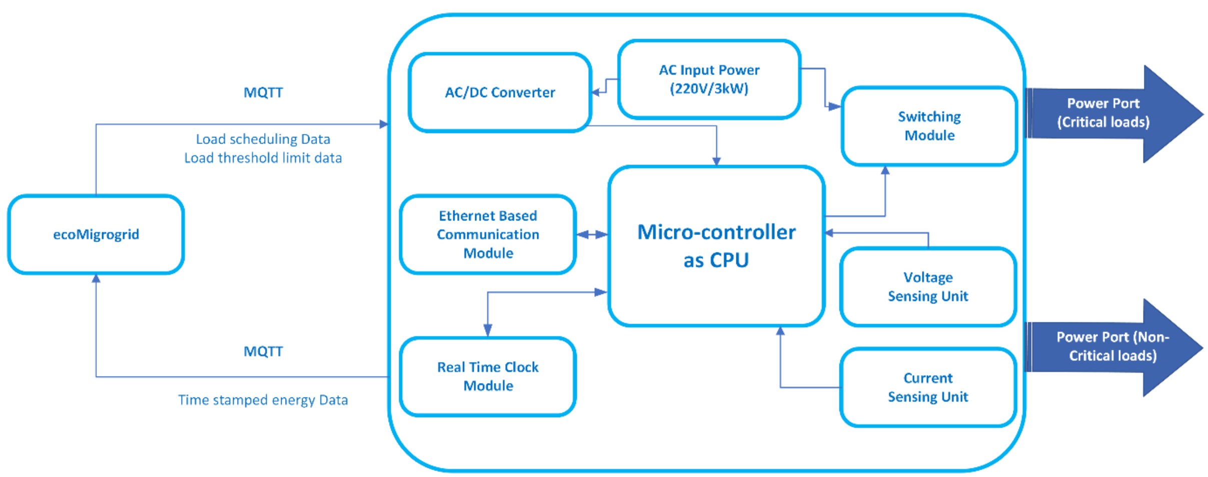


Figure 68 ecoDR structure

4.5 ecoPlatform

The functional specifications of ecoPlatform are presented in Table 41.

Table 41 Functional specifications of ecoPlatform

No	Main Features	Description
1	Data collection and storage	Acquire data from various developed solutions, such as other ecoTools, sensed weather data, including the solar irradiance, could also be integrated using MQTT over LoRaWAN
2	Data cleansing	The data filtration function will filter out the outliers and fill in missing data due to uncertainties in the sensors or communication channels and prevent penetration of corrupted data into the applications enhancing the reliability and efficiency of the system
3	Platform as a service for dependent tools integration	EcoPlatform will serve as a Platform as a Service (PaaS) that can integrate all the solutions in one software structure. In this way, it can assist the operation of the other tools for data exchange and cooperation

4.6 ecoMonitor

The functional specifications of ecoMonitor are presented in Table 42.

Table 42 Functional specifications of ecoMonitor

No	Main Features	Description
1	Acquisition and monitoring of water quality	Acquisition of Water quality parameters based on the desired water parameters of concern (temperature, dissolved oxygen, pH, conductivity, ORP, etc.)
2	Data processing and evaluation	Process and evaluation of the collected data, which must be available for both decision makers and end users

4.7 ecoCommunity

The functional specifications of ecoCommunity are shown in Table 43, while its structure is depicted in Figure 69.

Table 43 Functional specifications of ecoCommunity

No	Main Features	Description
1	Energy Consumption and Dynamic pricing	Display the cumulative meter reading and consumption profile of the consumers using the data received from ecoDR or Community Managers. Also displays the dynamic pricing of electricity and expected pricing bands for future time periods based on the input from ecoMicrogrid
2	Invoices and Payments	Generates the invoices using the consumption and pricing data based on the category of the consumer. The consumers will be able to pay the bills using the payment gateway portal
3	Load scheduling and coordination	This tool will facilitate scheduling and coordination of communal energy usage among its members, such as irrigation pumping, to address challenges in sharing communal resources. The available time slots for booking the load will be displayed based on the input from ecoPlatform and the consumers will be able to book the slots based on their requirement
4	Problem Reporting	A set of FAQs will be provided to tackle the various issues and problems faced by the consumers. The tool also facilitates an additional problem reporting form to report issues which are not able to be resolved by the FAQs
5	Community Forum	The tool provides a platform for the consumers and managers to share their experiences regarding the microgrid system and interact with one another on common topics regarding the operation of the system
6	Guidance and training	This platform will have guidance and training material on how to use various equipments in the microgrid and how to use the various modules in the ecoCommunity tool

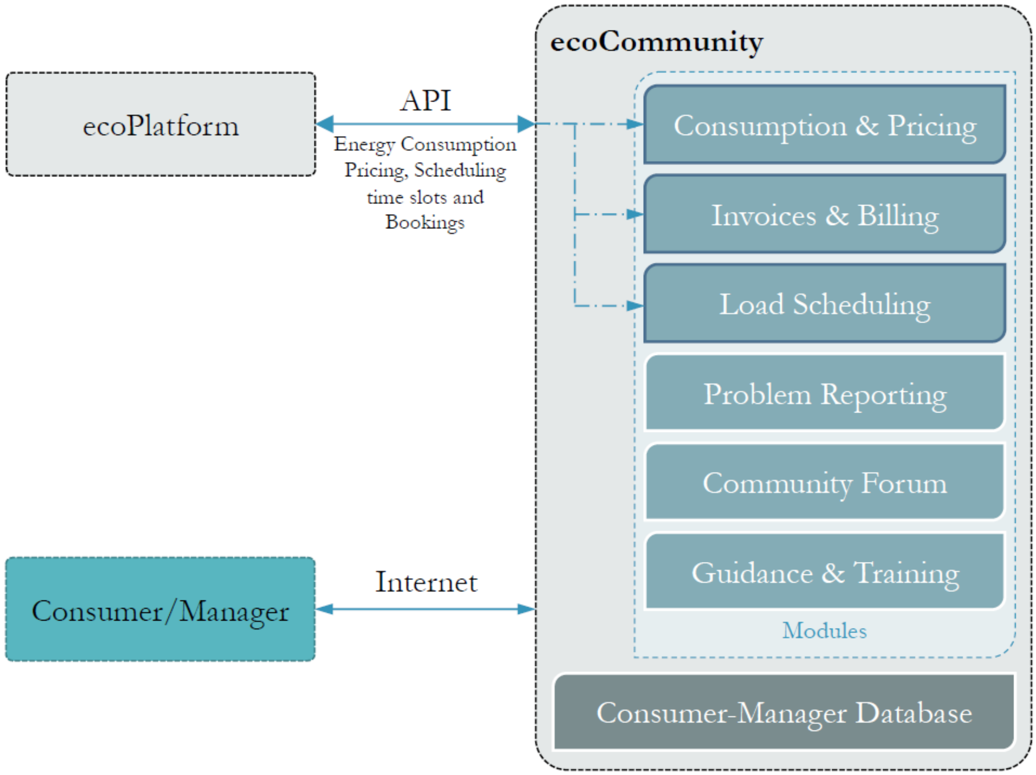


Figure 69 ecoCommunity structure

4.8 ecoResilience

The functional specifications of ecoResilience are presented in Table 44.

Table 44 Functional specifications of ecoResilience

No	Main Features	Description
1	Resilient support for solar PV systems	An optimal design procedure will be performed for the development of self-adaptive passive solar photovoltaic systems, to minimize the wind loads during severe cyclonic conditions. This mechanism will be developed to bring the incident angle of the solar panels to near zero to minimize the drag and lift forces. This subsequently reduces the overall load on the support structures and foundation
2	Resilient tower and passive mechanism for wind turbine blades	A survey of methods used to reduce wind loads on tower truss and wind turbine blades during cyclones will be assesed, as well as a tower truss will be designed and a

		mechanism to reduce loads on wind turbine blades at adverse environmental conditions. CFD simulation of flow past the wind turbine blades will be performed at different angle of attacks and free stream velocities. Stress distribution on the tower truss and the wind turbine blades will be examined through CSA from hydrostatic pressure obtained from simulations to optimize the support structures
3	WT Local Manufacturing and Testing	Local manufacturing of residential small wind turbines (SWT) will allow increased resilience of the wind energy system, by using the available material and human resources of the region, as part of a sustainable process that strengthens local economies, creates income sources, and facilitates knowledge sharing. Additionally, already existing designs for locally manufactured small wind turbines will be upscaled for higher rated power and validated using the IEC 61400-12-1 standard as a guide, in the small wind experimental facilities of ICCS-NTUA.

4.9 ecoVehicle

The functional specifications of ecoVehicle are presented in Table 45.

Table 45 Functional specifications of ecoVehicle

No	Main Features	Description
1	Effective control strategies for dc-bus voltage regulation	The charger and the charging station to be deployed, must support charging at faster rate. This type of operation affects the bus voltage and indirectly the grid. Therefore, it is important to address the bus voltage regulation. Different control strategies will be implemented
2	SoC and temperature estimation	The charger will perform SOC estimation, through the most basic approach of coulomb counting. Charging at faster rate results in the increase of battery temperature which requires to be regulated, to improve the battery life. For this purpose, electrothermal model of the battery pack is to be used as a temperature estimator. Both SOC and the temperature estimation requires information of charging/discharging current information
3	Temperature regulated charging strategies	Temperature regulation during the charging process can be achieved through the temperature estimator and according switching between conventional cc/cv or pulse charging profile

5 Conclusions – Next steps

Throughout this document the architecture of the Use Cases that will be developed and implemented in the framework of the RE-EMPOWERED project was modelled in an efficient and standardized manner.

The analysis of the several UCs of the project is performed through the European SGAM framework to provide all the necessary information for the subsequent development phase of the ecoToolset solutions. This is possible through the modelling and analyzing the different layers proposed by SGAM such as the component layer, communication layer, function layer and information layer, while describing at the same time the interoperability between all the involved systems. Moreover, this procedure considers the special needs and requirements of the four demo sites (Europe: Bornholm-Denmark, Kythnos-Greece), (India: Keonjhar, Ghoramara island) where these UCs will be applied.

Finally, it should be mentioned that the outcomes of this deliverable will also serve as inputs for WP3, WP4 and WP5 that focus on the development of the ecoToolset solutions, as well as for WP7 in which the main objective is to design, coordinate and perform the deployment and demonstration activities of the RE-EMPOWERED project.

6 References

[1] A. Chronis *et al.*, "Deliverable D2.1 'Report on requirements for each demo, use cases and KPIs definition'- RE-EMPOWERED project," 2021.

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