Platone
PLATFORM FOR OPERATION OF DISTRIBUTION NETWORKS

# Platone

## PLATform for Operation of distribution NEtworks

# D1.1 v1.0

# General functional requirements and specifications of joint activities in the demonstrators

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**Abstract**

This report is part of the Platone project, which aims to develop and test a cost-effective platform for distribution network operation and market operation ensuring a joint data management of volatile generation and consumption. The report provides an overview of the three Platone demo sites situated in Italy, Greece, and Germany, respectively, and of their different use cases. It makes use of the Smart Grid Architecture Model (SGAM) for its analytical part and provides an overview of the use cases according to the specific objectives of Platone. The report shows that the three demonstration sites dispose over different conditions and characteristics. It will constitute the base for further scalability and replicability analysis of Platone's solutions to other Distribution System operators (DSOs).

**Keyword list**

DSOs – Use cases – distribution networks - grid observability – flexibility – Smart Grid Architecture Model - SGAM – smart grid technology – platform – blockchain technology

# Executive Summary

The purpose of Platone project is to develop a cost effective two-layer platform for distribution network operation and market operation creating a seamless integration of local prosumer in an open market structure ensuring a joint data management of volatile generation and consumption. This document outlines the main outcome of Task 1.1. “Use Case definition and operation specification” and covers the architecture of the Platone demonstration sites and a description of the Use Cases (UCs) developed to test Platone concept. The UC development followed the IEC 62559-2 standard. A UC management methodology has been developed, which is based on non-proprietary tools, and has been selected as BRIDGE standard for H2020 projects. Two UCs are defined for the Platone Italian demo, five for the Greek demo and four for the German demo. A mapping of the UCs onto the five interoperability layers of the Smart Grid Architecture Model (SGAM) is presented. The UCs were chosen to meet some of the key challenges that grid operators face in integrating DERs while maintaining stable and secure electricity supply. The Platone UCs concern the introduction of flexibility measures and electricity grid services, new technologies for observation, automation and control of the grid, and new market mechanisms to incentivise flexibility. This report enables a better understanding of the deployed Platone UCs and facilitates the scalability and replicability activities of WP7.

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# 1 Introduction

The project Platone - “PLATform for Operation of distribution Networks –aims to develop an architecture for testing and implementing a data acquisitions system based on a two-layer approach (an access layer for customers and a service layer) that will allow greater stakeholder involvement and will enable an efficient and smart network management. The tools used for this purpose will be based on platforms able to receive data from different sources, such as weather forecasting systems or distributed smart devices spread all over the urban area. These platforms, by talking to each other and exchanging data, will allow collecting and elaborating information useful for DSOs, transmission system operators (TSOs), customers and aggregators. In particular, the DSO will invest in a standard, open, non-discriminating, economic dispute settlement blockchain-based infrastructure, to give to both the customers and to the aggregator the possibility to become flexibility market players more easily. This solution will see the DSO evolve into a new form: a market enabler for end users and a smarter observer of the distribution network. By defining this innovative two-layer architecture, Platone removes technical barriers to the achievement of a carbon-free society by 2050, creating the ecosystem for new market mechanisms for a rapid roll out among DSOs and for a large involvement of customers in the active management of grids and in the flexibility markets. The Platone platform will be tested in three European trials (Greek, Germany, and Italy) and within the Distributed Energy Management Initiative (DEMI) in Canada. The Platone consortium aims to go for a commercial exploitation of the results after the project is finished. Within the H2020 programme “A single, smart European electricity grid” Platone addresses the topic “Flexibility and retail market options for the distribution grid”.

Comprehensive testing of the Platone vision and the components developed by the project is of utmost importance for their further market viability after the end of the project. The demo activities must therefore take into account the main challenge which the DSOs are facing already now and will increasingly be facing in the future, as we move towards a carbon-neutral energy system, which is to facilitate the energy transition. The European DSOs integrate the vast majority of renewables in Europe, the amount of which continues to increase. To cater for these consumers who will take an active part in the energy market, the DSO must become more than just classic electricity supplier while keeping the system and the distribution safe and reliable. The challenge for the DSOs is therefore to maintain and develop their networks in such a way which will allow these climate-friendly developments to continue without disturbances to the supply. One way to deal with this can be to deploy new infrastructure with greater capacity; however, this only solves part of the challenge and is very costly. Instead, the Platone demos flexibility measures, smart grid technologies and market tools to make more optimal use of energy resources and enhance the observability of the grid. This deliverable is dedicated to giving an overview of the activities in the three demos which will altogether apply and test the Platone vision outlined above.

## 1.1 Task 1.1

Task 1.1. “Use Case definition and operation specification” has been performed during Platone’s first year. The task provides the basis to compare the different use cases and to understand the overall strategy of the Platone field trials bearing in mind the project objectives, which can be summarised in with following aims:

1. Unlock flexibility to address local congestion and voltage stability;
2. Improve grid operation through advanced observability approach;
3. Improve customers engagement and facilitate their fair participation in the market;
4. Support cooperation with the TSO;
5. Ensure reliable and secure power supplies in the context of increasing DER penetration.

In the view of these goals, Platone aims to test the following three aspects:

1. Flexibility measures and electricity grid services provided by storage of electricity, power-to-x, demand response, and variable generation enabling additional decarbonisation;
2. Smart grids technologies for an optimum observability and tools for a higher automation and control of the grid and distributed energy sources, for increased resilience of the electricity grid and for increased system security

3. Market mechanisms incentivising flexibility or other market tools should be defined and tested for mitigating short-term and long-term congestions or other problems in the network.

The specific methodology and analytical tools applied to Task 1.1 are further developed in chapter 2.

Task 1.1 constitutes the base for the scalability and replicability analysis, which is to be developed within Task 7.1 and Task 7.2.

## 1.2 Objectives of the Work Reported in this Deliverable

The objective of this deliverable is to compile and compare the use cases (UCs) of the three Platone demonstrations according to the objectives that they aim to test and the solutions they plan to apply. The deliverable will as well identify the DSO operation specifications as part of the SGAM layers representation. This method will be shared with WP6 and WP7 in order to ensure a consistent project framework representing business models, functional requirements, communication and data model standards across the project demos. The SGAM analysis will serve as an input to the development of the Platone platform developed in WP2 and support the scalability and replicability analysis developed in WP7.

## 1.3 Outline of the Deliverable

Chapter 2 defines the methodology and the analytical tools applied to compare the different demo use cases as well as demo architecture. Chapter 3 is dedicated to the demonstrations, with one sub chapter per country. Each sub chapter introduces the architecture of the demonstration site in question before presenting its UCs in general terms. Building on the information summarised in chapter 3, a representation and analysis based on the Smart Grid Architecture Model is provided in chapter 4 taking into consideration the information available after the first year of the project. Chapter 5 presents the similarities and differences between the demos and their use cases to give a holistic overview of the demonstration activities in the project. Conclusions from the work are drawn in chapter 6.

## 1.4 How to Read this Document

This document sums up and compares the use cases in the different demos. The complete use case descriptions elaborated by each demonstration can be found in the annexes of this deliverable as well as in the online repository, GitHub (see chapter 2.2.2).

Further details regarding the Italian demonstration, use cases and specific KPIs can be found in the deliverables:

- D3.2 “Report of optimal communication solutions between customer database and market players” [1];
- D3.3 “Delivering of technology (v1)” [2];
- D3.6 “Report on first integration activity in the field” [3].

Further details regarding the Greek and German demonstrations, their use cases and specific KPIs can be found in the D4.1 [4], D5.1 [5] and D5.2 [6].

The work presented in this deliverable has been done in parallel with the work in Task 1.3, which sets out the KPIs specific to the project. This work is represented in the D1.2. “Project KPI definition and measurement methods” [7].

While this document touches the application of the Platone platforms across the demos, a detailed description of the Platone platforms can be found in D2.1 [8].

# 2 Methodology

This chapter aims to describe the methodology applied to develop this deliverable. The first subchapter outlines the methodology applied by the Platone partners to develop this work. Subchapter 2.2. is dedicated to the core analytical framework applied, the Smart Grid Architecture Model, with specific sub chapters devoted to the mapping method within the framework (2.2.1) and to the storing of the information (2.2.2). Finally, subchapter 2.3 describes the specific definitions applicable to the work reported in this deliverable.

## 2.1 The Platone Methodology

The first step to develop a description at project level of the Platone demonstrations was to enhance the understanding of the particularities of each demo. This was done using a template based on the IEC 62559 standard for UCs, which is widely used in European projects. A questionnaire based on the template was circulated among all the project partners and tested at a first workshop session during the Project General Assembly in January 2020, to gain a common understanding of the methodology. This also allowed the project participants to enhance the understanding of the information needed to describe the use cases as well to get a common understanding at project level of the task. After the first initial feedback and information gathering, the Platone demonstrators continued the elaboration of their use case description in the online repository 'GitHub' described in chapter 2.2.2. This made it possible for participants outside the demonstrations to follow the elaboration of the use cases, as well as to provide continuous feedback to demos during the monthly WP calls as well as additional task calls set up ad-hoc according to the needs.

To ensure coherence at the project level, a second workshop was organised with the aim to check similarities and differences among the use cases. The participants, including work package 1 partners and the demo leaders discussed current needs of network operators and compared these to the use cases they had been less involved in Platone UCs were then mapped according to general system challenges for grid operators and the project objectives. Based on these discussions, it was possible to develop the Use Case cluster overview, which is presented in chapter. 5.

## 2.2 SGAM

The Smart Grid Architecture Model (SGAM) framework [9] is a well-known analytical tool to map smart grid use cases. The SGAM framework and its methodology allow the graphical representation and analysis of Smart Grid use cases in an architecturally and technologically neutral manner highlighting their interoperability aspects in its five interoperable layers, each layer covering a two-dimensional Smart Grid Plane. The Smart Grid Plane spans in two dimensions the complete electrical energy conversion chain constitutes one dimension, i.e. Bulk Generation, Transmission, Distribution, DER and Customers Premises domains, while the second dimension consists of the hierarchical levels of power system management, i.e. Process, Field, Station, Operation, Enterprise and Market. The SGAM framework allows both the business and technical viewpoints to be represented in five interoperable layers, i.e. the component, communication, information, function and business layers,

The information needed to perform the SGAM analysis is gathered in a UC template following the IEC 62559-2 standard [10] and available in Annex A. Based on the description of a use case the required level of abstraction in the SGAM layer(s) can be described. Actors and functions can be extracted from the narrative of the use case. Moreover, the use case can be mapped on the Smart Grid Plane of the SGAM framework in the affected domains and zones. In Platone, the UCs are defined in the Platone UC repository [14]. With its layers, zones and domains the SGAM analysis provides a comprehensive overview of activities related to the smart grid and will be used in this deliverable to sum up the various demo activities in one analysis.

### 2.2.1 SGAM Mapping Method

The UCs are mapped onto the layers of the SGAM framework by the SGAM mapping. For the component, function, communication, and information layers, the SGAM mapping is presented on an overall Platone level, covering the UCs of the German, Greek and Italian demos. In addition, an SGAM mapping on the level of the individual demos and on the level of the individual UCs is presented. The SGAM Mapping thus offers a synthesis of the information available at UC level. The exception to this approach is the business Layer, which is presented on a per-UC basis.

In addition, a first version of a per-UC SGAM mapping of the component, function, communication and information layers is included in Annex C. These per-UC mappings are at the level of a first draft and are likely to be subject to slight modification and integration during the project.

### 2.2.2 Smart Grid Use Case Repository and Methodology

Platone's approach to provide use case definition tools and a Use Case Repository is to avoid using proprietary tools and repository solutions. Platone has adopted an approach to defining UCs that did not require Platone partners to take out licenses to commercial products in order to define their use cases and wanted to use a repository that would enable Platone's Use Cases to be freely available for use after the project. In addition, Platone wanted to avoid the cost and effort developing a new repository but to use an existing repository framework as basis for a solution.

Platone has therefore targeted a solution for the definition and storage of use cases based on freely available technologies and platforms. The aim is for the Platone Use Case repository to also fulfil H2020 BRIDGE's recent call for a general use case repository in which existing and future use cases of European RD&I projects can be gathered and made freely available.

Platone's approach has recognised when, on July 1st 2020, the Bridge workgroup on Use Cases selected the Platone approach as the standard to be used to store the Use Cases for all the H2020 projects.

Some detailed requirements of the tool for definition and storage of the UCs are as follows:

- A web page where UCs can be entered and edited
- Access to this web page controlled by login procedure
- An IEC-62559 compliant UC template already available for editing
- Support for editing of UCs with markdown files, supporting text and graphics (fixed pictures, .png for example or Visio files).

**The Solution: Smart Grid Use Case Repository**

Platone decided to use GitHub as the web tool and repository for developing and storing the UCs. Using GitHub for the Platone UC repository means that the basic repository functionality of storing and versioning of files and multi-user collaboration is available. Also, using GitHub has proved to be an efficient tool for development and review of UCs. The GitHub has two repositories:

- A **smart-grid-use-cases development environment** in GitHub where UCs can be worked on [12]. In this environment, there are project-specific folders, e.g. the folder where the Platone UCs are developed, where Platone partners submit and edit the UCs.
- A general-purpose repository for UCs from different projects, called the **Smart Grid Use Case Repository** [13]. This repository's purpose is to be a place where UCs are freely available to users. No GitHub account is needed to access it. The Smart Grid Use Case Repository is generated from the UC development environment with the following automation toolchain.

**Automation Toolchain for Generating Smart Grid Use Cases Repository**

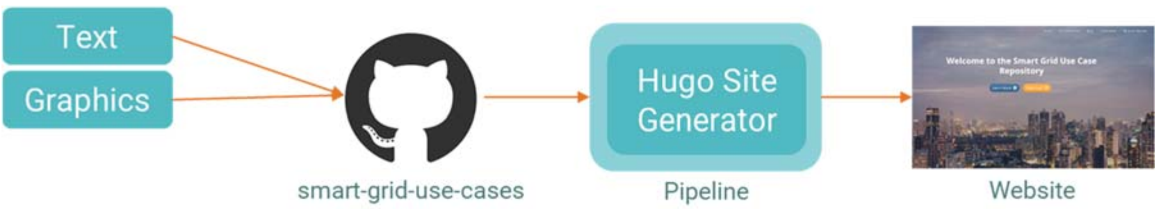


Figure 1: Automatic Generation of Smart Grid Use Cases Repository from smart-grid-use-cases GitHub

The Smart Grid Use Case Repository is automatically generated from the smart-grid-use-cases GitHub using the open-source Hugo[1] and Docsy[2] tools, as shown in Figure 1:

Hugo is a static site generator that we use to transform the content of the "github-pages" of the smart-grid-use-cases repo to a website. Basically, it does markdown to HTML conversion. Docsy is a template for Hugo to determine the design of the generated website.

In a second step, the generated site is copied in to the "smart-grid-use-cases.github.io" repository.

**Using the UC Repository in Platone**

A markdown UC template was used as base for the preparation of the Platone UCs. Each UC has a folder in the Platone UC repository on GitHub [14] where the UC description is written in markdown, linking to the UC diagrams, which are also stored in the folder.

The Platone UC repository is publicly readable. Users can edit the UC descriptions directly in the web browser. Making changes to the files requires branching or forking the repository and then pushing the changes. Any changes need to be accepted by a person with maintainer rights for the repository (i.e. an authorised Platone project member).

There is also a button to create issues, which can be tracked in GitHub.

**Diagrams in UCs**

Diagrams can be linked to the UC descriptions as images (.svg, .png etc.), thus avoiding prescribing any particular drawing tool on the UC developers. Any drawing tool can be used to draw the diagrams e.g. draw.io or Visio.

For example, for the case of Visio, the proprietary Visio file can be stored in original format in the repository, as well as versions of the diagrams as images, which can be linked to the UC descriptions.

**Use of XML**

Mapping of the UCs in XML format [11] to HTML for publishing on the Smart Grid Use Cases Repository, as shown in Figure 2, is planned in the timeframe of Platone.

This functionality means that existing UCs written in Enterprise Architect could be exported from there in XML format to be processed and published on the Smart Grid Use Cases Repository.


Figure 2: Automatic Generation of Smart Grid Use Cases Repository from smart-grid-use-cases GitHub and XML files

## 2.3 Terminology

This deliverable as well as the rest of the work in WP1 has been carried out in close collaboration with the rest of the work in the project. The terminology below is as well the result of WP2 efforts and summarises a list of the terms used in this deliverable and their definition. The full list of terms applicable to the Platone project as well as detailed descriptions of the Platone platforms' architecture can be found in D2.1 [8]

[1] https://gohugo.io/

[2] https://www.docsy.dev/

| Term | Description |
|---|---|
| Actor | An actor is an entity participating in the Use Case. Actors can be of three types: devices, systems and persons (humans or organisations). |
| Application Interface | An Application Interface represents a point of access where application services are made available to a user, another application component, or a Node. It specifies how the functionality of a Component can be accessed by other elements. An Application Interface exposes Application Services to the environment. |
| Blockchain | A blockchain is a digital record of transactions. The name comes from its structure, in which individual records, called blocks, are linked together in single list, called a chain. |
| Communication Protocol | Defined set of rules that allow two or more systems to transmit information. The protocol defines the rules, syntax, semantics and synchronization of communication and possible error recovery methods. Protocols may be implemented by hardware, software, or a combination of both |
| Component | A Component represents an encapsulation of functionality aligned to implementation structure, which is modular and replaceable.<br><br>A Component is a self-contained unit. As such, it is independently deployable, re-usable, and replaceable. A Component performs one or more Application Functions. It encapsulates its contents: its functionality is only accessible through a set of Application Interfaces |
| Demo Architecture | A specific demo architecture represents the list of specific demo platforms and functionalities that will be used in the different demo sites. |
| Demo Site | A demo site is a pilot test of the Platone Open Framework in a specific geographic area. Platone has three demo sites in Italy, Greece, and Germany. Each demo site will run its own demo architecture integrating the Platone Open Framework. The demo sites could run in different locations in the country depending on the use cases. |
| Device | A Device represents a physical IT resource upon which system software and artifacts may be stored or deployed for execution. It is typically used to model hardware systems such as mainframes, PCs, or routers. Usually, they are part of a node together with system software |
| Flexibility Market | Flexibility market helps energy networks to manage energy flows and create market signals to motivate changes in energy supply and demand, integrating smart meters, smart appliances, renewable energy resources and energy efficient resources accordingly.<br><br>In Platone, the Market Platform (see Platone Platforms) is a component that enables the flexibility market, making available a virtual place where the requests of flexibility match the offers. |
| Flexibility Service | The capability to change power supply/demand of the system as a whole or a particular unit, for responding to particular needs of the network. Some possible examples of flexibility services are: load balancing, congestion management, voltage control, inertial response and black start. |
| Functional Requirement | Functionalities, behaviour, and information that the solution will need |

| | |
|---|---|
| Interchangeability | The ability that an object (device, component) can be replaced by another without affecting system |
| Interoperability | Characteristic of a system to work with other systems in a clear and standardized way, without any restrictions |
| Non-Functional Requirement | The conditions under which the solution must remain effective, qualities that the solution must have, or constraints within which it must operate (reliability, testability, maintainability, availability) |
| Platform | Complex collection of systems, interfaces and processes integrated into each other for providing a set functionalities and services |
| Platone Platforms | The three core systems of the Platone Open Framework:<br>Platone Market Platform: Virtual Place where the requests of flexibility match the offers (developed and implemented within WP2;<br>Platone DSO Technical Platform: A software-based system that manages the distribution network. It performs grid state estimation and forecasting of production and consumption. Moreover, it defines the flexibility requests for DSO's grid. The DSO Technical Platform exchanges data with SCADA and other system comprised in the Operation Domain;<br>Platone Blockchain Access Platform: A software-based platform that certify, on Blockchain technology, the customers' data for flexibility and observability. |
| Person | A human user or entity that interacts with the subject under development |
| Requirement | A requirement is a singular documented physical or functional need that a particular design, product or process aims to satisfy. |
| Smart Contract | A smart contract is a self-executing contract with the terms of the agreement between buyer and seller being directly written into lines of code. The code and the agreements contained therein exist across a blockchain. The code controls the execution, and transactions are trackable and irreversible. Smart Contracts facilitate, verify, or enforce the negotiation or performance of contracts, allowing the execution of credible transactions without third parties. [3] |
| System | A software (Component) or Hardware (Device) that interacts with the subject under development |

**Table 1: Terminology used in D1.1**

[3] https://blockgeeks.com/guides/smart-contracts/

# 3 Use Cases of the Platone Demonstration Sites

The Platone Use Cases contribute to addressing the Platone objectives identified by the project as described in chapter 1. In the following a short introduction to each of the demo are given followed by a resume of its use cases. Details on involved actors and technologies are presented in chapters 4.1 and 4.2, while the UC diagrams are available in Annex A as part of the completed IEC-62559 templates per UC.

## 3.1 Italian demo – ARETI

The Italian demo is coordinated by Areti, the DSO of the Italian capital. Areti is Italy's third largest operator in terms of volumes of electricity distributed, with 10 TWh transported per year equal to 3.7% market share, and Italy's second largest operator in terms of withdrawal points, exactly, it manages 1,630,000 withdrawal points and 11,000 prosumers.

The Italian demo aims to carry out a comprehensive implementation of a **new local energy flexibility market** in a large metropolitan area of Rome, involving flexible resources connected in medium and low voltage in order to solve the TSO and DSO networks issues.

An **inclusive and complete end-to-end flexible** environment where the customer interacts with the Aggregator for accessing the flexibility market, by using the DSO's communication and infrastructure, becoming an active player capable to provide network services for the stability of the electrical system.

Hence, **all the customers** connected to the distribution grid can provide flexibility to the TSO and DSO in a Common Market, where the requests made by System Operators match the offers (that also gather the retail flexibility) presented by the Aggregator.

To reach this aim, the Italian Demo is implementing an innovative multi-layer System Architecture composed of multiple platforms based on the application of blockchain technologies and new grid equipment, allowing to promote an **efficient, democratic and non-discriminatory market model** for the exploitation of local flexibility with the involvement of all relevant players (TSO, DSO, Aggregator, end-users etc.).To break down the economic barriers and increase the trust in the energy exchanges, an innovative device, named Light Node, is installed by the DSO on the customer smart meter. The Light Node uses the blockchain technologies and shares the information with the main stakeholders, storing the data in a common database.

The trial involves several areas of the city. Specific portions of the electricity distribution network, sufficiently representative in terms of voltage levels, transformer size, number of users and cable length have been identified and selected. Some secondary substations are equipped with smart technologies interfaced with the central operational system, allowing to increase the observability and to improve the grid simulation.

The first areas selected for the Italian demo implementation and use cases execution are the following:

1. **EUR – Tor di Valle district**
   Located near the Tiber river, this is a residential area hosting one of the biggest European Wastewater Treatment plant powered by a high efficiency cogeneration plant. Tor di Valle is a "green neighbourhood": the houses located in the area are connected to the district-heating network fed by the cogeneration plant heat. In this area, there are several prosumers that use the energy provided by rooftop solar power plants for self-consumption, and some buildings interested in realizing collective self-consumption. In Tor di Valle area, voltages issues could be mainly due to the increasing penetration of Renewable Energy Resources (RES), expected for the next years, especially during the hours of low consumptions. The grid congestions, instead, can be caused by the electrification of the load (heat pumps, induction hobs, boilers and electric vehicles). The use of flexibility can help to manage congestion and voltage violations avoiding investment for upgrading the system.

2. **Ostiense district**
   This is a central and historical neighbourhood of Rome, but it is also an important railway junction attended every day by thousands of people. The zone includes the Aventino Hill, so

downstream there are the infrastructures for industrial and social activities, such as Acea's headquarter, several service companies, a bus station and a railway station; upstream, there are the residential zones. For the last two years, Areti has been updating the grid of this area, installing secondary substations technologies to increase the observability. In this area, the Italian demo aims to improve the simulation tool and test the flexibility provided by smart EV parking located in the district, to solve local congestion that occur during the hot season when the cooling loads are highest.

3. **Centocelle district**
This is a large and popular neighbourhood located in the southeast of Rome. Here, the residential buildings usually host ten apartments and shops located on the ground floor. Customers involved in the Italian demo belong to an already existing Citizen Energy Community (CEC). The users of the virtual community are distributed over a broad territory, and it is therefore very important to implement a coordination activity, thanks to the role of the aggregator. The Italian demo aims at testing the demand response of the CEC to respond to the local flexibility requests, in order to solve the congestion and the voltage issues.

Once the System Architecture is released and made operative, the Italian demo will execute two main use cases in the target areas regarding "Voltage management in transmission and distribution systems" and "Congestion management in transmission and distribution systems" (described below, in chapters 3.1.1. and 3.1.2).

### 3.1.1 UC-IT-1 – Voltage Management

| Name | Voltage management in transmission and distribution systems |
|---|---|
| Scope | Avoiding the voltage violations in distribution and transmission grid by use of flexibility resources connected to the transmission and distribution systems that provide ancillary services through a market mechanism. |
| Networks | MV, LV (HV users have their own market) |
| Markets | Day-ahead, Near Real Time |
| Objective | • To support the TSO in using flexibility provided by the resources connected to the distribution system for voltage violation, respecting the distribution system constraints<br>• To ensure an inclusive and non-discriminatory access to the market to all the actors that provide grid services<br>• To empower coordination between system operators<br>• To activate flexibility to solve voltage violations in the distribution grid |
| Description | This use case describes the **main steps to avoid voltage violations in transmission and distribution systems by exploiting flexibility resources**, contemplating all the phases concerned (procurement, activation and settlement) in the day-ahead and real time flexibility market. The DSO can use flexible resources connected to the distribution system and the TSO can use flexible resources connected to distribution systems under the DSO's approval. The state estimation is assessed and monitored respectively by DSO in order to keep the electrical quantities within admissible ranges.<br><br>In the day-ahead market, the FR Owner sends to the Aggregator Platform the list of resources available for the day after. The list is subsequently transmitted by the Aggregator Platform to the Italian Shared Customer |

| | |
|---|---|
| | Database (SCD). For each Point of delivery (PODs), the SCD collects quarterly measures and data useful for flexibility and sends them to the DSO Technical Platform, the TSO simulator and the Aggregator Platform.<br><br>Other three processes take place in parallel:<br><br>• Detection of voltage violations on the distribution grid by the Italian DSO Technical Platform and definition of local flexibility requests, in the event the issue cannot be solved through its own solutions.<br><br>• Definition of voltage violations on the transmission network by the TSO simulator and request of flexibility to solve them in HV grid.<br><br>• Gathering by the Aggregator Platform of flexibility offers from customers in LV and MV and offering to the Market Platform.<br><br>At gate closure, all day ahead requests and offers are stored in the Market Platform, which matches the offers with the DSO's requests and orders them economically; then, it repeats the same procedure with the TSO requests.<br><br>The list of awarded offers is sent to DSOTP for evaluating the grid constraints violations. Finally, the market platform receives the list of offers compliant with local grid constraints and sends it to all the stakeholders.<br><br>At this step, the Aggregator Platform sends a reservation to the FR Owner for the resources that will be selected for the day-ahead market.<br><br>The same steps are also followed in the Real Time sessions. Indeed, in these Market sessions, the offers to be matched with DSO and TSO Real Time requests are the ones still valid because not matched in previous market sessions.<br><br>The activation phase begins when the DSO and TSO need flexibility. The DSOTP and the TSO simulator communicate to the market Platform to move a specific offer. The Market Platform sends the order to the DSOTP, which divides it for every POD and dispatches the set point to the light nodes. The light nodes make available the set points to the BMS and measures the electrical quantities to be sent to the SCD for evaluate the energy flexibility.<br><br>For the settlement phase, the Market Platform acquires data from the SCD and calculates the difference between market baseline, evaluated by BRP, and electrical quantities measured in the same time frame, uploaded in the SCD by Light Nodes. The Market Platform runs the settlement algorithm and finds the outcomes. Settlement outcomes are transmitted to the Aggregator Platform, the DSO and the TSO Simulator.<br><br>Finally, the DSO pays the flexibility to the Aggregator, who can pay the fee to the FR Owner. |

### 3.1.2 UC-IT-2 – Congestion management

| Name | Congestion management in transmission and distribution systems |
|---|---|
| **Scope** | Avoiding the Congestions on the distribution and transmission grids, by use of flexibility resources connected to distribution system, that provide flexibility services through a market mechanism. |

| | |
|---|---|
| **Networks** | MV, LV (HV users have their own market) |
| **Markets** | Day-ahead, Near Real Time |
| **Objective** | • To support the TSO in using flexibility provided by resources connected to the distribution system for congestion management, respecting distribution system constraints<br>• To ensure an inclusive and non-discriminatory access to the market for all actors that provide grid services<br>• To enable and empower coordination between system operators<br>• To activate flexibility to solve congestions in the distribution grid |
| **Short description** | This use case describes the steps to **prevent congestion issues in transmission and distribution systems, by using flexible resources**, contemplating all the phases concerned (procurement, activation and settlement) in the day-ahead and real time flexibility market. The DSO can use flexible resources connected to the distribution system and the TSO can use flexible resources connected to distribution systems under the DSO's approval. The state of the grid is assessed and monitored respectively by DSO in order to keep the electrical quantities of the system within admissible ranges.<br><br>Main steps described for the UC-IT-1 are valid also for UC-IT-2. |

## 3.2 Greek demo – HEDNO

The Greek demo is led by the Greek DSO HEDNO and is situated in Mesogia in the Attica region which encompasses a mix of rural and urban and sub-urban areas servicing Athens as well as the islands Kea, Andros and Tinos. The area counts 226,558 customers at LV and MV, varied from households to small, medium and large industries. The area benefits from installations of various forms of renewables, windfarms and PV including as well net metering and rooftop PV.

The Greek demo aims at testing the Platone architecture and investigating whether the novel approach of a variable instead of a flat network tariff will incentivise appropriately customers with flexible loads, and lead to an optimal dispatch for the distribution network. The trial in the Mesogia site will also develop state estimation techniques for grid forecasting and real-time grid monitoring purposes to both enhance distribution network operation and allow the exploration of diverse dispatch scenarios. PMUs to be installed in selected nodes of the demo site will further improve the observability of the associated network to provide technically the most accurate results.

The Greek demo is elaborated together with NTUA and will test five different uses cases (described below, in chapters 3.2.1 - 3.2.5).

### 3.2.1 UC-GR-1 – Functions of the State Estimation tool given conventional measurements

| Name | Functions of SE tool given conventional measurements |
|---|---|
| **Scope** | The scope of the UC is to investigate whether a high quality estimative of the network state will be acquired via the state estimation tool in real-time conditions under various network operation scenarios. The estimated network state will be used as an input to distribution management applications. |

| | |
|---|---|
| **Networks** | MV |
| **Markets** | Near real time, Day Ahead |
| **Objective** | *To improve confidence in actual measurement data obtained throughout the network as well as available load forecasts.<br>*To capture the real-time operational network state. |
| **Short description** | The UC investigates the capability of the state estimation tool to filter the available measurement data, comprising actual measurements obtained from active metering devices and pseudo-measurements, i.e. data derived from load forecasting or RES scheduling for network observability accomplishment, in order to identify measurement with gross errors (bad data), to suppress measurement errors, to reconcile inconsistent data and, ultimately, to estimate the actual operational network state.<br><br>The goal is to ensure that high quality estimative of the network state will be acquired via the state estimation tool in real-time conditions under various network operating scenarios. The estimated network state will be used as an input to distribution management applications. |

### 3.2.2 UC-GR-2 – PMU data integration into SE tool

| **Name** | **PMU data integration into SE tool** |
|---|---|
| **Scope** | The scope of the UC is the integration of measurement data obtained from PMUs into the State Estimation tool. |
| **Networks** | MV |
| **Markets** | Near real time, Day Ahead |
| **Objective** | • To reinforce network observability and controllability via improved state estimation performance.<br>• To ensure smooth incorporation of synchronised measurement data derived from PMUs into the pre-existing system of conventional measurements. |
| **Short description** | Measurement data obtained from the installed PMUs are integrated in the State Estimation tool and used to enhance the network observability. The installation of PMUs at selected buses is sure to upgrade the overall metering infrastructure of the network, since they record synchronized measurements of bus voltage phasors as well as a number of line current phasors—all of which are independent of each other and count as individual measurements. However, proper utilization of the PMUs via the SE tool is a challenging task. This owes to the intense discrepancies in update rates between conventional and PMU measurements, to the provision of current measurements which often lead to various numerical problems, and to the contrast between the large weighting factors linked to PMU measurements compared to the much lower ones linked to pseudo-measurements, which usually raises ill-conditioning issues. The goal is to ensure that the integration of PMU data will be smooth, and all the previously mentioned problems will be circumvented. |

| | |
|---|---|
| | In this way, the overall performance of the SE tool will be enhanced; the network state will be calculated with increased precision; and the high quality real-time operational standards for distribution management applications will be met. |

### 3.2.3 UC-GR-3 – Distribution Network limit violation mitigation

| **Name** | **Distribution Network limit violation mitigation** |
|---|---|
| **Scope** | The scope of the UC is to examine the operational use of flexibility tools in order to satisfy EN50160 in case of a voltage level limit violation in the distribution network or mitigate line congestion, especially in MV lines with flexible loads availability. |
| **Networks** | MV |
| **Markets** | N/A |
| **Objective** | • To use network tariffs in order to incentivise a more efficient operation of the network while respecting operation limits (voltages, lines). |
| **Short description** | The DSO will examine the operation of tools and services for decision making support to mitigate voltage/thermal line limits violations, assuming that the grid state estimation has a good degree of certainty. For that purpose, various types of flexible loads -aggregated for the scope of the Use Case- react to network tariffs sent by the DSO. |

### 3.2.4 UC-GR-4 – Frequency support by the distribution network

| **Name** | **Frequency support by the distribution network** |
|---|---|
| **Scope** | The scope of the UC is to examine the operational use of flexibility tools in order to satisfy that line and voltage limits of the distribution network are not violated in the case of a frequency support request by the transmission system. |
| **Networks** | MV |
| **Markets** | Near real time |
| **Objective** | • To keep the distribution network within physical limits (line and voltage) with appropriate actions in the case of a frequency restoration reserve activation request by the TSO |
| **Short description** | Various types of flexible loads -aggregated for the scope of the Use Case- react to network tariffs sent by the DSO, so that frequency restoration request from the TSO is adequately handled. More in detail, customers with flexible loads will respond to such requests and the DSO will use flexibility tools to coordinate their response aiming at achieving the frequency support objective while ensuring distribution network operational safety. As in the |

| | |
|---|---|
| | previous Use Cases, the state of the system is provided by the state estimation tool. |

### 3.2.5 UC-GR-5 – PMU integration and Data Visualization

| Name | PMU integration and Data Visualization for Flexibility Services Management |
|---|---|
| Scope | The scope of the UC is to examine the integration and operational use of low-cost PMUs in order to increase network observability collecting measurement data such as voltage, current and phases in various points of the distribution network. |
| Networks | MV |
| Markets | Near Real Time |
| Objective | • To increase network observability.<br>• To integrate data coming from different sources in the Platone DSO Technical Platform. |
| Short description | PMUs are installed in critical network nodes to increase network observability. PMU measurements along with other DSO data (network topology, customer loads, etc.) are integrated in the Platone DSO Technical Platform to be visualised in a User Interface (UI), so that DSO can make use of tools and services developed in the project. Aforementioned data is going through the Platone Blockchain Access Platform developed in the project to ensure data access security and data integrity. |

## 3.3 German demo – AVACON

The German demo is led by the German DSO AVACON and situated in a rural area denominated by a low residential and commercial consumption and a high penetration of DER. AVACON has over the past years been uprating numerous of its distribution transformers and lines to account the increasing number of distributed RES.

The strategic aim of the demo is to develop and test innovative strategies for the integration of future energy community into DSO grid operation strategies to increase hosting capacities of distribution grids and make them more efficient. In frame of the field test trial Avacon will set up a testing environment and integrate local customers and RES in a local EMS enabling the community to maximize local consumption, provide flexibility on external request and apply new strategies of energy supply based on a package based energy delivery and export approach.

The German demo will execute four use cases (described below, in chapters 3.3.1-3.3.4).

### 3.3.1 UC-DE-1 – Islanding

| Name | Islanding |
|---|---|
| Scope | The scope of the UC is the implementation of an EMS that operates a specific low voltage network in virtual island mode, i.e. minimization of the power exchange with the connected medium voltage feeder by utilizing |

| | |
|---|---|
| | available flexibility (local energy storage systems and controllable loads). The UC focuses on a local energy community. |
| **Networks** | LV |
| **Markets** | N/A |
| **Objective** | • Maximize consumption of local generation/Minimize demand satisfied by public grid<br>• Islanding of local grid by making use of flexible loads and storages<br>• Maximizing duration of islanding operation UC-DE-1 is prerequisite for UC-GE-2-3-4 |
| **Short description** | The use case "Islanding" of an energy community aims to balance generation and demand of a local energy community in such a way that the load flow across the connecting MV/LV transformer is reduced to a minimum. The balancing is enabled by an EMS called Avacon Local Flex Controller (ALF-C). The ALF-C monitors the power flow across the transformer and controls a battery energy storage system (BESS) connected directly to the LV-terminal of the substation. Generated energy surplus will be stored in the BESS and released at times of a generation deficit. Private households equipped with batteries and controllable electric heaters can be dispatched to increase the degree of self-sufficiency further. |

### 3.3.2 UC-DE-2 – Third Party Flex Request

| Name | Third Party Flex Request |
|---|---|
| **Scope** | Communities with a high penetration of photovoltaic systems and correspondingly high installed generation capacity can be expected to generate an energy surplus during times of peak generation and low local demand, and vice versa to run into an energy deficit during seasons of low generation. Surplus energy can be stored and shifted to times of low generation in order to satisfy temporary demand and hence increase the degree of self-sufficiency. UC-DE-2 demonstrates how the flexibility required to enable a local balancing mechanism could temporarily be allocated to other uses, for example the provision of flexibility to a third party, e.g. the connecting grid operator. Use Case 2 uses the available flexibility in a given local energy community to maintain an externally defined non-zero setpoint at the point of connection. |
| **Networks** | LV |
| **Markets** | N/A |
| **Objective** | Maintain a fixed non-zero power exchange between energy community and the distribution network for a limited duration. |
| **Short description** | Local energy communities are likely to emerge in Europe in the near future but will most likely retain an interconnection to the distribution grid. These communities will require a large share of flexibility to enable their primary use case. Situations could arise that require the community to provide |

| | |
|---|---|
| | flexibility to third parties – driven by technical circumstances or following economic considerations (market incentives). Use Case 2 demonstrates the ability and practical feasibility of a local community to maintain constant non-zero power exchange with the distribution network for a previously defined duration. |

### 3.3.3 UC-DE-3 – Energy Delivery

| **Name** | **Energy Delivery** |
|---|---|
| **Scope** | Energy communities with a high proportion of self-generation and flexible consumers and storage can maximize the self-consumption of locally generated energy. These communities are unlikely to meet their own needs with locally generated energy throughout the year and will potentially run into energy-deficit in times of low local generation. Energy deficits could be compensated by the supplying distribution network. To reduce the stress on the mid-voltage feeder and reduce overall network cost, energy deficits occurring could be forecasted and delivered in discrete packages ahead of time at fixed time slots and be stored in local storages until demand arises. |
| **Networks** | LV, MV |
| **Markets** | N/A |
| **Objective** | • Enabling temporary islanding even in times of energy deficit of the local community<br>• Forecasting of residual energy demand of an energy community<br>• Forecasting of residual energy generation of an energy community<br>• Execution of power exchange schedule for the energy community for the grid connection point LV/MV (time and power of load exchange)<br>• Determination of a setpoint schedule for individual local asset to meet energy community setpoint schedule<br>• Execution of defined power exchange between energy community and the distribution network |
| **Short description** | Local energy communities (LEC, CEC) are likely to emerge in Europe in the near future but will most likely retain an interconnection to the distribution grid. These communities will require a large share of flexibility to enable their primary use case (islanding).<br><br>In the absence of sufficient generation and storage, the community is unlikely to be self-sufficient at all times. When energy deficits occur, they must be provided by the distribution network. Instead of a real time energy supply by the connected distribution network, energy deficits could be forecast and supplied as an energy package with a defined time, duration and power value for the load exchange at the LV/ MV-grid connection point that connects the community with the distribution grid. The energy package shall be stored in local storages within the community and available for use, when the demand is rising. Outside of the defined periods of energy provision, no power exchange shall all the grid connection point shall take place, according to DE-UC1. This use case enables the DSO to reduce overall network costs, for example by gaining the ability to stagger the |

| | |
|---|---|
| | demand of multiple communities along a single feeder, thusly reducing the factor of coincidence of peak load and peak load level accordingly. |

### 3.3.4 UC-DE-4 – Energy Export in Discrete Packages

| Name | Energy Export in Discrete Packages |
|---|---|
| **Scope** | Energy communities with a high proportion of self-generation and little amount flexible consumers, can make use of local storages to maximize the self-consumption of locally generated energy. These communities are unlikely to full consume locally generated energy throughout the year and will potentially run into generation of surplus in times of low demand. Energy surplus could be exported to the supplying distribution network. To reduce the stress on the mid-voltage feeder and reduce overall network cost, generation of surplus could be forecasted, be stored in local storages and exported delayed in discrete packages at fixed time slots. |
| **Networks** | LV, MV |
| **Markets** | N/A |
| **Objective** | • Enabling temporary islanding even in times of energy deficit of the local community<br>• Forecasting of residual energy demand of an energy community<br>• Forecasting of residual energy generation of an energy community<br>• Execution of power exchange schedule for the energy community for the grid connection point LV/MV (time and power of load exchange)<br>• Determination of a setpoint schedule for individual local asset to meet energy community setpoint schedule<br>• Execution of defined power exchange between energy community and the distribution network |
| **Short description** | In the absence of sufficient generation and storage, the community is unlikely to be self-sufficient at all times. When surplus generation occurs, it must be exported into the distribution network. Instead of a real time energy export to the connected distribution network, energy surplus could be forecast and exported delayed as an energy package within a defined time, duration and power value for the load exchange at the LV/ MV-grid connection point. The generated energy surplus first shall be stored in local storages located within the community and be exported as an energy package delayed, when the load in the upper grid decreases. Outside of the defined periods of energy export, no power exchange shall take place, according to DE-UC1. This use case enables the DSO to reduce overall network costs, for example by gaining the ability to stagger the export of multiple communities along a single feeder, thusly reducing the factor of coincidence of peak load and peak load level accordingly. |

# 4 SGAM Analysis

The Platone SGAM analysis has been performed using the method outlined in chapter 2.2. The base information for the SGAM analysis comes from the detailed UC descriptions, which are available on the Platone development environment of Smart Grid Use Case Repository [14] and Annex A. This has been synthesised in order to obtain the SGAM layers. The SGAM analysis is made primarily on project level, considering the three demos and the totality of the use cases, highlighting their use of the Platone architecture (which is described in detail in D2.1). The analysis also gives insights into the commonalities shared by the demos but also their individual special characteristics. First, an overview of the Actors is given in chapter 4.1. Then the SGAM Component, Function, Information, Communication and Business Layers are developed in chapters 4.2 to 4.6. Additionally, a per-UC SGAM analysis is presented in Annex C.

## 4.1 Actors

The starting point for the SGAM analysis is to identify and categorise the entities that interact to execute the Use Cases. These entities are called Actors and are presented in Table 2, Table 3 and Table 4 according to their type. The project actors are of type Person: representing a business entity), System: an entity which processes information, and Device: an entity which produces or sinks information, following the IEC 62559-2 standard [10].

| Short Name | Actor Name | Actor Type | Description |
|---|---|---|---|
| Agg | Aggregator/ Flexibility operator | Person | A party that aggregates resources for usage by a service provider for energy market services [15]. |
| BRP | Balance Responsible Party | Person | A Balance Responsible Party is responsible for its imbalances, meaning the difference between the energy volume physically injected to or withdrawn from the system and the final nominated energy volume, including any imbalance adjustment within a given imbalance settlement period [15]. |
| CC | Commercial consumer | Person | A commercial electricity end-user. |
| DSO | Distribution System Operator | Person | Operator of the electricity distribution system. |
| FRO | Flexibility Resource Owner | Person | A natural or legal person who owns a flexible electricity resource. |
| MO | Market Operator | Person | A market operator is a party that provides a service whereby the offers to sell electricity are matched with bids to buy electricity [15]. |
| RC | Residential consumer | Person | A residential electricity end-user. |
| TSO | Transmission System Operator | Person | Operator of the electricity transmission system. Simulated in the project. |

Table 2: Platone Actors of Type Person

| Short Name | Actor Name | Actor Type | Description |
|---|---|---|---|
| AP | Aggregator Platform | System | System that gathers the data measurement from the customers, calculates the energy flexibility to offer on the market. |
| BAP | Platone Blockchain Access Platform | System | Platform that certifies by use of blockchain the customer data for the flexibility |
| BAP_Ita | Italian Blockchain Access Platform | System | Version of BAP used in Italian demo |
| BESS | Battery Energy Storage System | System | Stores electrical energy, at substation. |
| BESS_Backend | BESS Data Management Backend | System | Cloud service platform of BESS manufacturer for storing data and providing measurement data and forwarding setpoint to BESS. |
| BMS | Building Management System | System | System which manages the Flexibility Resources related specifically to buildings. |
| CL | Consumer Load | System | Load from household, agricultural Buildings |
| DM_Backend | Sensor & Controller Data Management Backend | System | Cloud service of assets vendor (can be individual for different assets) storing data, providing measurement data of asset and/or interface for transmission of setpoints to asset. |
| DMS | Distribution Management System | System | An IT system that supports the overall distribution grid management including functions that automate outage response and optimised grid operations among others. |
| DSODS | DSO Data Server | System | Data storage system in Greek demo |
| DSOTP | Platone DSO Technical Platform | System | An IT environment that includes all the tools and services that enable monitoring and control of the grid to allow DSOs to manage the distribution grid in a secure, efficient and stable manner. |

| | | | |
|---|---|---|---|
| DSOTP_Ita | Italian DSO Technical Platform | System | A software-based system that manages the distribution network. It performs the grid state estimation and the productions and consumptions forecasting. Moreover, it defines the flexibility requests for DSO's grid. The Italian DSO Technical Platform communicates with all the systems included in the Operation Domain. |
| EMS | Energy Management System | System | System to monitor, control, and optimize the energy consumption and production.<br>Note: internally in the Italian demo, the customers' BMS, which acts on the set-point make available by Light-Node, is called EMS. |
| FL | Flexible Loads | System | Night Storage Heater, Heat Pumps |
| GIS | Geographic Information System | System | System to store, analyse and visualise geographical data. |
| HES | Household Energy Storage | System | Stores electrical energy. |
| IntCon | Integrated Controller | System | Summarises all controllers that are already installed in local flexible loads. |
| LN | Light Node | System | Device installed on the DSO's smart meter in order to read, order, certify on Blockchain (at a first level) and send to the SCD the measurements for the flexibility market. Moreover, the device receives set-points from the Italian DSO Technical Platform and makes them available to customers (e.g. to customer's EMS). |
| MP | Market Platform | System | Virtual Place where the requests of flexibility match the offers |
| OS | Operational Systems | System | Generic term for systems used to manage the grid (SCADA, GIS, AMR, ERP) |
| SCADA | Supervisory Control and Data Acquisition | System | Control system architecture comprising computers, networked data communications and graphical user interfaces (GUI) for high-level process supervisory management. |
| SCD | Platone Shared Customer Database | System | Database that gathers all the data of flexibility resources and services and shares them with all the stakeholders. |

| | | | |
|---|---|---|---|
| SCD_Ita | Italian Shared Customer Database | System | Italian version of SCD |
| TSOsim | TSO simulator | System | Tool to emulate the TSO flexibility requests that involve the DER connected in medium and in low voltage |
| WFS | Weather Forecast Service | System | Service forecasting the weather |

**Table 3: Platone Actors of Type System**

| Short Name | Actor Name | Actor Type | Description |
|---|---|---|---|
| AMR | Automatic Metering Reading | Device | Remote reading solution for electronic meters installed either in customers’ premises or DERs |
| EV | EV charging station | Device | Public charging points equipped with a socket of 3 kW and another of 22 kW. |
| FR | Flexibility Resource | Device | Resources, in customer premises, that provide flexibility to the market. They could be generation plants, electric vehicles, batteries, active demand. |
| PMU | Phasor Measurement Unit | Device | A device gathering real-time measurements to be used for magnitude and phase angle estimation of an electrical phasor quantity in the electricity grid using a common time source for synchronization. Time synchronization allows synchronized monitoring of multiple remote points on the grid. |
| RES | Renewable Energy Source | Device | Source of energy based on a renewable input. Input can be variable or steady. |
| Sensor | Sensor | Device | Devices installed on the field to measure electrical quantities for the grid monitoring. |
| StoHeat | Storage heater | Device | Electrical Heater with a large-scale water storage, able to store electrical generated heat. Heater is used by household for generation of domestic heat. |
| SSBS | Small Scale Battery Storage | Device | Smaller storage device able to store energy over a period of time. |

| | | | |
|---|---|---|---|
| SA | Smart Appliance | Device | Controllable electrical load. |
| StHouse | Standard Household | Device | Household with a standard load profile energy consumption of a single household |
| Storage | Storage | Device | Device able to store smaller or bigger amounts of energy over a shorter or longer period of time. |
| SS | Storage System | Device | Lithium battery installed in premises of the LV customer |

**Table 4: Platone Actors of Type Device**

In terms of the IEC62559-2 standard [10], the components are Actors of type Person, System or Device. The relationship between the actors of the type “Person” and the components with which they interact is shown in Figure 3. The Person Actors are shown as stick men in Figure 3. A detailed breakdown of the components’ location in the SGAM zones, domains, and the UCs in which each component is present is shown in Table 18: Actors in Platone in Annex B.

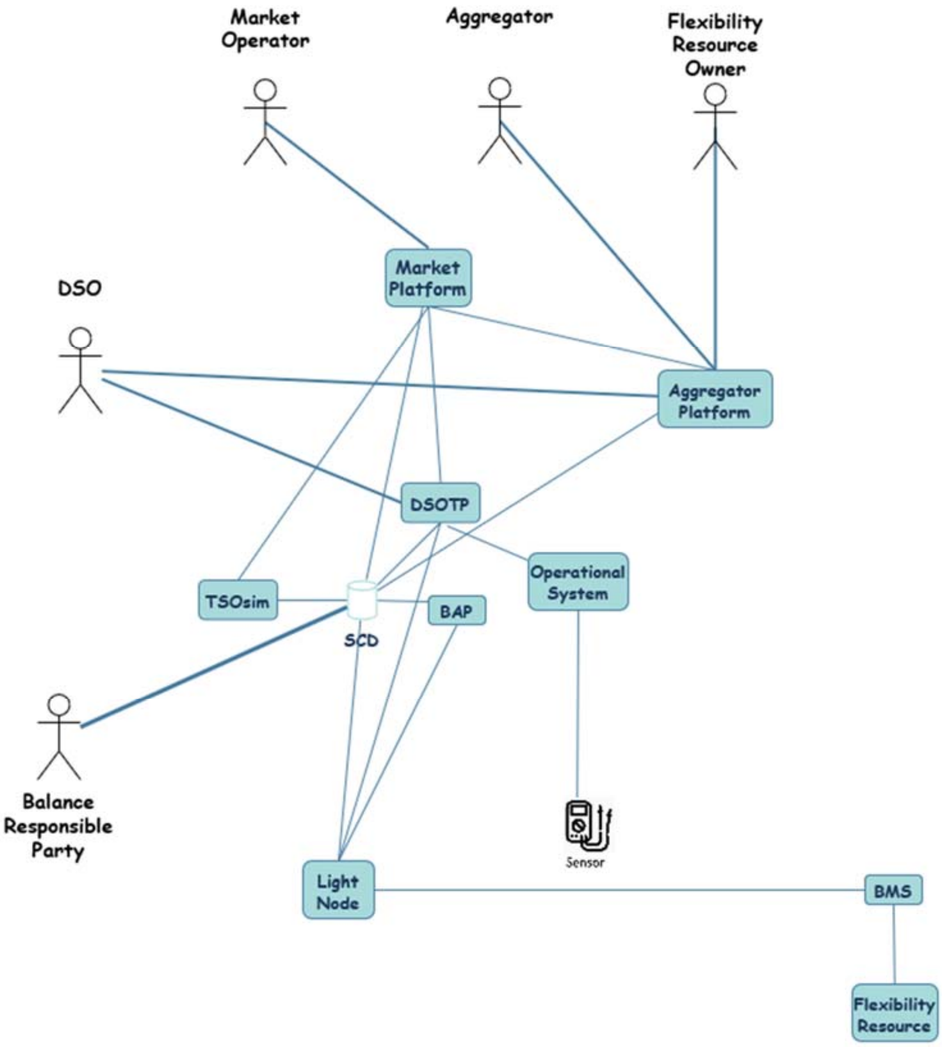


**Figure 3: Person Actors Interactions with Components**

Note that, as also mentioned in Table 3, that in the Italian demo the customers' BMS acts on the set-point make available by Light-Node, while in the German use cases EMS is used the customer premises, to monitor, control, and optimize the energy consumption and production. Further details on the mapping are provided in Table 7 of the following chapter.

## 4.2 Component Layer

As mentioned in chapter 2, the component layer shows the physical distribution of all participating components. In Table 5 below, the specific mapping applied to these components is demonstrated.

| Actors | In Demo | Mapping |
|---|---|---|
| Automatic Metering Reading | GR | mapped to Sensor |
| Agricultural Buildings | DE | mapped to Flexibility Resource |
| App Aggregator-Customer | IT | mapped to Aggregator Platform |
| Italian Blockchain Access Platform | IT | mapped to Blockchain Access Platform |
| Consumer Load | DE | mapped to Flexibility Resource |
| Controller | DE | mapped to BMS |
| Commercial Consumer | IT | mapped to Flexibility Resource Owner |
| Distribution Management System | GR | mapped to Operational Systems |
| DSO Data Server | GR | mapped to Operational Systems |
| Italian DSO Technical Platform | IT | mapped to DSO Technical Platform |
| Energy Management System | DE | mapped to DSOTP |
| Energy Management System | IT | mapped to BMS |
| EV charging station | IT | mapped to Flexibility Resource |
| Flexible Loads | DE | mapped to Flexibility Resource |
| Generator | DE | mapped to Flexibility Resource |
| Geographic Information System | GR | mapped to Operational Systems |
| Household Energy Storage | DE | mapped to Flexibility Resource |
| LV Circuit breaker | IT | mapped to Sensor |
| Phasor Measurement Unit | DE, GR | mapped to Sensor |
| Renewable Energy Source | GR | mapped to Flexibility Resource |
| Residential Consumer | IT | mapped to Flexibility Resource Owner |
| Italian Shared Customer Database | IT | mapped to Shared Customer Database |
| Supervisory Control and Data Acquisition | GR | mapped to Operational Systems |
| Storage heater | DE | mapped to Flexibility Resource |
| Small Scale Battery Storage | DE | mapped to Flexibility Resource |
| Smart Appliance | IT | mapped to Flexibility Resource |

| | | |
|---|---|---|
| Standard Household | DE | mapped to Flexibility Resource |
| Storage System | IT | mapped to Flexibility Resource |
| Voltage and current sensors | IT | mapped to Sensor |

Table 5: Mapping of Low-level Components to generic Components

Following the logic of the table above, Figure 4 shows the hardware and software components used to implement the UCs in the Italian demo in Platone. The components are shown allocated to the SGAM domains and zones where they are active.

While the component layer shown in Figure 4 is based on the Italian demo, but is valid also for the Greek and German demos with the remark that TSOsim, the field sensors (circuit breaker) and the Light Node are only present in the Italian demo. The differences in the component layer in the Greek and German demos are shown in Figure 5 and Figure 6.

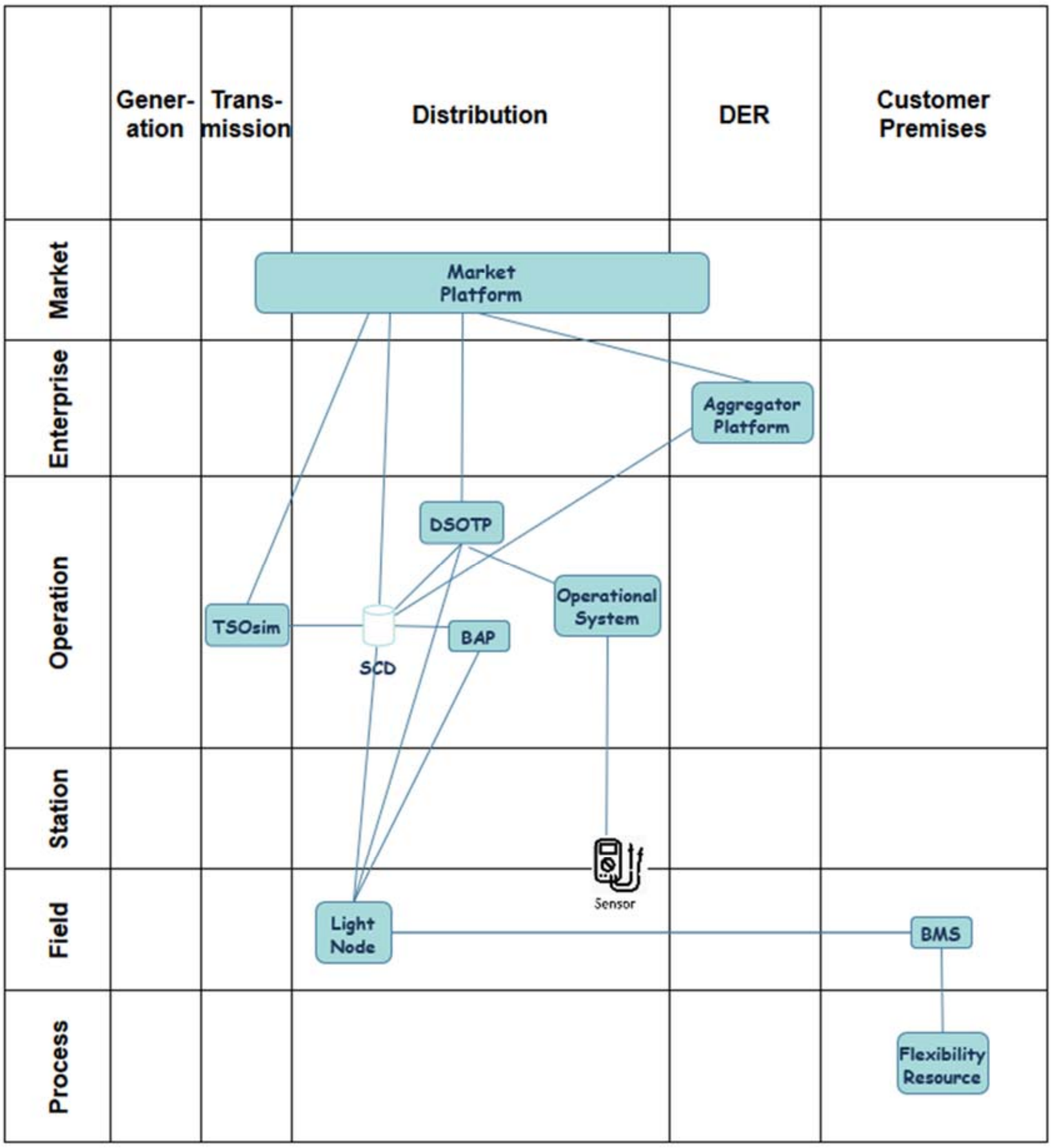


Figure 4: Component Layer based on Italian demo

In order to make Figure 4 more readable, some of the low-level components have been grouped and are represented in the SGAM mapping as generic components, according to the mapping presented in Table 5. Different types of sensors and PMUs are mapped to a common term “Sensor”. Different types of flexible loads and storages are mapped to “Flexible Resource”.

The German demo contains an EMS which fulfils the same role as the DSOTP, which represents it in Figure 4. The term “Operational System” is used to cover systems such as DMS, SCADA and GIS. The Italian demo uses proprietary versions of the DSOTP, BAP and SCD, whereas the Greek and German demos use versions made in Platone WP2: these different versions are not shown separately in Figure 4.

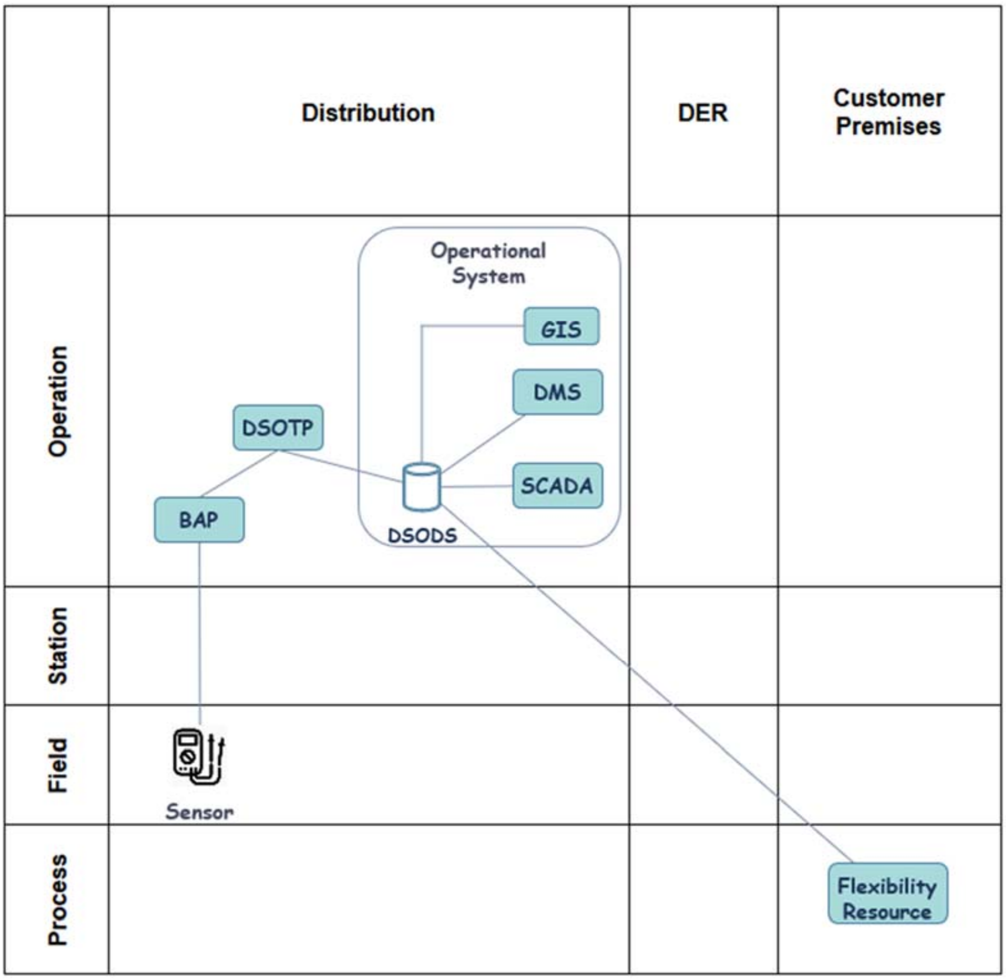


Figure 5: Detail of Greek Demo Component Layer

In the Greek demo (Figure 5), there are several-previously existing operational systems which provide data to the DSOTP through a data server (DSODS). The data from the Greek flexibility resources is also sent through DSODS, whereas the data from the Sensors which are being installed in the field during Platone is sent directly through the BAP to DSOTP. The Greek demo uses the BAP to benefit from its MQTT data security but does not use the SCD. The data from both paths is subsequently processed on DSOTP.

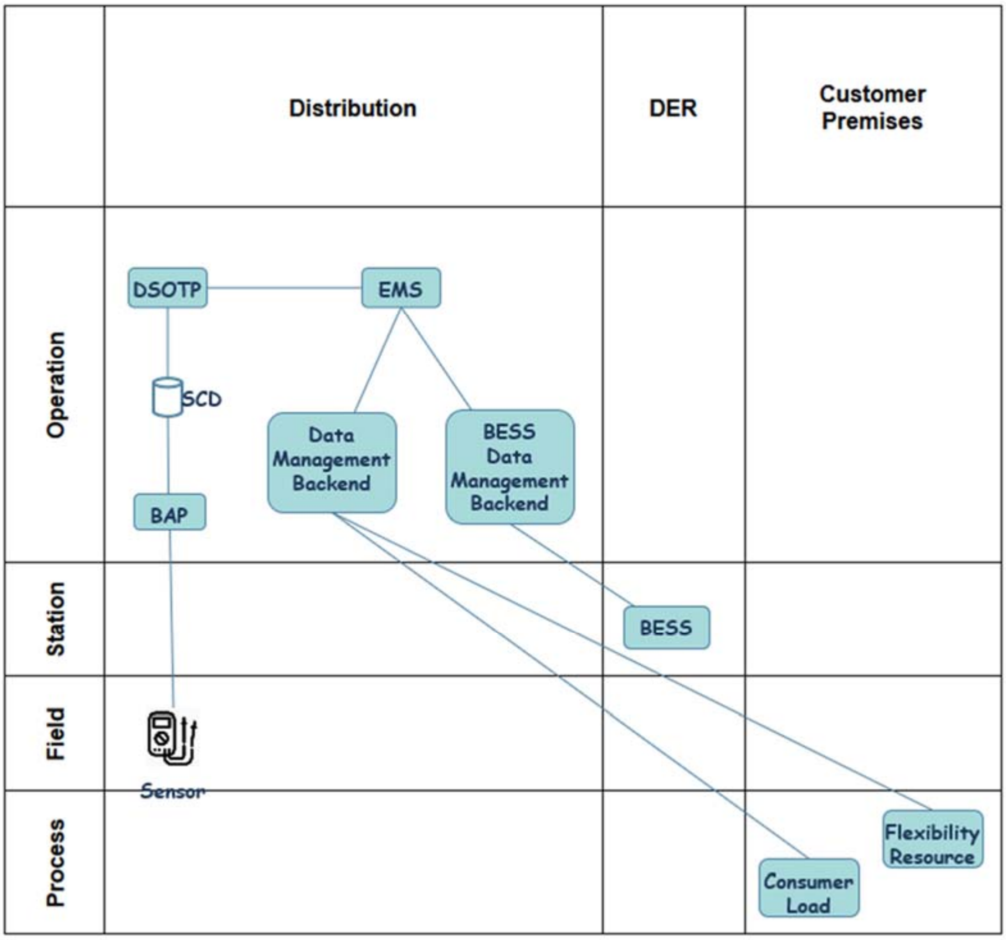


**Figure 6: Detail of German Demo Component Layer**

Similarly, to the Greek demo, the data from the PMUs (shown as sensors) is routed through the Blockchain Access Layer (BAP and SCD) to the DSOTP in the German demo (Figure 6). The data processing functions in the German demo are hosted by a separate EMS. Communication with the FR and BESS is relayed over separate (BESS) Data Management Backend components, which implement the communication protocols supported by FR and BESS.

## 4.3 Function Layer

Functions are blocks which process information, coming from one or more actors, and provide it to one or more other actors. They can be implemented in the hardware belonging to one or more actors. The functions in Table 6 are extracted from the UC descriptions and mapped to the function layer in terms of zones and domains.

| UC | Function | Domain | Zone | In Component | Description |
|---|---|---|---|---|---|
| DE1-4 | Forecasting of generation and demand | Distribution | Operation | EMS | Forecasting of the generation and demand based on weather data, measurements, and load profiles. |
| DE1-4, GR1-4 | Data – Acquisition | Distribution | Operation | EMS in DE,<br>DSODP, DSOTP in GR | Germany: Gathering of real time weather data, measurement values from sensors located at the secondary substation of the power exchange along the MV/LV grid connection point, load demand and SOC values of local customer flexible loads, household energy storages and Battery Energy Storage System.<br>Greece: Various field measurements that reflect the network state are communicated. Additional/alternative data to substitute for missing or inconsistent measurements are integrated in the State Estimation tool. |
| DE1-4 | Evaluation and determination of control strategy and setpoints | Distribution | Operation | EMS | A local EMS monitors local generation, demand and storage capacities and control available flexibilities in such a way that consumption of locally generated energy will be maximized. When local generation exceeds local demand, surplus energy will automatically be stored in local storages and the consumption of available flexible loads will be increased. When local consumption is exceeding local generation, stored electrical energy in local batteries will be discharged. |
| DE1-4 | Verification of setpoint execution Comparison of | Distribution | Operation | EMS | A sensor located at the grid connection measures the power exchange of all 3 phases between the medium voltage and low voltage grid. The measured values indicate the residual demand or export of surplus of generated energy/power. Data is provided to the EMS based on the information |

| | | | | | |
|---|---|---|---|---|---|
| | target and measured values | | | | increases or decreases the load in order balance the grid. Additionally, customer households provide flexible load and storage capacities for steering. Flexible assets in the field are equipped with sensors and controllers for steering to increase or decrease demand and to command charging or discharging of local large Battery Energy Storage System and private customer household storages. |
| DE1-4, GR1-4 | FR Control | Distribution | Operation | EMS | DE1: Based on measurement data and asset key data, EMS calculates the controllable power bandwidth of each asset. Based on generation, load and SOC forecasts the EMS calculates the optimum strategy of load and storage activation to maximize the consumption of local generation, while avoiding a load exchange along the grid connecting feeder, enabling a virtual islanding of the community.<br><br>DE2: Based on measurement data and asset key data, EMS calculates the controllable power bandwidth of each asset and determines its setpoint.<br><br>The EMS determines for each asset a setpoint in order to reach and maintain a predefined value for the load exchange along the grid connecting feeder (MV/LV). The determination of setpoints for flexible loads and storages located at customer premises is repeated regularly in intervals from 60 up to 10 seconds for the BESS and every 15 minutes.<br><br>DE3: The EMS receives a setpoint schedule containing time slots for the import of energy along the grid connecting feeder (UC 2) and time slots in which the community shall be islanded (UC 1). Based on all provided data and load and generation forecasts, the EMS determines setpoints for the BESS and flexible loads and household energy storages in the field to maintain the given schedule.<br><br>DE4: The EMS receives a setpoint schedule containing time slots for the export of generation surplus along the grid connecting feeder (UC 2) and time slots in which the community shall be islanded (UC 1). Based on all provided data and load and generation forecasts, the EMS determines setpoints for the BESS, flexible loads and household energy storages in the field to maintain the given schedule. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | GR1-4: Optimal dispatching of FRs in distribution networks. Tariff charged to FRs for network is varied according the distribution network conditions and is known before the FRs optimize their strategy and bid in the Day-Ahead (DA) market, i.e. the day before real-time operation. |
| DE1-4, IT1-2 | Weather Forecast | Distribution | Operation | DSOTP | Historical measurement data and weather forecasts provided by external service providers enable the EMS to predict energy generation and consumption to maximize self-sufficiency. |
| IT1-2 | Forecasting of generation and demand | Distribution | Operation | DSOTP | Forecasting of the generation and demand based on weather data, measurements and load profiles. |
| IT1-2 | Resources Planning definition | Customer Premises | Enterprise | AP | FR Owner sends the availability for the DA and receives the planning of the service to provide |
| IT1-2 | Provision of flexibility from FR | DER | Enterprise | AP | The Aggregator calculates the baseline and the flexibility energy for every customer in our premises |
| IT1-2 | Offering | DER | Enterprise | AP | The Aggregator Platform defines flexibility offers. |
| IT1-2 | Payment | Distribution, Transmission, DER | Market | MP | Function implemented in the Market Platform. |
| IT1-2 | Offers Acquisition | DER | Market | MP | The Market Platform receives from the Aggregator Platform the flexibility offers. |

| | | | | | |
|---|---|---|---|---|---|
| IT1-2 | Flexibility Requests Acquisition | Transmission, Distribution | Market | MP | The Market Platform receives from the System Operators the flexibility requests |
| IT1-2 | Final Market Clearing | Distribution, Transmission, DER | Market | MP | The market platform receives from DSOTP the list of offers comply with local grid constraints and sends them to all the stakeholders. |
| IT1-2 | Economic market clearing | Transmission, Distribution | Market | MP | At gate closure, all the requests and offers are stored on the Market Platform. The Market Platform matches first the offers with the DSO's requests, and orders them in economic manner, after repeats the procedure with the TSO requests. Hence the list of auctioned offers is sent to DSOTP for evaluate the grid constraints violations. |
| IT1-2 | Settlement | Distribution, Transmission, DER | Market | MP | For the settlement phase, the Market Platform acquires the data from the SCD and calculates the difference between market baseline, uploaded in the SCD by BRP, and electrical quantities measured in the same time frame, uploaded in the SCD by Light Node. The Market Platform runs the settlement algorithm and finds the outcomes. The settlement outcomes are transmitted to Aggregator Platform, DSO and TSO Simulator. Finally, the DSO pays the flexibility to the Aggregator, who can pay the fee to the FR Owner. |
| IT1-2 | Smart Contract and token | Distribution, Transmission, DER | Market | MP | Function Implemented in the market Platform |
| IT1-2 | Data FR Acquisition | Distribution | Field, Operation | LN,SCD_Ita | Function implemented in the Light Node and in the SCD |
| IT1-2 | Data quality | Distribution | Operation | SCD_Ita | Function implemented in the SCD |

| | | | | | |
|---|---|---|---|---|---|
| IT1-2 | DSO Data Acquisition | Distribution | Operation | OS, DSOTP, SCD_Ita | Function implemented in the OS and in the DSOTP to acquire the data coming from the field |
| IT1-2 | Day Ahead Grid Assessment | Distribution | Operation | DSOTP | To define the DA requests, the DSOTP runs the state estimation tool to assess the grid for the day after. |
| IT1-2 | Technical assessment (Grid constraints assessment) | Distribution | Operation | DSOTP | DSO receives from Market the list of all auctioned offers and assesses the grid constraints. |
| IT1-2 | Real Time Grid Assessment | Distribution | Operation | DSOTP | To define the RT requests, the DSOTP runs the state estimation tool to assess the grid for the next hours. |
| IT1-2 | Data Certification | Distribution | Operation | BAP_Ita | Function implemented in the BAP |
| IT1-2 | TSO requests | Transmission | Operation | TSOsim | Function implemented in the TSO simulator |
| IT 1-2 | Set-point Broadcasting | Operation | Distribution | DSOTP | DSOTP sends to LN the set-points according to scheduled planning |
| GR1-4 | Observability Analysis | Distribution | Operation | SET in DSOTP | A numerical observability method is used in order to determine observability status, i.e. whether the state estimation problem can be resolved or not. |
| GR1-4 | State Estimation Procedure | Distribution | Operation | SET in DSOTP | Calculation of the state vector (Voltage magnitudes and angles of all network of all network buses |
| GR2,3,4 | PMU Data Integration | Distribution | Operation | DSOTP | Measurement data obtained from the installed PMUs are integrated in the State Estimation tool and used to enhance the network observability. The |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | installation of PMUs at selected buses is sure to upgrade the overall metering infrastructure of the network, since they record synchronized measurements of bus voltage phasors as well as a number of line current phasors—all of which are independent of each other and count as individual measurements. |
| GR4 | Frequency Support Ancillary Service | Distribution | Operation | DSOTP, FR | Triggered by frequency response activation requests from the TSO, the tariff charged to FRs for network is varied for a short balancing period in which the Aggregators sell frequency response activation products. |

**Table 6: List of Functions in Platone**

The function layers of the three demos are presented in the next three figures (Figure 7-Figure 9). In these figures, the location of the functions in the SGAM plane is shown: the UCs' functions are present in three different domains (Transmission, Distribution, DER) and four zones (Field, Operation, Enterprise and Market). In addition, the dependencies between the individual functions are indicated by drawing lines between them. The presence of such a line joining two functions indicates that information is passed between the functions; the details of the information are not shown here, but in the chapters related to the Communication and Information Layers.

Figure 7 below similarly shows the function layer for the two Italian UCs. Unlike the Greek UCs, those of the Italian demo spans into a wider range of zones and domains reflecting not least the ambition to cover support to the TSO as well as flexibility markets.

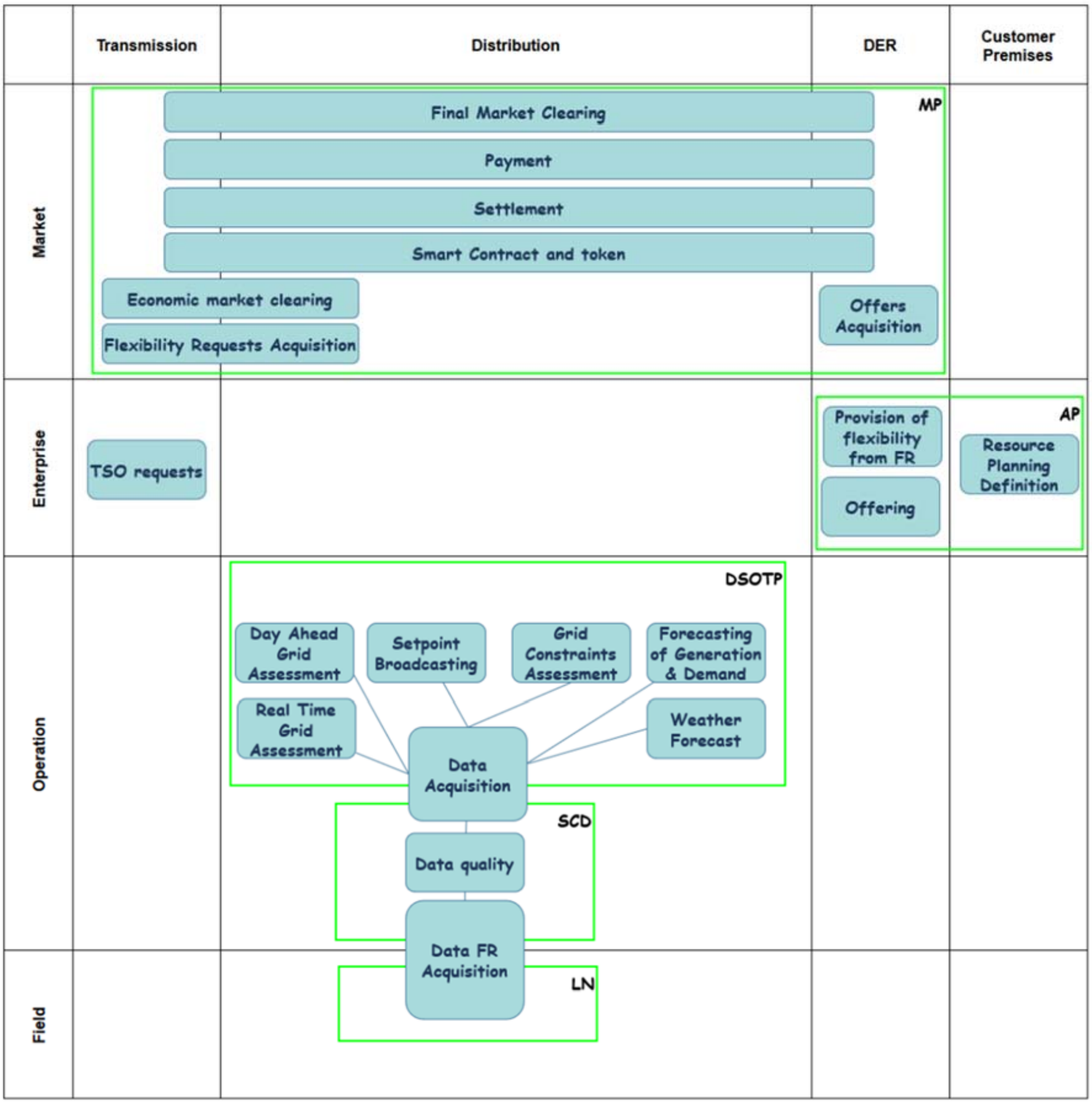


Figure 7: Italian Demo Function Layer

The functions involved in the Greek UCs 1-4 are shown in Figure 8. UC1 and UC2 in the Greek demo are all about getting the most accurate possible view of the network (real-time and forecast), based on which optimal dispatch/DER control and frequency support ancillary service develop models to test different scenarios. The Frequency support ancillary service is only in UC4. The PMUs are not part of UC1 but are introduced in UC2 and are also present in UC3 and UC4.

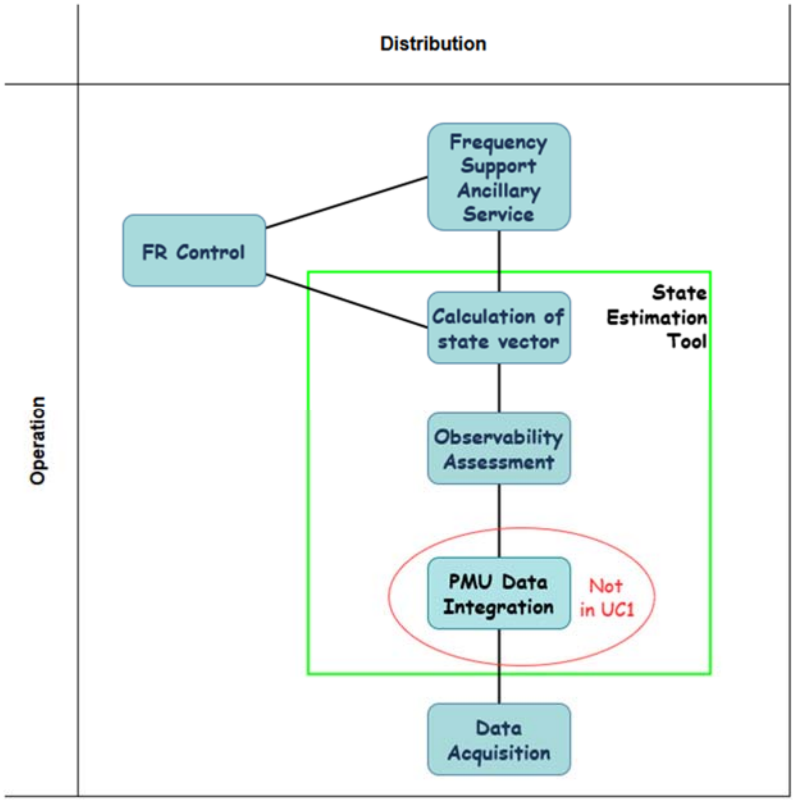


Figure 8: Greek Demo Function Layer for Greek Use Cases 1-4

Lastly, Figure 9 shows the functions implemented in the German demo and is valid for all its four UCs.

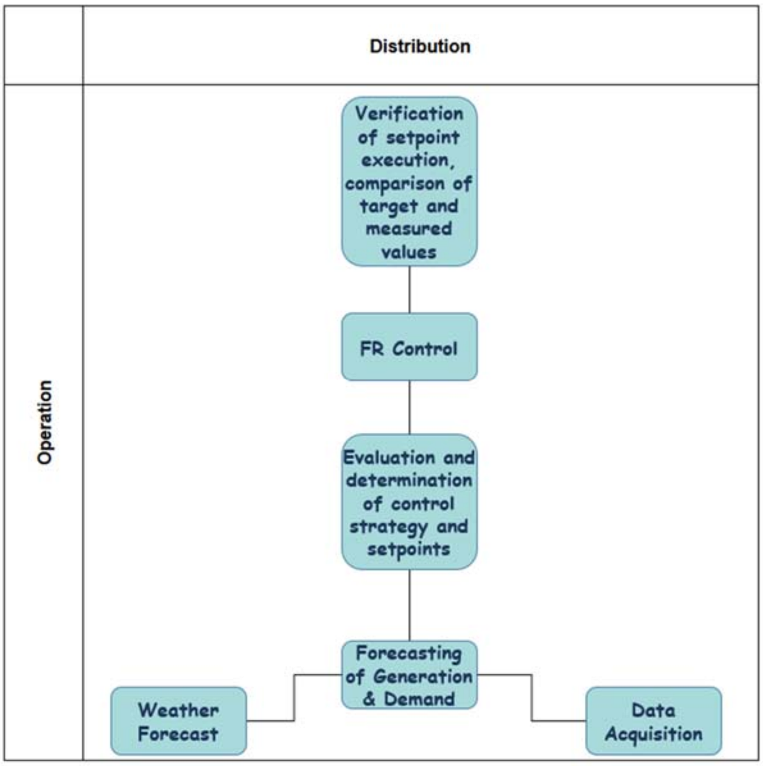


Figure 9: German Demo Function Layer

The implementation of the UCs requires the usage of several functions. In Table 7, the full mapping of these functions across the project onto use cases is shown.

| Functions → | Use Cases |
|---|---|
| • Data Acquisition | DE1-4, GR1-4, IT1-2 |
| • FR Control | DE1-4, GR1-4 |
| • Forecasting of generation and demand<br>• Evaluation and determination of control strategy and setpoints<br>• Verification of setpoint execution, comparison of target and measured values<br>• Weather Forecast | DE1-4 |
| • Observability Analysis<br>• State Estimation procedure | GR1-4 |
| • PMU Data Integration | GR2-4 |
| • Frequency Support Ancillary Service | GR4 |
| • Forecasting of generation and demand<br>• Weather Forecast<br>• Resources Planning definition<br>• Final Market Clearing<br>• App Aggregator-Customer<br>• Day Ahead Grid Assessment<br>• Flexibility Requests Acquisition<br>• Data FR Acquisition<br>• Data quality<br>• Provision of flexibility from FR<br>• Offering<br>• Offers Acquisition<br>• TSO requests<br>• Requests Acquisition<br>• Economic market clearing<br>• Technical assessment (Grid constraints assessment)<br>• Real Time Grid Assessment<br>• Data Certification<br>• Settlement<br>• Payment<br>• Smart Contract and token<br>• DSO Data Acquisition<br>• Set-point Broadcasting | IT1-2 |

Table 7: Functions mapped to UCs

Actors exploit some functions that can be dedicated to the single actor or distributed among several actors. In Table 8, an overview is given about the mapping of functions onto actors and the functions that are exploited by every actor.

| Functions → | Actors |
|---|---|
| • Data Acquisition | EMS, OS, DSOTP |
| • Forecasting of generation and demand<br>• Evaluation and determination of control strategy and setpoints<br>• Verification of setpoint execution, comparison of target and measured values | EMS |
| • FR Control | EMS, OS |
| • Weather Forecast | DSOTP |
| • Observability Analysis<br>• State Estimation procedure<br>• PMU Data Integration | DSOTP |
| • Frequency Support Ancillary Service | DSOTP, FR |
| • Day Ahead Grid Assessment<br>• Technical assessment (Grid constraints assessment)<br>• Real Time Grid Assessment | DSOTP |
| • Flexibility Requests Acquisition<br>• Offers Acquisition<br>• Requests Acquisition<br>• Economic market clearing<br>• Settlement<br>• Payment<br>• Smart Contract and token | MP |
| • Data FR Acquisition | LN,SCD_Ita |
| • Data quality | SCD_Ita |
| • App Aggregator-Customer<br>• Provision of flexibility from FR<br>• Offering<br>• Payment | AP |
| • TSO requests | TSOsim |
| • Data Certification | BAP_Ita |

Table 8: Functions mapped to Actors

## 4.4 Communication Layer

The communication layer describes protocols and communication technologies for the interoperable exchange of information between the use case actors.

Table 9, Table 10 and Table 11 list the information exchanged between the use case actors together with the employed protocols for the German, Greek and Italian demos respectively.

| Information exchanged ID | Name of Information | Description of Information Exchanged | Communications Protocol |
|---|---|---|---|
| IT-I-01 | Quarterly measures | The aggregator baseline or the DSO grid forecast uses the data measurements (active power, energy consumption, energy production) stored in SCD. These measurements have a 15 minutes granularity | TOPIC KAFKA/REST API |
| IT-I-02 | Customer list | This information contains the list of customers involved in the flexibility providers for the day after | TOPIC KAFKA/REST API |
| IT-I-03 | BRP Baseline | The BRP defines for every POD the day after load profile, in compliance with the market day ahead | To be defined |
| IT-I-04 | Near real time measures | This information contains, for every POD involved in the flexibility market, the active power measured every 4 second | MQTTs, REST API, TOPIC KAFKA |
| IT-I-05 | Data for Offer | The flexibility offer contains the volume, the time frame and the price provided by the FR involved in the group | REST-API (HTTPS) |
| IT-I-06 | Data for Requests | The flexibility request contains the needs of flexibility (volume and time frame) localized in specific nodes of the grid | REST-API (HTTPS) or web UI |
| IT-I-07 | Technical Validation | This information contains the assessment of the local grid constraints | REST-API (HTTPS) |
| IT-I-08 | Market Outcomes | This information contains the list of offers arranges for economic order and in compliance with the grid constraint | TOPIC KAFKA/REST-API (HTTPS) |
| IT-I-09 | Order | The TSO and the DSO send a signal of activation to move the FR involved in the service | REST-API (HTTPS) or web UI MQTTs Modbus TCP/Modbus RTU/HTTP REST API |
| IT-I-10 | Voltage violation localization | The Italian DSO technical platform defines a list of grid nodes subject to voltage violations | To be defined |
| IT-I-11 | Grid configuration | The DSO detects the possible grid configuration to solve the issue | To be defined |
| IT-I-12 | FR Status | This information contains the customer availability for move own FR | REST-API |
| IT-I-13 | FR Planning | This information contains the time frame, and the power that the customer has to provide during the activation | REST-API |
| IT-I-14 | Activation Signal | The EMS sends the signal of activation to smart load | Depending on the Customers |

| | | | |
|---|---|---|---|
| | | | (could be e.g. Z-Wave - Modbus RTU - ZigBee - Rest API - Modbus TCP) |
| IT-I-15 | Settlement outcomes | This information contains for every offer the energy moved and the payment | TOPIC KAFKA |
| IT-I-16 | DSO payment | It is the payment of DSO for the energy provided | REST-API (HTTPS) |
| IT-I-17 | Aggregator payment | It is the remuneration that the aggregator recognizes to the customer | REST-API |
| IT-I-18 | Technical Measurement | Electrical quantities coming from the field sensors (Voltage and current sensors or Low Voltage circuit breaker embedded with IED) | IEC 60870-5 -104<br>IEC 60870-5 -101<br>IEC 61850 |
| IT-II-10 | Congestion localization | The Italian DSO technical platform defines a list of grid nodes subject to congestion | To be defined |

Table 9: Platone Italian Demo Information Exchanges

| **Information exchanged ID** | **Name of Information** | **Description of Information Exchanged** | **Communications Protocol** |
|---|---|---|---|
| GR-I-01 | Measurements | Measurements from the Distribution Network (e.g. voltage levels, power injections, etc.) | TCP/IP, IP over GPRS |
| GR-I-02 | State Vector | Voltage magnitudes and angles of all network buses | TBD |
| GR-I-03 | Observability status | The result of the observability assessment of the Distribution Network | TBD |
| GR-I-04 | PMU Measurements | Measurements from PMUs (e.g. voltage magnitudes, voltage phasors, current phasors) | MQTT |
| GR-I-06 | Network tariffs | Network tariffs that reflect the Distribution Network state | IP |
| GR-I-07 | Setpoint | Setpoint for adjustment of flexible load/RES production | IP |
| GR-I-08 | Frequency support request | Frequency support request from the TSO | IP |

Table 10: Platone Greek Demo Information Exchanges

| Information exchanged ID | Name of Information | Description of Information Exchanged | Communications Protocol |
|---|---|---|---|
| DE-I-01 | Signal from user via GUI | A user triggers the use case via a GUI to the EMS to apply islanding. | HTTP/HTTPS |
| DE-I-02 | Weather forecasts | The weather forecast provider pushes real time measurement data and weather forecast of:<br>• Solar radiation (t + 24h)<br>• Cloudiness (t + 24 h)<br>• Temperature (t + 24 h)<br>• Humidity (t + 24 h)<br>• Windspeed (t + 24 h) | REST API |
| DE-I-03 | Signal from Sensor | The Sensor sends measurement values containing: voltage (U), current (I) and angle of phase (Phi) values for all 3 phases measured in secondary substation. Values indicate the residual power demand/generation as sum of demand or feed of BESS, household energy storage, flexible loads, generators and customer households and agricultural buildings. | PMU: MQTT or IEC6180<br>Household energy storage: MQTT, HTTP or other<br>BESS: MODBUS/TCP or IEC VPN 60970 |
| DE-I-04 | Setpoint or setpoint schedule transmission | Setpoint to increase or decrease demand/generation as static value [P] or relative value [%] or [SOC] | Household energy storage: MQTT, HTTP, or other<br>BESS: MODBUS/TCP or IEC VPN 60870 |

Table 11: Platone German Demo Information Exchanges

Figure 10 shows the Platone communication layer, indicating the communication protocols, used for the information exchanges listed in Table 9.

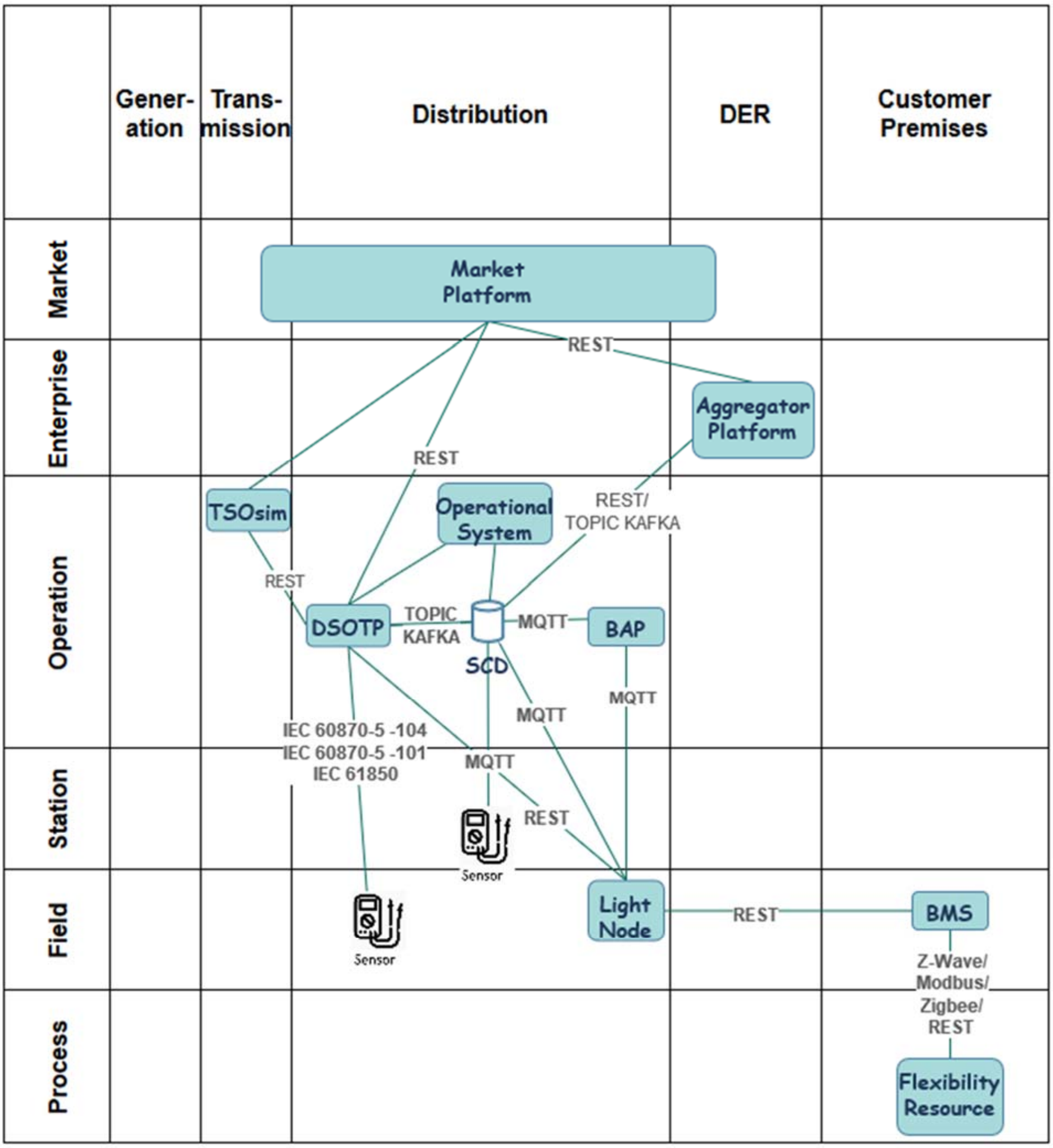


Figure 10: Communication Layer

## 4.5 Information Layer

The purpose of the SGAM Information Layer is to model the information object flows between Actors, in terms of data content, and to identify proper data model standards that are suitable to reflect these information objects. In Table 12 below, the data content is listed according to the information while the use cases to which they apply are indicated in the rightmost column.

| Information exchanged ID | Name of Information | Data Content | UC |
|---|---|---|---|
| DE-I-01 | Signal from user via GUI | The trigger signal is:<br>0 = stop current use case<br>1 = application of UC 1<br>2 = application of UC 2<br>3 = application of UC 3<br>4 = application of UC 4<br><br>In Case of UC 1 – P'Breaker will automatically be defined as P'Breaker = 0.<br>In Case of UC 2 – The user will additionally define P'Breaker via UI.<br>In Case of UC 3 – The user will additionally define a schedule P'Breaker (t + 1) for energy import via UI.<br>In Case of UC 4 – The user will additionally define a schedule P'Breaker (t + 1) for energy export via UI. | DE1-4 |
| DE-I-02 | Weather forecasts | ● Solar radiation (t + 24h)<br>● Cloudiness (t + 24 h)<br>● Temperature (t + 24 h)<br>● Humidity (t + 24 h)<br>● Windspeed (t + 24 h) | DE1-4 |
| DE-I-03 | Signal from Sensor | The Sensors sends measurement values containing voltage (U), current (I) and angle of phase (Phi) values for all 3 phases of residual power demand/generation as sum of demand or feed of BESS, household energy storage, flexible loads, generators and customer households. | DE4 |
| DE-I-04 | Setpoint transmission | Setpoint to increase or decrease demand/generation as static value [P] of flexible load, passive household consumption, total or residual generation of households with PV and State of Charge (SOC) or State of Energy of (SOE) of household battery energy storages and BESS. | DE2-3 |

| | | | |
|---|---|---|---|
| GR-I-01 | Measurements | Measurements from the Distribution Network (voltage magnitudes, active and reactive power injections/flows) | GR-1-5 |
| GR-I-02 | State Vector | Voltage magnitudes and angles of all network buses | GR-1,2,3,4 |
| GR-I-03 | Observability status | The result of the observability assessment of the Distribution Network, i.e. whether the state estimation problem can be resolved or not | GR-1,2 |
| GR-I-04 | PMU Measurements | Measurements from PMUs (voltage phasors (angle and magnitude), current phasors (angle and magnitude)) | GR-2,4,5 |
| GR-I-06 | Network tariffs | Network tariffs that reflect the Distribution Network state | GR-3,4 |
| GR-I-07 | Setpoint | Setpoint for adjustment of flexible load/RES production | GR-3,4 |
| GR-I-08 | Frequency support request | Frequency support request from the TSO | GR-4 |
| IT-I-01 | Quarterly measures | Active power injection, active power withdrawal, active energy injection, active energy withdrawal, reactive energy injection, reactive energy withdrawal. Each with a 15 minutes granularity<br>More in detail it includes:<br>● POD code<br>● Average of Active power<br>● Average of Reactive power<br>● Max Value of Active Power<br>● Max Value of Reactive Power<br>● Active Energy Demanded (measured every 15min)<br>● Reactive Energy Demanded (measured every 15min)<br>● Active Energy Injected (measured every 15min)<br>● Reactive Energy Injected (measured every 15min)<br>● Measurement Date | IT-1,2 |
| IT-I-02 | Customer list | List of customers. It includes:<br>● Aggregator ID (ID of Aggregator in the SCD)<br>● POD code<br>● Market area (market zone in which the POD is located)<br>● Distributor ID (ID of the DSO which serves the POD)<br>● Contractual Power<br>Nominal Flexible Power (max flexible power of POD) | IT-1,2 |

| | | | |
|---|---|---|---|
| IT-I-03 | BRP Baseline | POD load profile. It is the energy profile foreseen for the day after by BRP for any POD involved in the pilot. It a curve made up of 96 quarter-hourly active energy (or reactive energy) values. In the Italian Demo, BRP will be simulated. | IT-1,2 |
| IT-I-04 | Near real time measures | Instant active power injection, instant active power withdraw, measured every 4 seconds. It includes:<br>● POD code<br>● Average of Active power (calculated on 4s)*<br>● Max Value of Active Power (calculated on 4s or 15min)*<br>● Active Energy Demanded (measured every 15min)<br>● Reactive Energy Demanded (measured every 15min)<br>● Active Energy Injected (measured every 15min)<br>● Reactive Energy Injected (measured every 15min)<br>● Measurement Date<br>*Where available | IT-1,2 |
| IT-I-05 | Data for Offer | Volume (in kWh or in kW for a time frame) the time frame and the price provided by the FR involved in the group. Every offer has an identity code<br>In detail, it includes:<br>● Aggregator ID<br>● POD Code<br>● Offer ID<br>● Real Time Flag*<br>● Active Power Value (up or down)/Price**<br>● Time frame***<br>● No. of quarter-hourly slots****<br>● Availability range*****<br>● Baseline#<br><br>*(yes / no), a flag determining if the presented offer, will be automatically re-proposed in the real-time phase, if not accepted in the DA phase.<br>**(for the number of steps offered), a data couple identifying the flexibility value offered to the market and the corresponding unitary price. An offer can have multiple steps, so multiple power/price couples.<br>***time frame to which offer refers (if not specified “No. of quarter-hourly slots” and “Availability range”. | IT-1,2 |

| | | | |
|---|---|---|---|
| | | ****(if not specified “Time frame”). This field defines the number of Market Time Units (MTUs) for which the aggregator has the flexibility available. E.g. if the aggregator offers 4 kW, for e.g. 4 MTU, this means that the aggregators has 4 kWh of energy available for flexibility purpose.<br>*****(if not specified “Time frame”). The availability range, with respect to the MTUs, in which the Flexible Block offer is valid. E.g. if the availability interval is 1-48, it means that the flexible block offer is valid from 00:00 to 11:45.<br><br>#the baseline determined for the POD in the Timestamp in which the offer is presented. | |
| IT-I-06 | Data for Requests | Needs of flexibility (kW for time frame) localized in specific nodes of the grid. Every request has an identity code.<br>In detail, it includes:<br>● Player ID (System Operator ID)<br>● Time frame (by 15min slots)<br>● Market Type (Day Ahead, Real Time)<br>● Flexibility Service Type (Congestion, voltage violation)<br>● Request ID (reference to the flexibility request)<br>● PODs (list of PODs able to provide services to the relevant areas)<br>● Active Power requested (or Reactive Power Requested*)<br>● Maximum purchase price (Maximum price for the flexibility request)<br>*Under investigation | IT-1,2 |
| IT-I-07 | Technical Validation | Assessment of the local grid constraints. This is a process that consists in performing load flow calculations in the distribution network taking into account the consumption increase or decrease defined into the offers and associated to certain network locations. After executing the calculation process, the DSO will verify that all the network constraints are met, that is, power flows and voltage profiles in the distribution lines and nodes are within admissible limits. If this is not the case, the DSO will discard or put limits in the power modifications planned. The output could be, for every POD comprises in the offer and for the time frame of the offer:<br>- a profile (curve made up of energy or average power in fifteen minute intervals) confirmation;<br>- a profile modification (like a partial acceptance);<br>- the profile can’t be accepted<br>The output includes:<br>● ID code<br>● Time Frame<br>● Market Type<br>● Flexibility Service Type<br>● Offer Id | IT-1,2 |

| | | | |
|---|---|---|---|
| | | ● POD code<br>● Active Power<br>● Priority (priority of offer)<br>● Validation Outcome for each POD (the result of the technical validation process) | |
| IT-I-08 | Market Outcomes | List of offers. For every offer, there is the POD list with the accepted profile.<br>It includes:<br>● Id (id of outcome)<br>● Time frame<br>● Market Type<br>● Flexibility Services<br>● Offer Id<br>● Request Id<br>● POD code<br>● Active Power<br>● Status (OK or KO) | IT-1,2 |
| IT-I-09 | Order | Order signal. Comprises the offer code, and for every POD the power (kW) and the time frame activation.<br>It includes:<br>● Player Id<br>● Time Frame<br>● Market Type<br>● Flexibility Service Type<br>● Activation Id (created by Market Platform)<br>● Offer Id<br>● POD code (POD to be activated)<br>● Set Point (set-point to be activated for each POD) | IT-1,2 |
| IT-I-10 | Voltage violation localization | List of grid nodes. For every node, there is a POD list that are interested by the voltage violation but can be involved to solve the problem. | IT-1,2 |
| IT-I-11 | Grid configuration | Grid configuration. It is an alert on video managed by the DSO operator | IT-1,2 |
| IT-I-12 | FR Status | It is an information implemented on the Customer-Aggregator App. Every day the FR Owner can select the availability of our resources for the day after. | IT-1,2 |
| IT-I-13 | FR Planning | Time frame, power. It is the accepted profile (curve made up of quarter-hourly energy or average power in fifteen minutes for the time frame of the offer). | IT-1,2 |

| | | | |
|---|---|---|---|
| IT-I-14 | Activation Signal | Order signal. For every POD comprises a power (in kW) for time frame activation. | IT-1,2 |
| IT-I-15 | Settlement outcomes | Energy quantity (comparing between quarter-hourly energy measured and the baseline for the same time frame), payment amount (energy quantity x €/kWh). | IT-1,2 |
| IT-I-16 | DSO payment | € | IT-1,2 |
| IT-I-17 | Aggregator payment | € | IT-1,2 |
| IT-I-18 | Technical Measurement | V, I, P, Q, cos phi (measured every 10 minutes)*<br>*Electrical quantities actually measured and gathered depend on type of sensors Installed in the relevant asset (e.g. lines) or grid point (e.g. node). | IT-1,2 |
| IT-II-10 | Congestion localization | List of grid nodes. For every locality, there is a POD list that are interested by the congestion but can be involved to solve the problem. | IT-1,2 |

**Table 12: Information Objects**

## 4.6 Business Layer

The business layer of the SGAM framework is used to map regulatory and economic market structures and policies, business models, business portfolios (products and services) of involved market parties.

The mapping is performed on a per Use Case basis and it shows the business actors (defined as actors of type Person in chapter 4.1) and how their business goals are supported via the information exchange that supports the actors' business processes. A tabular approach has been adopted because regulatory peculiarities and constraints are different per country and are not easily captured graphically.

The SGAM Business Layer analysis for the UC-IT-1 (Voltage Management) and UC-IT-2 (Congestion Management) of the Italian Demo are shown in Table 13. The analysis is valid for both Italian UCs.

| Actor | Business Goal | Business Processes | Information exchange |
|---|---|---|---|
| TSO<br>(Simulated) | Decrease the system costs, involving the MV and LV flexibility resources in the flexibility market to solve the HV issues | Market Process | TSO sends flexibility Request to Market Platform |
| DSO | Enable the local flexibility market to solve the grid issues using flexibility resources | Network Simulation | DSOTP calculates the flexibility needs for the local grid and sends the requests to the market |
| DSO | Avoid the local grid constraints violations, through the technical assessment of the flexibility offers selected by the market | Network Simulation | DSOTP receives the awarded offers from the market, assess the grid constraints, and sends the outcomes to market |
| DSO | Activation of FR units providing flexibility by sending set-points | Communication | DSOTP receives the set-points from the market and sends it to Light Node |
| DSO | Increasing the data sharing creating a unique repository for the flexibility market | Market Processes<br>Monitoring | All the stakeholders (DSO, TSO, Aggregator) can acquire and write on the SCD |
| MO | Perform market clearing | Market Processes | Market Platform receives the request from the DSOTP and the offers from Aggregators |
| MO | Perform market settlement | Market Processes | Market Platform acquires the data (measurements and baseline) from SCD |

| | | | |
|---|---|---|---|
| BRP (Simulated) | Decrease the imbalances of the customers in his portfolio, evaluating a reliable baseline | Business Operation | The BRP evaluates the baselines for every customer and sends them in the SCD |
| Aggregator | Optimize energy costs – portfolio | Business Operation | The Aggregator Platform assess the optimal configuration and sends the offers to market |
| FR Owner | Maximize income obtained selling energy and flexibility through Aggregator vs the bought energy | Business Operation | The FR Owner evaluates the benefits coming from the market and decides if to give FR availability to Aggregator |

Table 13: Italian Demo Business Layer Analysis

The SGAM Business Layer analysis for the Greek Demo are shown in Table 14: Greek Demo Business Layer. The analysis is valid for all five Greek UCs.

| Actor | Business Goal | Business process | Information exchange |
|---|---|---|---|
| DSO | Obtain MV network state estimation | Monitoring (UC-GR-1,2) | Network measurements (Voltage, active-reactive power), PMU measurements |
| DSO | Reduce curtailment | Control (UC-GR-3,4) | Network tariffs (DA, Reserve market time context) |
| Aggregator | Minimize costs | Business Operation and Market Processes (UC-GR-3,4) | DER setpoints (DA, Reserve market time context) |
| DSO | Enhance observability | Monitoring (UC-GR-5) | Network data (various sources) |

Table 14: Greek Demo Business Layer Analysis

The SGAM Business Layer analysis for the German Demo is shown in Table 15. The analysis is valid for all four German UCs.

| Actor | Business Goal | Business Process | Information Exchange |
|---|---|---|---|
| DSO | Monitor of grid status to verify compliance of power quality and security requirements. | Monitoring | Sensors (e.g. PMU) data collection and transfer via DSOTP and BAP to EMS |

| | | | |
|---|---|---|---|
| DSO | Control of DERs, flexible loads and storages. Activation of flexibilities (scheduled/conditional reprofiling) to increase efficient grid operation, minimize problems due to poor power quality and respect of security requirements. Also, check the technical viability of flexibilities (scheduled/ conditional reprofiling) | Controlling | EMS dispatches Setpoints or Setpoint schedules from DSOTP and BAP to DER |
| Residential Consumer | Maximize income from energy bought vs energy and flexibility sold on markets or provided to DSO or TSO for grid optimization purposes. | Provision of Measurement values | Sensor data provision and transfer via DSOTP and BAP to EMS |
| Residential Consumer | Maximize income of energy bought vs energy and flexibility sold on markets or provided to DSO or TSO for grid optimization purposes. | Provision of flexibility for steering | Controller receiving setpoints along DSOTP and BAP to EMS |

Table 15: German Demo Business Layer Analysis

# 5 Demo Comparison and Use Case Clustering

This chapter will build on the previous chapters to provide a general understanding and overview of the Platone's demo activities.

The demo sites are compared in chapter 5.1 regarding their geographical situation, type of electricity network, DERs, loads and technologies.

The way in which the UCs cover Platone's objectives and electricity system challenges is analysed in chapter 5.2.

## 5.1 Categorisation of the Demos

Table 16 presents an analysis of the Platone demos where they are compared under a number of different categories related to the demo infrastructures of the DSOs.

| Category | German Demo | Greek Demo | Italian Demo |
|---|---|---|---|
| Geography | rural | urban and rural | urban |
| Networks | LV, MV | MV | LV, MV |
| Presence of variable generation | Yes – PV | Yes – PV, wind farms | Yes - PV |
| Load type | Households, agricultural buildings, electrical heaters such as heat pumps, storage heaters | Small/medium/large industries, households | Small/medium industries, households, public buildings, EV charging stations |
| Smart grid technologies | PMU, Flex Controller, EMS, Forecasting sensors | PMU, State Estimation Tool, Algorithms for optimal dispatching, ancillary services provision | LN, State estimation tool, load & generation forecasting tool |

Table 16. Comparison of demonstration sites.

The first two selected categories are Geography and Networks. They help illustrate the general conditions concerning the demo site. The distinction between rural and urban areas gives indications about the density of consumers on the network and a great diversity among the three demos can be seen in this regard. Regarding the voltage level, there is no significant difference between the demos, which reflects that Platone is a DSO-oriented project.

From the following two categories – Presence of variable generation and Load type – it can be seen that in all three demos the DSOs are dealing with variable generation, which due to its character enhances the complexity of the management. The different loads can provide flexibility services, of smaller or greater importance for the DSO in their grid services. The table shows in this regard great differences in types of consumers; however, at the time of writing, the specific capacities of the different loads are not available.

The last category concerns the application of smart grid technologies, summing up the information provided in the previous chapters. All the demos use smart grid technologies in addition to the solutions being developed within the project, to support the optimization of the observability as well as automation and control of the grid, in accordance with the second project objective (see chapter 5.2).

## 5.2 Use Case Clustering

An analysis of how the Platone UCs address identified grid operator system challenges and Platone's objectives is presented in Table 17. The second column lists different relevant aspects of the system challenges and project objective, chosen to show the link from the system challenges and project objectives to the UCs. A column for each Platone UC indicates whether the UC covers this aspect.

The first row of Table 17 identifies the system challenges to the grid operator which Platone solutions address and attempt to solve. The challenges have been discussed during a WP1 workshop where the partners have mapped their UCs to the challenges. These challenges bear in mind the responsibility of the DSO to ensure a stable and secure distribution of electricity.

Rows 2-4 in Table 17 show how Platone's UCs relate to the project's objectives. Platone's objectives, which were also mentioned in chapter 1.1, are to test:

1. **Flexibility measures and electricity grid services** provided by storage of electricity, power-to-x, demand response, and variable generation enabling additional decarbonisation;
2. **Smart grids technologies** for an optimum observability and tools for a higher automation and control of the grid and distributed energy sources, for increased resilience of the electricity grid and for increased system security
3. **Market** mechanisms incentivising flexibility or other market tools should be defined and tested for mitigating short-term and long-term congestions or other problems in the network.

| Challenge / Project Objective | Aspect | DE-1 | DE-2 | DE-3 | DE-4 | GR-1 | GR-2 | GR-3 | GR-4 | GR-5 | IT-1 | IT-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| System challenges | Voltage control | | | | | X | X | X | X | | X | |
| | Congestion management | | | | | X | X | X | X | | | X |
| | Local balancing | X | X | X | X | | | | | | | |
| | Frequency support | | | | | | | | X | | | |
| | Enhance observability | | X | | | X | X | X | X | X | | |
| Flexibility measures and grid services | Variable generation | X | X | X | X | | | X | X | | X | X |
| | Aggregators | | | | | | | X | X | X | X | X |
| | Customers/demand response | X | X | X | X | | | X | X | X | X | X |
| | Storage | X | X | X | X | | | | | | X | X |
| | Power-to-X | X | X | X | X | | | | | | | |
| | Electric vehicles | | | | | | | | | | X | X |
| Smart Grid Technologies | Market Platform | | | | | | | | | | X | X |
| | DSO Technical Platform | X | X | X | X | X | X | X | X | X | X[4] | X[4] |
| | Aggregator Platform | | | | | | | | | | X | X |
| | Blockchain Access Platform | X | X | X | X | X | X | X | X | X | X[5] | X[5] |
| | Shared Customer Database | X | X | X | X | | | | | | X[6] | X[6] |
| Market | Near Real Time | | | | | X | X | | X | X | X | X |
| | Day ahead | | | | | X | X | X | | | X | X |

Table 17. Clustering of the use cases

[4] developed by Siemens

[5] developed by APIO

[6] developed by areti

The Smart Grid Technologies covered in Table 17 are those developed in Platone. For details on other smart grid technologies, not developed specifically by the project, but deployed in the demos, see Table 16.

Differences among the use cases concerning the third test objective regarding market operation are treated from the point of view of electricity markets time horizon. Further information on the specific market measures to be taken by the individual demo will be available in the deliverables corresponding to the demo WP in question. It is worth noticing that while both the Italian and Greek demos address market aspects with their use cases, they take different approaches. In the Italian demo, active use of a market platform will be applied to the use cases, whereas the focus of the Greek demo focus in this regard is on making use of tariffs to incentivise certain behaviour.

This analysis is the base for further work related to replicability and scalability in WP7 and for the regulatory analysis to be performed in Task 1.2.

# 6 Conclusions

This deliverable provides a broad overview of all three demos to be deployed in Platone project and compares their UCs according to the Platone objectives and the solutions to be applied. Information needed for this task was gathered using a template based on the IEC 62559 standard for UCs. In addition, a methodology for UC management, based on non-proprietary tools, was developed and applied. The Platone UC repository will make the Platone UCs available publically and has been adopted by BRIDGE for all H2020 projects.

Moreover, an analytical tool to map smart grid use cases was implemented – the SGAM. Its graphical representation and analysis of Smart Grid use cases in an architecturally and technologically neutral manner have provided a better understanding of the activities in the demos deployed in Platone project.

The three Platone demonstration sites with their different operation conditions have the potential enhance the project's relevance across Europe's diverse DSO landscape. The eleven UCs will deal with the four system challenges – voltage control, congestion management, frequency support and observability- and provide good coverage of Platone's objectives to test flexibility measures and electricity grid services, smart grid technologies and market mechanisms.

Flexibility measures and grid services will be tested in all three demonstrations in the form of variable generation, demand response and by use of aggregators. In addition, Italy and Germany will introduce flexibility from storage as well as EVs in Italy and Power-to-x in Germany. New smart grid technology, including blockchain-based platforms developed for the project, will be deployed in all three demos. The market aspect will be tested in Italy and to some extent in Greece.

# 7 List of Tables

# 8 List of Figures

# 9 List of References


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# 10 List of Abbreviations

| Abbreviation | Term |
|---|---|
| ALF-C | Avacon Local Flex Controller |
| AMR | Automatic Metering Reading |
| API | Application Programming Interface |
| BAP | Blockchain Access Platform |
| BESS | Battery Energy Storage System |
| BRP | Balance Responsible Party |
| CEC | Citizen Energy Community |
| CL | Consumer Load |
| CSP | Concentrated Solar Power |
| DA | Day Ahead |
| DER | Distributed Energy Resources |
| DM | Data Management |
| DMS | Distribution Management System |
| DSO | Distribution System Operator |
| DSODS | Distribution System Operator Data Server |
| DSOTP | Distribution System Operator Technical Platform |
| DSOTP_Ita | Italian demo version of Distribution System Operator Technical Platform |
| EMS | Energy Management System |
| ERP | Enterprise Reserve Planning software |
| EV | Electrical Vehicles |
| FL | Flexible Loads |
| FR | Flexible Resource |
| GIS | Geographical Information System |
| GPRS | General Packet Radio Service |
| GUI | Graphical User Interfaces |
| HES | Household Energy Storage |
| HV | High Voltage |
| INEA | Innovation and Networks Executive Agency |
| IntCon | Integrated Controller |
| KPI | Key Performance Indicator |
| LEC | Local Energy Community |
| LN | Light Node |
| LV | Low voltage |
| MP | Market Platform |
| MQTT | Message Queueing Telemetry Transport |

| | |
|---|---|
| MTU | Market Time Units |
| MV | Medium Voltage |
| OS | Operation Systems |
| PMU | Phasor Measurement Unit |
| POD | Point of Delivery |
| PV | Photo Voltaic |
| RD&I | Research Development & Innovation |
| RES | Renewable energy sources |
| REST | Representational State Transfer |
| Req. | Requirements |
| RTU | Remote Terminal Unit |
| SA | Smart Appliance |
| SCADA | Supervisory Control and Data Acquisition |
| SCD | Shared Customer Database |
| SCD_Ita | Italian Shared Customer Database |
| SE | State estimation |
| SET | State Estimation Tool |
| SGAM | Smart Grid Architecture Model |
| SOC | State of Charge |
| SOE | State of Energy |
| SS | Storage System |
| SSBS | Small Scale Battery Storage |
| StHouse | Standard Household |
| StoHeat | Storage heater |
| TBD | To be defined |
| TCP | Transmission Control Protocol |
| TSO | Transmission system operator |
| TSOsim | TSO simulator |
| UC | Use case |
| UI | User Interface |
| WFS | Weather Forecast Service |
| WP | Work package |

# Annex A Platone UCs in GitHub Repository

This annex presents the information available at moment of uploading this deliverable (August 2020). The information is organised according to IEC-62559 standard template, which is filled in per use case, starting with the use cases of the Italian demo (A.1), and then followed by the Greek (A.2) and German (A.3) use cases.

## A.1 Detailed Italian Demo UCs

### A.1.1 UC-IT-1 Voltage Management

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-IT-1 | Area: Energy system | Voltage Management in transmission and distribution system using also the resources connected to the distribution system |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | | areti, Acea Energia, Engineering, Siemens | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| **Scope** | Avoiding the voltage violations in distribution and transmission grid, using the flexibility resources connected to the distribution systems which provide flexibility services through a market mechanism.<br>Networks: MV, LV<br>Markets: Day Ahead, Real Time |
| **Objective(s)** | * To support the TSO to use the flexibility provided by the resources connected to the distribution system for voltage violation, respecting the distribution system constraints<br>* To ensure an inclusive and non-discriminatory access to the market to all the actors that provide grid services<br>* To empower coordination between system operators<br>* To activate flexibility to solve voltage violations in the distribution grid |
| **Related business case(s)** | - |

1.4. Narrative of Use Case

**Short description**

This use case describes the main steps to avoid voltage violations in transmission and distribution systems by exploiting flexibility resources, contemplating all the phases concerned (procurement, activation and settlement) in the day-ahead and real time flexibility market. The DSO can use flexible resources connected to the distribution system and the TSO can use flexible resources connected to distribution systems under the DSO's approval. The state estimation is assessed and monitored by the DSO in order to keep the electrical quantities within admissible ranges.

**Complete description**

The Use Case describes the main steps to avoid voltage violations in transmission and distribution systems by exploiting flexibility resources, contemplating all the phases concerned (procurement, activation and settlement) in the day-ahead and real time flexibility market. The DSO can use flexible resources connected to the distribution system and the TSO can use flexible resources connected to distribution systems under the DSO's approval. The state estimation is assessed and monitored by the DSO in order to keep the electrical quantities within admissible ranges.

In the day ahead market, the FR Owner sends to Aggregator Platform the list of the resources available for the day after. The list is subsequently transmitted by the Aggregator Platform to the Shared Customer Database (SCD). For each Point of delivery (PODs), the SCD collects quarterly measures and data useful for flexibility and sends them to the DSO Technical Platform, the TSO simulator and the Aggregator Platform.

Other three processes take place in parallel:

- Detection of voltage violations on the distribution grid by the DSO Technical Platform and definition of local flexibility requests, in the event the issue cannot be solved through its own solutions;
- Definition of voltage violations on the transmission network by the TSO simulator and request of flexibility to solve them in HV grid;
- Gathering by the Aggregator Platform of flexibility offers from customers in LV and MV and offering to the Market.

At gate closure, all day ahead requests and offers are stored in the Market Platform, which matches first the offers with the DSO's requests, and orders them economically; then, it repeats the same procedure with the TSO requests.

The list of awarded offers is sent to DSOTP for evaluating the grid constraints violations. Finally, the market platform receives the list of offers compliant with local grid constraints and sends it to all the stakeholders. At this step, the Aggregator Platform sends a reservation to the FR Owner for the resources that will be selected for the day-ahead market.

The same steps are also followed in the Real Time sessions. Indeed, in these Market sessions, the offers to be matched with DSO and TSO Real Time requests are the ones still valid because not matched in previous market sessions.

The activation phase begins when the DSO and TSO need flexibility. The DSOTP and the TSO simulator communicate to the market Platform to move a specific offer. The Market Platform sends the order to the DSOTP, which divides it for every POD and dispatches the set point to the light nodes. The light nodes make available the set points to the BMS and measures the electrical quantities to be sent to the SCD for evaluate the energy flexibility. For the settlement phase, the Market Platform acquires data from the SCD and calculates the difference between market baseline, evaluated by BRP, and electrical quantities measured in the same time frame, uploaded in the SCD by Light Nodes. The Market Platform runs the settlement algorithm and finds the outcomes. Settlement outcomes are transmitted to the Aggregator Platform, the DSO and the TSO Simulator.

Finally, the DSO pays the flexibility to the Aggregator, who can pay the fee to the FR Owner.

### 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_PR_01 | Participants' recruitment | This indicator calculates the percentage of customers accepted their participation in the demo in relation with the total amount of customers contacted to participate in the demo. This indicator can be used to evaluate customer engagement plan. | |
| KPI_PR_02 | Active participation | This indicator measures the percentage of customers actively participating in the Platone demo with respect to the total customers that accepted the participation. This indicator can be used to evaluate customer engagement. | |
| KPI_PR_03 | Flexibility Availability | This KPI aims to measure the potential amount of flexibility that is available to the grid by flexible resources. | |
| KPI_PR_04 | Flexibility Effectiveness | This KPI is targeting to measure the effectiveness of flexibility provision. The KPI measures the sum of successfully provided flexibility in relation to the requested demand for flexibility. | |
| KPI_PR_05 | Forecast reliability – customer profile | This KPI evaluates the reliability of the tool performing forecasting of power flows exchange by each Resource with the grid. The indicator is calculated for forecasted time range (next 24h or next 4h). | |
| KPI_PR_06 | Forecast reliability – grid profile | This KPI evaluates the reliability of the tool performing forecasting of power flow in significant assets of the grid. The indicator is calculated for forecasted time range (next 24h or next 4h). | |
| KPI_IT_01 | Market Liquidity | This KPI is targeting to measure the market liquidity. The ratio of the sum of flexibility offered to the requested demand for flexibility is measured. | |

### 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| | |

### 1.7. Further information to the use case for classification/mapping

| | |
|---|---|
| **Relation to other use cases** | |
| Level of depth | |
| Prioritization | |
| Generic, regional or national relation | |
| Nature of the use cases | |

| Further keywords for classification | |
|---|---|

## 1.8. General remarks

| General remarks |
|---|
| |

# 2. Diagrams of Use Case

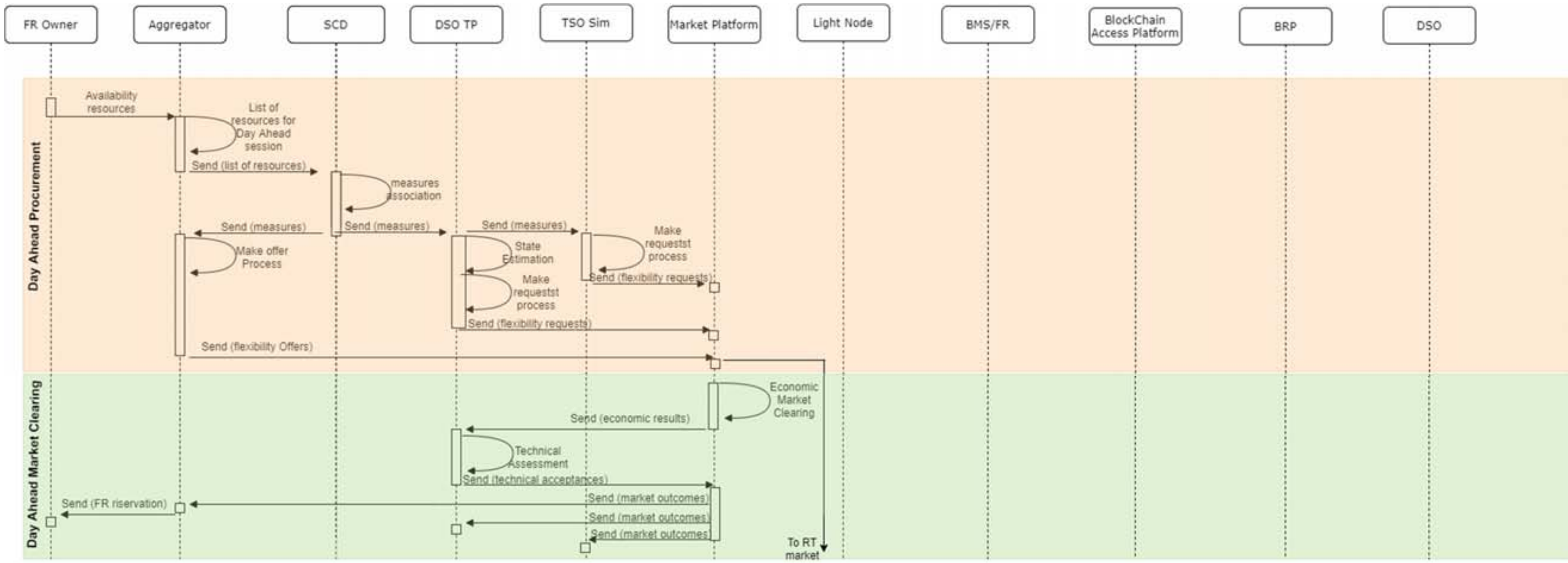



Figure 11: Sequence Diagram – Day Ahead IT

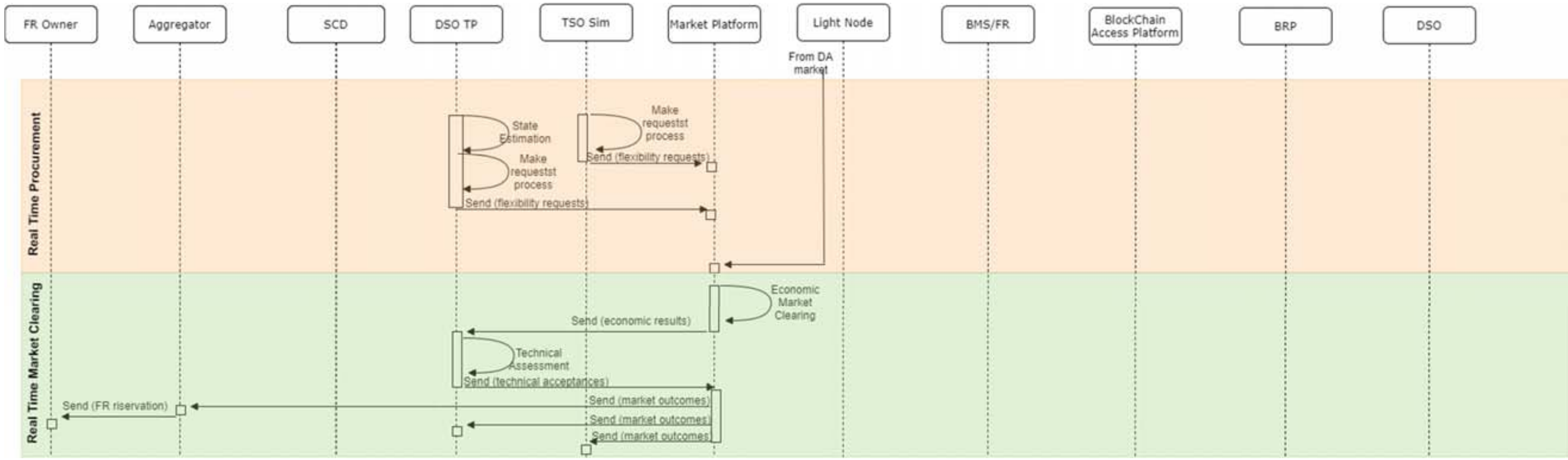



Figure 12: Sequence Diagram – Real Time UC-IT-1

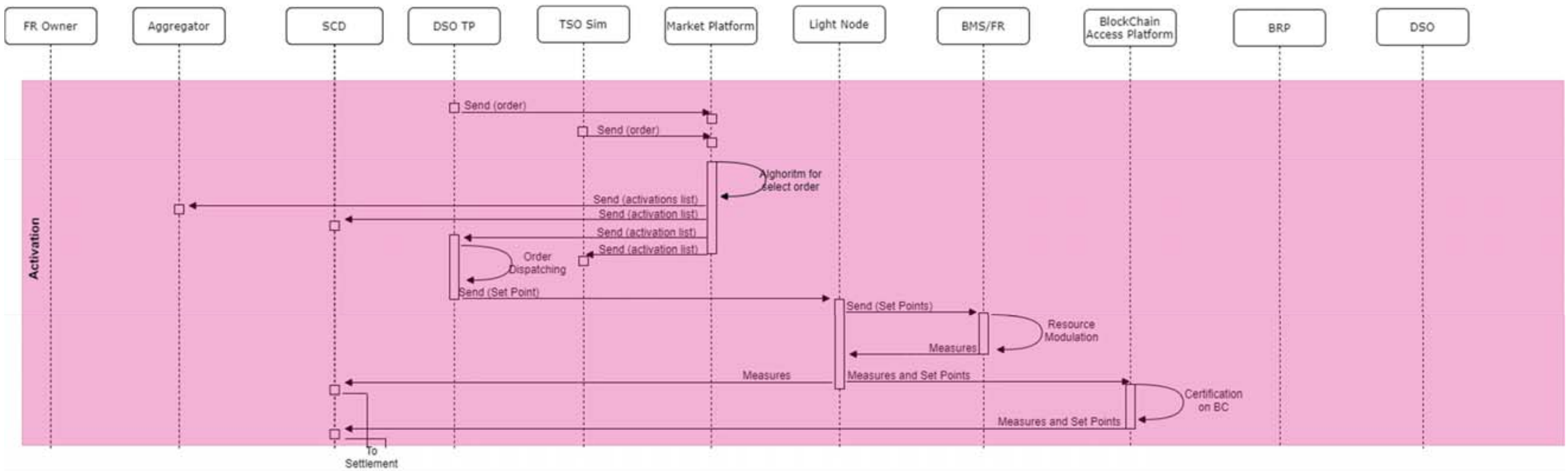



Figure 13: Sequence Diagram – Activation UC-IT-1

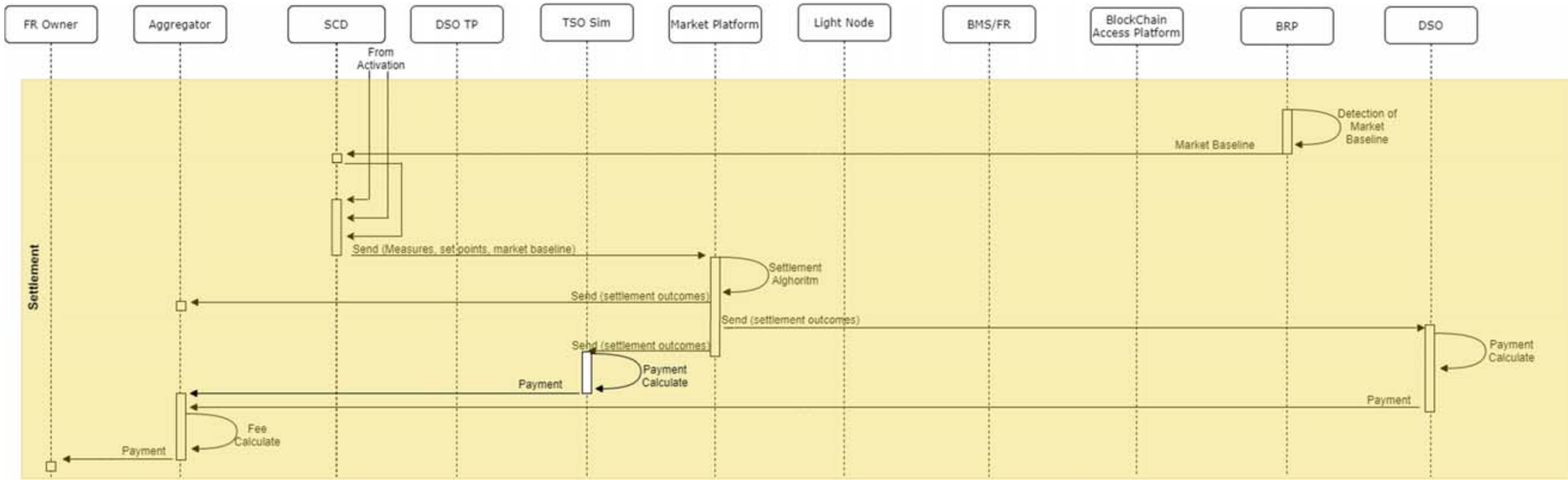



Figure 14: Sequence Diagram – Settlement UC-IT-1

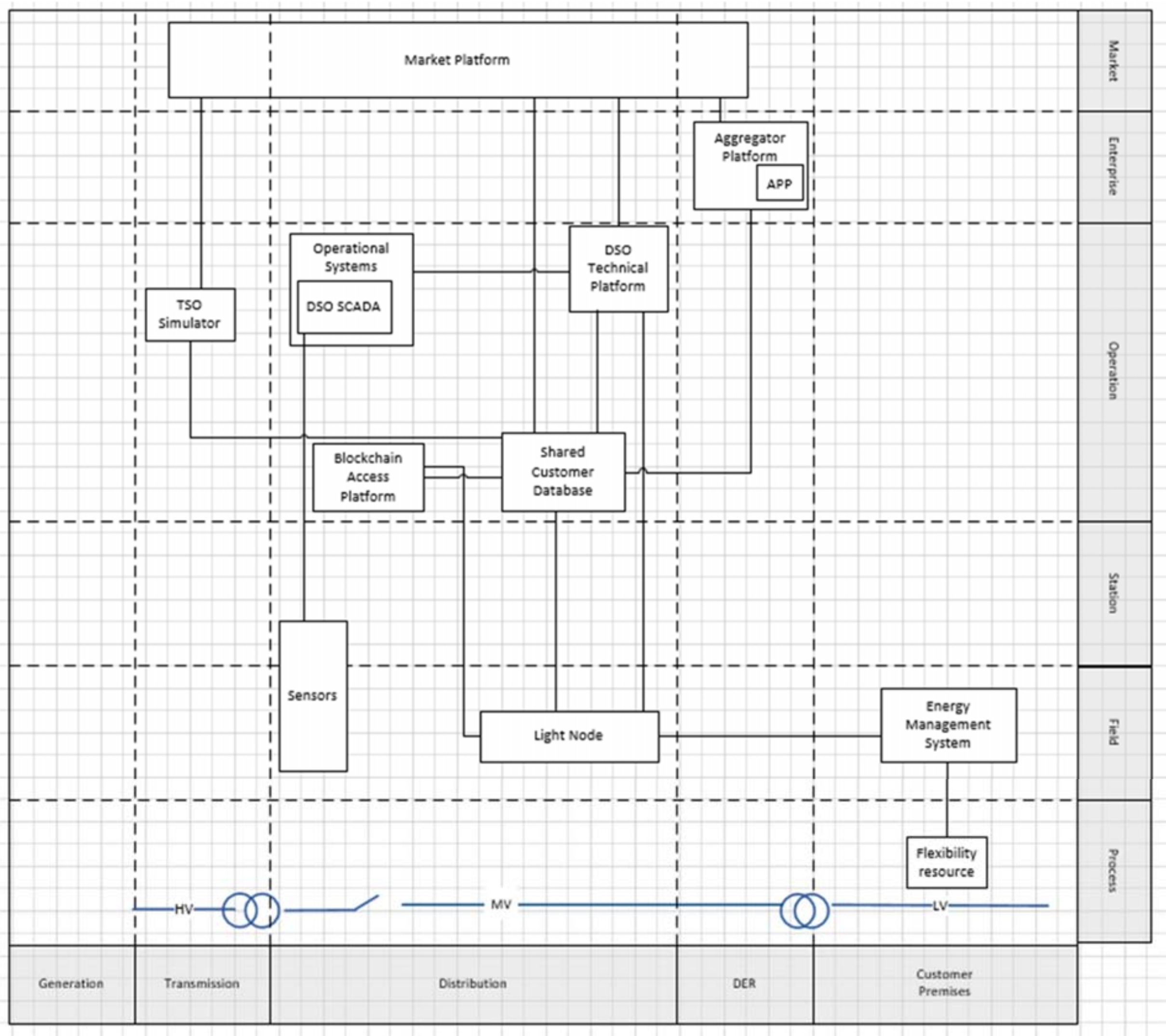



Figure 15: Use case diagram UC-IT-1

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| DSO | Person | DSO is each Distribution System Operator. It is an entity in charge for the management of the energy distribution networks | |
| Light Node | Device | Device installed on the DSO's smart meter in order to read, arrange, certify in Blockchain (at first level) and send to the SCD measurements and other data for the flexibility market and observability. Moreover, the device receives set-point from DSO Platform and make it available to client on client's apparatus (e.g. EMS). | |
| DSO Technical Platform | System | A software-based system that manages the distribution network. It performs grid state estimation and productions and consumptions forecasting. Moreover, it defines the flexibility requests for DSO's grid. The DSO Technical Platform exchanges data with SCADA and other system comprised in the Operation Domain. | |
| EMS (Energy Management System) | System | A system, in customer premises, used to monitor, control, and optimize the energy consumption and production. It could include the Building Energy Management System (BEMS) for tertiary sector, the Home Management System (HMS) for residential users, the Battery Management System (BMS) and the management system for EV charging points | |
| Blockchain Access Platform (BAP) | System | A software-based platform that certify, on Blockchain technology, the customers' data for flexibility and observability | |
| Shared Customer Database (SCD) | System | Database that gathers all the data and services of flexibility resources and shares them with all the stakeholders | |
| TSO | Person | TSO is each Transmission System Operator. It is an entity in charge for the management of the energy transmission networks. | Within the Italian Demo, the TSO is simulated by tool "TSO Simulator" (see below) |
| TSO simulator | Software component | Tool that emulates the TSO flexibility requests involving the resources connected in medium and in low voltage | Developed and implemented by WP2 |
| Market Operator (MO) | Person | Party responsible for the Market Platform. The Market Operator matches the flexibility offers and requests on the Market Platform | |

| | | | |
|---|---|---|---|
| Platone Market Platform (MP) | Software component | Virtual Place where the requests of flexibility match the offers | Developed and implemented within WP2 |
| Flexibility Resources (FR) | System | Resources, in customer premises, that provide flexibility to the market. They could be generation plants, electric vehicles, batteries, active demand. They are closely related to the demo's areas | |
| Flexibility Resources Owner (FR Owner) | Person | FR Owner is the customer that makes available its flexibility to provide services | |
| Aggregator/Flexibility Operator | Person | Aggregator / Flexibility Operator is an entity that aggregates the flexibility offers in the market and provides them to the DSO in case of needs for the grid | Aggregator Platform |
| Aggregator Platform/Software component | Software component | A software-based system that gathers the data measurement from the customers and calculates the flexibility to be offered on the market | |
| Balance responsible party | Person | A market participant or its chosen representative responsible for its imbalances | |

## 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organization | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

# 4. Step by Step Analysis of Use Case

## 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Day Ahead | DSO | The DSO assesses the Grid for the day after and finds a Voltage Violation | The DSO Technical Platform is capable to foresee the grid status for the day after | The DSO acquires in the market the energy flexibility to solve the grid issues for the day after |
| 2 | Real Time | DSO | The DSO assesses the Grid for the next 4 hours to take into account last grid outages or reconfiguration | The DSOTP is capable to detect the critical issues in the short term | The DSO acquires in the market the energy flexibility to solve the grid issues for the real time |
| 3 | Activation | DSO | The DSO sends the order to move the resources | The resources have won the session market | The Light Node measures the quantity of service provided |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Settlement | BRP | The BRP sends the baseline to the SCD | The BRP estimates the baseline for the energy market | The market operator calculates the energy flexibility with respect to BRP's baseline |

## 4.2. Steps – Scenarios

Scenario Name: No. 1 - Day Ahead

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Information Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 a | FR availability | Availability of Flexibility resources | FR Owner, through the app developed in the demo, communicates the availability of its resources to the Aggregator, for the day after | CREATE | FR Owner | Aggregator Platform | I - 12 | |
| 2 a | Users involved | List of flexible customer - step 1 | The Aggregator shares the flexible resources list with the SCD | CREATE | Aggregator Platform | SCD | I - 02 | |
| 3 a | Active POD | List of flexible customer - step 2 | The DSOTP acquires from SCD the list of POD involved | CREATE | SCD | DSO Technical Platform | I - 02 | |
| 4 a | DSO forecasts for day after | DSO Data acquisition | The DSO Technical Platform acquires the data from the SCD and from the field sensors (like V&C sensors and LV3G), through the Operational Systems, and runs the forecast tool to evaluate the production and the consumption | CREATE | Operation Systems | DSO Technical Platform | I-18 / I-01 | |
| 5 a | DSO simulates the grid for day after | Day Ahead grid assessment | The DSO Technical Platform runs the state estimation tool to assess the grid for the day after | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 6 a | Voltage Violation | Violation localization | If the DSO Technical Platform detects a voltage violation, it sends an alert to the DSO operator | CREATE | DSO Technical Platform | DSO | I - 10 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 a | Using of solutions in the DSO premises | Grid management | The DSO first tries to solve the issues, using its own technical solutions. | CREATE | DSO | Operational systems | I - 11 | |
| 8 a | Involving of the FR | Active Grid Management | The DSO Technical Platform checks further amount of flexibility that is required to solve the voltage violation and detects the location of the flexibility resources connected to distribution system, that can contribute to eliminate the issue | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 9 a | Flexibility Procurement | Flexibility requests | The DSO communicates the flexibility requests (Volumes, time frame) to the market | CREATE | DSO Technical Platform | Market Platform | I - 06 | |
| 10 a | Market session | Requests Acquisition | The market Platform acquires and stores the DSO Day Ahead Requests | CREATE | Market Platform | Market Platform | | |
| 1 b | Data acquisition | Data FR Acquisition | The Aggregator, once known the available resources, acquires their measurements from the Shared Customer Database | GET | SCD | Aggregator Platform | I - 01 | |
| 2 b | Customer flexibility | Provision of flexibility from FR | The Aggregator calculates the baseline and the energy flexibility for every customer in its premises | Execute | Aggregator Platform | Aggregator Platform | | |
| 3 b | Definition of the offer | Offering | The Aggregator arranges the offers for PODs defining the flexibility to be offered | CREATE | Aggregator Platform | Aggregator Platform | | |
| 4 b | Offers providing | Offers sending | The Aggregator sends the scheduling (max. volumes, time frame and price) per POD to the market | CREATE | Aggregator Platform | Market Platform | I - 05 | |
| 5 b | Market session | Offers Acquisition | The Market Operator acquires and stores the Aggregator Day Ahead Bids | GET | Market Platform | Market Platform | | |
| 1 c | TSO flexibility | TSO requests | The TSO acquires from SCD the list of flexible resources that can contribute to | CREATE | SCD | TSO Simulator | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | requests for day after | | eliminate the voltage violation at transmission level | | | | | |
| 2 c | Procurement of flexibility | Flexibility requests | The TSO communicates the requests (Volumes, time frame) of flexibility to the market | CREATE | TSO Simulator | Market | I - 06 | |
| 3 c | Market session | Requests Acquisition | The Market Operator acquires and stores the TSO Day Ahead Requests | CREATE | Market Platform | Market | | |
| 11 a | Selection of the cheapest requests for the DSO | Economic market clearing | The Market Operator solves the DSO requests, selecting the best offers located in the distribution network area subjected to voltage violation. To increase the reliability, the Market Platform also selects some additional offers beyond the requests | REPEAT | Market Platform | Market Platform | | |
| 12 a | Selection of the cheapest requests for the TSO | Economic market clearing | The Market Operator uses the remaining flexibility to clear the TSO requests | REPEAT | Market Platform | Market platform | | |
| 13 a | Preliminary list of auctioned offers | Economical Auctioned offers | The Market Operator gathers and orders the list of auctioned offers and sends it to the DSO | REPORT | Market Platform | DSO | I - 08 | |
| 14 a | Grid constraints assessment | Technical assessment | The DSO receives from the Market the list of auctioned offers and assesses the grid constraints | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 15 a | Final list of auctioned offers | Auctioned offers | The DSO sends the list of approved offers to the Market | REPORT | DSO Technical Platform | Market Platform | I - 07 | |
| 16 a | Market outcomes | Market Day Ahead outcomes | The DSO, TSO and Aggregator receive Market Day Ahead outcomes from the Market Operator | REPORT | Market Platform | DSO/TSO/ Aggregator Platform | I - 08 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 17 a | Available resources | Resource Planning | FR Owner receives the detail of the service to be provide for the day after | REPORT | Aggregator Platform | FR Owner | I - 13 | |

Scenario Name: No. 2 - Real Time

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 a | DSO forecast for the next hours | DSO Data acquisition | DSO Technical Platform acquires the data from SCD and from the field sensors (V&C sensors and LV3G), through the Operational Systems and runs the forecast tool, to evaluate the production and the consumption | CREATE | Operational Systems | DSO Technical Platform | I-18 / I-01 | |
| 2 a | DSO simulate the grid for the next hours | Real Time grid assessment | DSO Technical Platform run the state estimation tool to assesses the grid for the next four hours | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 3 a | Voltage Violation | Violation Localization | If the DSO Technical Platform detect a voltage violation sends an alert to DSO Operator | CREATE | DSO Technical Platform | DSO | I - 10 | |
| 4 a | Using of solution in premises of DSO | Grid management | DSO tries first to solve the issue, using its own technical solutions. | CREATE | DSO | Operational Systems | I - 11 | |
| 5 a | Involving of the customer | Active Grid Management | DSO Technical Platform assess the amount of flexibility that is required to solve the voltage violation and decides the location of the flexibility resources connected to distribution system, that can contribute to eliminate the issue | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 6 a | Flexibility Procurement | Flexibility requests | DSO communicates the requests (Volumes, time frame) of flexibility | CREATE | DSO Technical Platform | Market Platform | I - 06 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 a | Open market session | Requests publishing | Market Platform acquires and stores the DSO Real time Requests | CREATE | DSO Technical Platform | Market Platform | | |
| 1 c | Flexibility Procurement | Flexibility requests | TSO communicates the further requests (Volumes, time frame) of flexibility to market | CREATE | TSO Simulator | Market Platform | I-06 | |
| 2 c | Open market session | Requests publishing | Market Platform Acquires and stores the TSO Real time Requests | CREATE | TSO Simulator | Market Platform | | |
| 8 a | Select of the cheaper requests for DSO | Economic market clearing | Market Platform solves the DSO requests, selecting the best offers located in the distribution network area subjected to voltage violation. To increase the reliability Market Platform select also some additional offers beyond the requests | REPEAT | market platform | Market Platform | | |
| 9 a | Select of the cheapest requests for TSO | Economic market clearing | The Market Platform uses the remaining flexibility to clear the TSO requests | REPEAT | market platform | Market Platform | | |
| 10 a | Preliminary list of auctioned offers | Economical Auctioned offers | The Market Platform gathers and orders the list of all auctioned offers and sends it to DSO Technical Platform | REPORT | market platform | DSO Technical Platform | I - 08 | |
| 11 a | Grid constraints assessment | Technical assessment | DSO Technical Platform receives from Market Operator the list of auctioned offers and assesses the grid constraints | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 12 a | Finally list of auctioned offers | Auctioned offers | DSO Technical Platform sends the list of all approved offers to Market | REPORT | DSO technical Platform | Market Platform | I -07 | |
| 13 a | Market outcomes | Market Real Time outcomes | DSO, TSO and Aggregator receives Market Real Time outcomes from the Market Operator | REPORT | Market Platform | DSO/TSO/ Aggregator Platform | I - 08 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14 a | Available resources | Resources planning | FR Owner receives the detail on the service to provide in the Real Time | REPORT | Aggregator Platform | FR Owner | I-13 | |

Scenario Name: No. 3 - Activation

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Information Exchanged | Requirements, R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 a | The DSO needs to solve a voltage violation | DSO Flexibility order | The DSO Technical Platform sends the order to move flexibility to the market operator | CREATE | DSO Technical Platform | Market Platform | I-09 | |
| 1 b | The TSO needs to solve a voltage violation | TSO Flexibility order | The TSO sends the order to move flexibility to the market operator | CREATE | TSO Simulator | Market Platform | I-09 | |
| 2 a | Order transmission | Forwarding the set point - step 1 | The Market Platform receives and sends the order to the DSO Technical Platform, the SCD and the Aggregator | CREATE | Market Platform | DSO Technical Platform/SCD/Aggregator | I-09 | |
| 3a | Order transmission | Forwarding the of set point - step 2 | The DSO receives from the Market the scheduling and sends the set points to Light Nodes | CREATE | DSO Technical Platform | Light Nodes | I-09 | |
| 4 a | Order available | Delivering of set point | The Light Node receives and makes available the set point to the EMS (it can be BMS or HMS) and FR | CREATE | Light Node | EMS / FR | I-09 | |
| 5 a | Moving of flexibility | Activation | Energy Management System acquires the set point and selects the correct scenario for electrical appliances (it can be | CREATE | EMS / FR | Smart Appliance / EV / Storage | I-14 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | also EV or storage), and/or suggests the right behavior for the customers (e.g. through an alert); | | | | | |
| 6 a | Use of Blockchain Access Layer | Data Certification | The Light Node forwards the set point and the measurements (in Blockchain | CREATE | Light Nodes | Blockchain Access Platform | I-04 / I-09 | |
| 7 a | Flexibility Certification | Blockchain outcomes | The Blockchain sends the certification data to the SCD | CREATE | Blockchain Access Platform | Shared Customer Database | I-04 / I-09 | |
| 8 a | Measurement of flexibility | Energy Monitoring | Light Node measures the electrical quantities for calculating the flexibility and sends them to the SCD | CREATE | Light Node | Shared Customer Database | I-04 / I-09 | |

Scenario Name: No. 4 - Settlement

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 | Baseline Definition | Market Baseline | The BRP defines the production and/or consumption programs for all the resources involved in the local flexibility market, and sends it to the SCD | CREATE | BRP | SCD | I-03 | |
| 2 | Energy moved after a flexibility request | Flexibility measurements | The light node sends the measurements to the SCD | CREATE | Light Node | SCD | I-04 | |
| 3 | Gathering of data | Settlement - step 1 | The Market Platform acquires the data from the SCD | CREATE | SCD | Market Platform | I-04 | |
| 4 | Flexibility evaluation | Settlement - step 2 | The Market Operator performs the settlement comparing the metering data with the BRP baseline | CREATE | Market Platform | Market Platform | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | Settlements outcomes | Settlement - step 3 | The Market Operator communicates the settlements outcomes to the DSO, TSO and Aggregator | CREATE | Market Platform | DSO / TSO / Aggregator Platform | I -15 | |
| 6 | Payment of Energy provided | Payment | The DSO pays the Energy provided for flexibility to Aggregator | CREATE | DSO | Aggregator Platform | I -16 | |
| 7 | Customer payment | Payment | The Aggregator shares the revenues with the flexibility resources under their jurisdiction | CREATE | Aggregator Platform | FR Owner | I -17 | |

## 5. Information Exchanged

| **Information exchanged ID** | **Name of Information** | **Description of Information Exchanged** | **Protocol** |
|---|---|---|---|
| I-01 | Quarterly measures | The data measurements (active power, energy consumption, energy production, etc.) stored in the SCD. These measures have a 15-minute granularity | |
| I-02 | Customer list | The list of customers available to provide flexibility services for the day after | |
| I-03 | BRP Baseline | The BRP defines for every POD the day after load profile, in compliance with the day ahead market | |
| I-04 | Near real time measures | This information contains for every POD involved in the flexibility market, the active power measured every 4 seconds | |
| I-05 | Data for Offer | The flexibility offer contains the volume, the time frame and the price provided by the FR involved in the group | |
| I-06 | Data for Requests | The flexibility request contains the needs of flexibility (volume and time frame) localized in specific nodes of the grid | |
| I-07 | Technical Validation | This information contains the assessment of the local grid constraints | |
| I-08 | Market Outcomes | This information contains the list of offers arranged in economic order and in compliance with the grid constraint | |
| I-09 | Order | The TSO and the DSO send a signal of activation to move the FR involved in the service | |
| I-10 | Voltage violation localization | The DSO technical platform defines a list of grid nodes subject to voltage violations | |
| I-11 | Grid configuration | The DSO technical platform detects the possible grid configuration to solve the issue | |

| | | | |
|---|---|---|---|
| I-12 | FR status | This information contains the customer availability to move its own FR | |
| I-13 | FR planning | This information contains the time frame and the power that the customer has to provide during the activation | |
| I-14 | Activation Signal | The EMS sends the signal of activation to smart load | |
| I-15 | Settlement outcomes | This information contains for every offer the energy moved and the payment | |
| I-16 | DSO payment | It is the payment realized by the DSO for the energy provided | |
| I-17 | Aggregator payment | It is the remuneration that the aggregator recognizes to the customer | |
| I-18 | Technical Measurement | Electrical quantities coming from the field sensors (Voltage and current sensors or Low Voltage circuit breakers embedded with IED) | |

## 6. Requirements

## 7. Common Terms and Definitions

| Term | Definition |
|---|---|
| | |

## 8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

### A.1.2 UC-IT-2 Congestion Management

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-IT-2 | Area: Energy system | Congestion Management in transmission and distribution system using resources connected to distribution system |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | | Areti, Acea Energia, Engineering, Siemens | Initial creation | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | Avoiding the congestions in distribution and transmission grid, using the flexibility resources connected to the distribution systems which provide flexibility services through a market mechanism.<br>Network: MV, LV<br>Market: Day Ahead, Real Time |
| **Objective(s)** | * To support the TSO in using the flexibility provided by resources connected to the distribution system for congestion management, while respecting distribution system constraints<br>* To ensure an inclusive and non-discriminatory access to the market for all agents that provide grid services<br>* To empower coordination between system operators<br>* To activate flexibility to solve congestion in the distribution grid |
| Related business case(s) | - |

1.4. Narrative of Use Case

**Short description**

This use case describes the main steps to prevent congestion issues in transmission and distribution systems by exploiting flexibility resources, contemplating all the phases concerned (procurement, activation and settlement) in the day-ahead and real time flexibility market. The DSO can use flexible resources connected to the distribution system and the TSO can use flexible resources connected to distribution systems under the DSO's approval. The state estimation is assessed and monitored by the DSO in order to keep the electrical quantities within admissible ranges.

**Complete description**

The Use Case describes the main steps to prevent congestion issues in transmission and distribution systems by exploiting flexibility resources, contemplating all the phases concerned (procurement, activation and settlement) in the day-ahead and real time flexibility market. The DSO can use flexible resources connected to the distribution system and the TSO can use flexible resources connected to distribution systems under the DSO's approval. The state estimation is assessed and monitored by the DSO in order to keep the electrical quantities within admissible ranges. In the day ahead market, the FR Owner sends to Aggregator Platform the list of the resources available for the day after. The list is subsequently

transmitted by the Aggregator Platform to the Shared Customer Database (SCD). For each Point of delivery (PODs), the SCD collects quarterly measures and data useful for flexibility and sends them to the DSO Technical Platform, the TSO simulator and the Aggregator Platform.
Other three processes take place in parallel:

- Detection of congestion issues on the distribution grid by the DSO Technical Platform and definition of local flexibility requests, in the event the issue cannot be solved through its own solutions;
- Definition of congestion issues on the transmission network by the TSO simulator and request of flexibility to solve them in HV grid;
- Gathering by the Aggregator Platform of flexibility offers from customers in LV and MV and offering to the Market.

At gate closure, all day ahead requests and offers are stored in the Market Platform, which matches first the offers with the DSO's requests, and orders them economically; then, it repeats the same procedure with the TSO requests.
The list of awarded offers is sent to DSOTP for evaluating the grid constraints violations. Finally, the market platform receives the list of offers compliant with local grid constraints and sends it to all the stakeholders.
At this step, the Aggregator Platform sends a reservation to the FR Owner for the resources that will be selected for the day-ahead market. The same steps are also followed in the Real Time sessions. Indeed, in these Market sessions, the offers to be matched with DSO and TSO Real Time requests are the ones still valid because not matched in previous market sessions.
The activation phase begins when the DSO and TSO need flexibility. The DSOTP and the TSO simulator communicate to the market Platform to move a specific offer. The Market Platform sends the order to the DSOTP, which divides it for every POD and dispatches the set point to the light nodes. The light nodes make available the set points to the BMS and measures the electrical quantities to be sent to the SCD for evaluate the energy flexibility.
For the settlement phase, the Market Platform acquires data from the SCD and calculates the difference between market baseline, evaluated by BRP, and electrical quantities measured in the same time frame, uploaded in the SCD by Light Nodes. The Market Platform runs the settlement algorithm and finds the outcomes. Settlement outcomes are transmitted to the Aggregator Platform, the DSO and the TSO Simulator.
Finally, the DSO pays the flexibility to the Aggregator, who can pay the fee to the FR Owner.

### 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_PR_01 | Participants' recruitment | This indicator calculates the percentage of customers accepted their participation in the demo in relation with the total amount of customers contacted to participate in the demo. This indicator can be used to evaluate customer engagement plan. | |
| KPI_PR_02 | Active participation | This indicator measures the percentage of customers actively participating in the Platone demo with respect to the total customers that accepted the participation. This indicator can be used to evaluate customer engagement. | |
| KPI_PR_03 | Flexibility Availability | This KPI aims to measure the potential amount of flexibility that is available to the grid by flexible resources. | |

| | | | |
|---|---|---|---|
| KPI_PR_04 | Flexibility Effectiveness | This KPI is targeting to measure the effectiveness of flexibility provision. The KPI measures the sum of successfully provided flexibility in relation to the requested demand for flexibility. | |
| KPI_PR_05 | Forecast reliability – customer profile | This KPI evaluates the reliability of the tool performing forecasting of power flows exchange by each Resource with the grid. The indicator is calculated for forecasted time range (next 24h or next 4h). | |
| KPI_PR_06 | Forecast reliability – grid profile | This KPI evaluates the reliability of the tool performing forecasting of power flow in significant assets of the grid. The indicator is calculated for forecasted time range (next 24h or next 4h). | |
| KPI_IT_01 | Market Liquidity | This KPI is targeting to measure the market liquidity. The ratio of the sum of flexibility offered to the requested demand for flexibility is measured. | |

## 1.6. Use case conditions

| **Assumptions** | **Prerequisites** |
|---|---|
| | |

## 1.7. Further information to the use case for classification/mapping

| **Relation to other use cases** | |
|---|---|
| Level of depth | |
| Prioritization | |
| Generic, regional or national relation | |
| Nature of the use cases | |
| Further keywords for classification | |

## 1.8. General remarks

| **General remarks** |
|---|
| |

## 2. Diagrams of Use Case

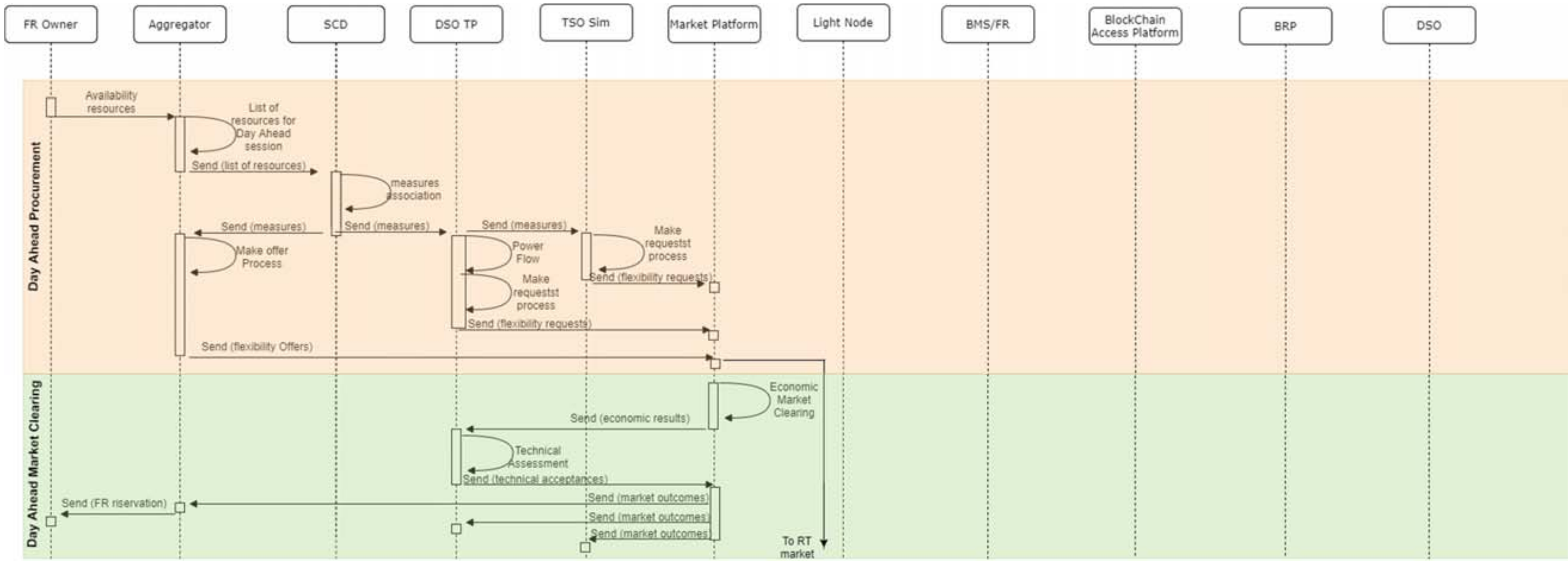



**Figure 16: Sequence Diagram – Day Ahead UC-IT-2**

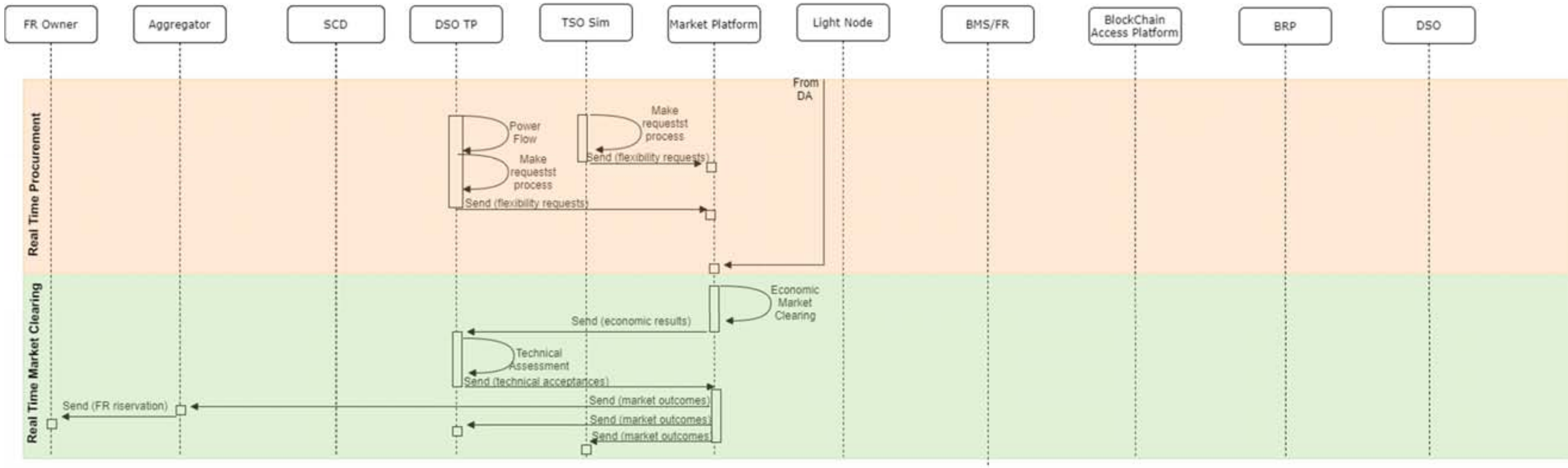



Figure 17: Sequence Diagram – Real Time UC-IT-2

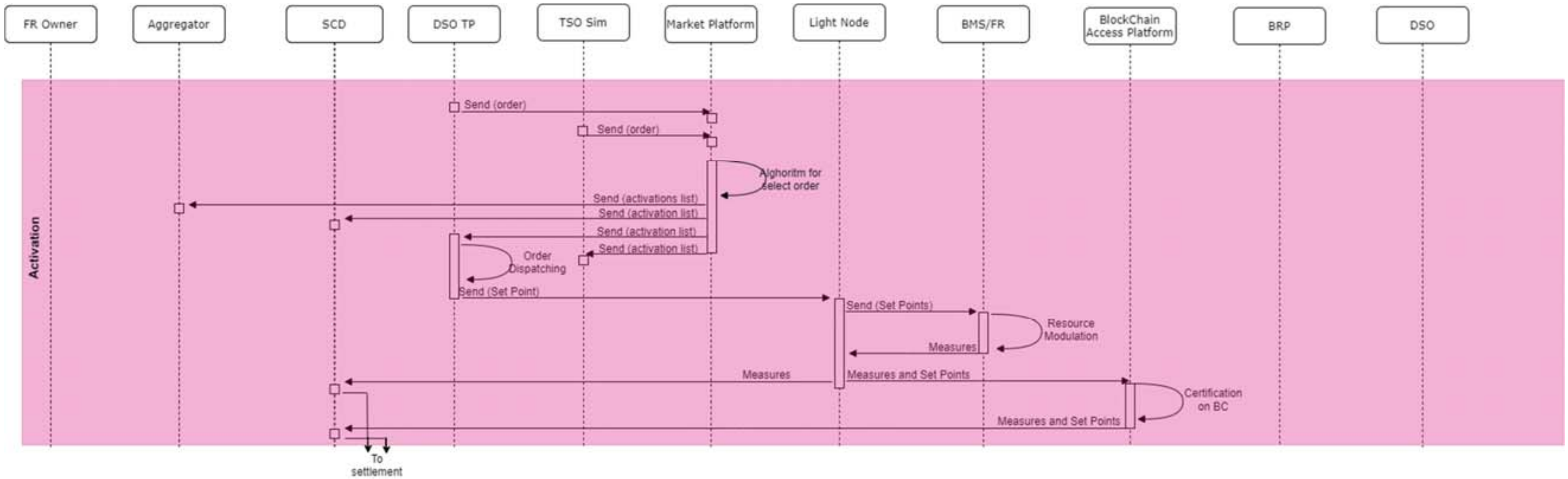



Figure 18: Sequence Diagram – Activation UC-IT-2

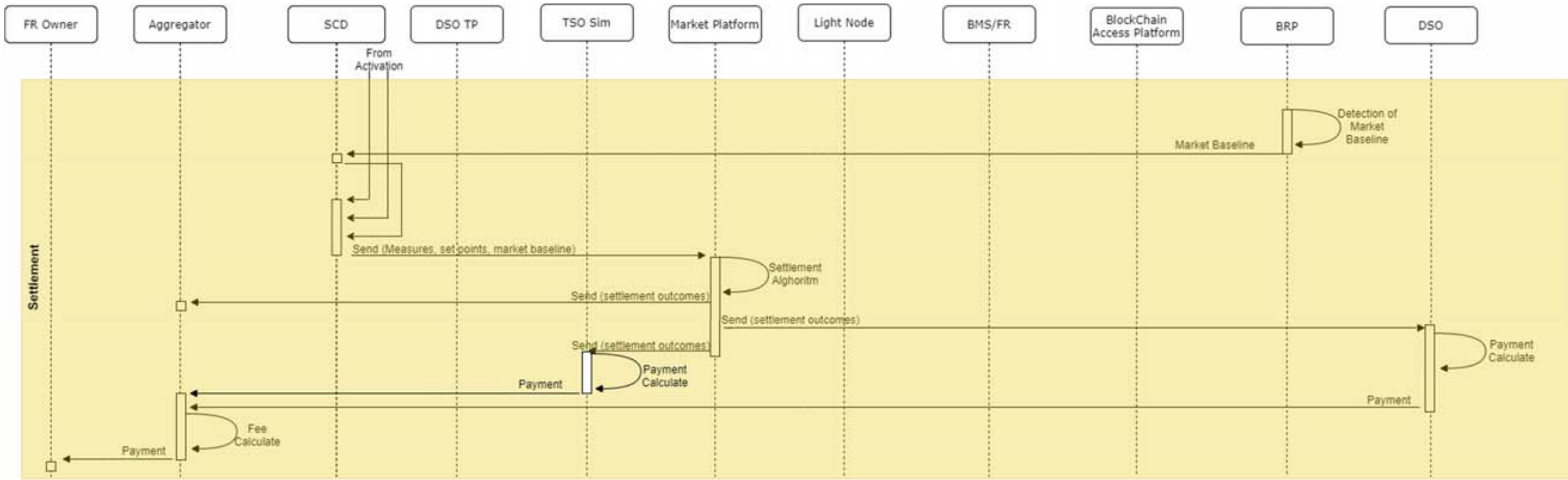



Figure 19: Sequence Diagram – Settlement UC-IT-2

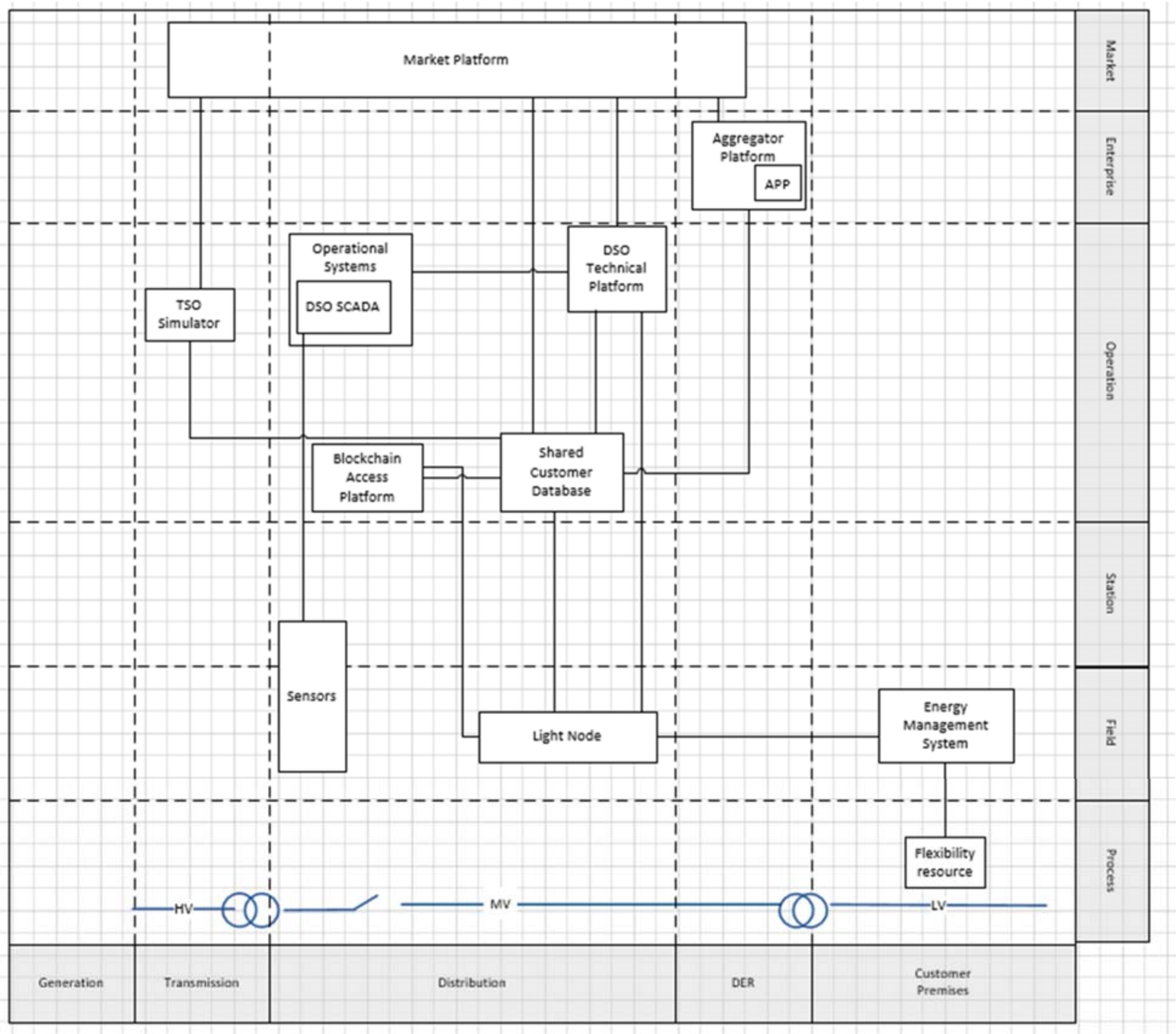



Figure 20: Use case diagram UC-IT-2

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| DSO | Person | DSO is each Distribution System Operator. It is an entity in charge for the management of the energy distribution networks | |
| Light Node | Device | Device installed on the DSO’s smart meter in order to read, arrange, certify in Blockchain (at first level) and send to the SCD measurements and other data for the flexibility market and observability. Moreover, the device receives set-point from DSO Platform and make it available to client on client’s apparatus (e.g. EMS). | |
| DSO Technical Platform | System | A software-based system that manages the distribution network. It performs grid state estimation and productions and consumptions forecasting. Moreover, it defines the flexibility requests for DSO’s grid. The DSO Technical Platform exchanges data with SCADA and other system comprised in the Operation Domain. | |
| EMS (Energy Management System) | System | A system, in customer premises, used to monitor, control, and optimize the energy consumption and production. It could include the Building Energy Management System (BEMS) for tertiary sector, the Home Management System (HMS) for residential users, the Battery Management System (BMS) and the management system for EV charging points | |
| Blockchain Access Platform (BAP) | System | A software-based platform that certify, on Blockchain technology, the customers’ data for flexibility and observability | |
| Shared Customer Database (SCD) | System | Database that gathers all the data and services of flexibility resources and shares them with all the stakeholders | |
| TSO | Person | TSO is each Transmission System Operator. It is an entity in charge for the management of the energy transmission networks. | Within the Italian Demo, the TSO is simulated by tool “TSO Simulator” (see below) |
| TSO simulator | Software component | Tool that emulates the TSO flexibility requests involving the resources connected in medium and in low voltage | Developed and implemented by WP2 |

| | | | |
|---|---|---|---|
| Market Operator (MO) | Person | Party responsible for the Market Platform. The Market Operator matches the flexibility offers and requests on the Market Platform | |
| Platone Market Platform (MP) | Software component | Virtual Place where the requests of flexibility match the offers | Developed and implemented within WP2 |
| Flexibility Resources (FR) | System | Resources, in customer premises, that provide flexibility to the market. They could be generation plants, electric vehicles, batteries, active demand. They are closely related to the demo's areas | |
| Flexibility Resources Owner (FR Owner) | Person | FR Owner is the customer that makes available its flexibility to provide services | |
| Aggregator/Flexibility Operator | Person | Aggregator / Flexibility Operator is an entity that aggregates the flexibility offers in the market and provides them to the DSO in case of needs for the grid | Aggregator Platform |
| Aggregator Platform/Software component | Software component | A software-based system that gathers the data measurement from the customers and calculates the flexibility to be offered on the market | |
| Balance responsible party | Person | A market participant or its chosen representative responsible for its imbalances | |

### 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organization | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

## 4. Step by Step Analysis of Use Case

### 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Day Ahead | DSO | The DSO assesses the Grid for the day after and finds a Congestion | The DSO Technical Platform is capable to foresee the grid status for the day after | The DSO acquires in the market the energy flexibility to solve the grid issues for the day after |
| 2 | Real Time | DSO | The DSO assesses the Grid for the next 4 hours to take into account last grid outages or reconfiguration | The DSOTP is capable to detect the critical issues in the short term | The DSO acquires in the market the energy flexibility to solve the grid issues for the real time |
| 3 | Activation | DSO | The DSO sends the order to move the resources | The resources have won the session market | The Light Node measures the quantity of service provided |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Settlement | BRP | The BRP sends the baseline to the SCD | The BRP estimates the baseline for the energy market | The market operator calculates the energy flexibility with respect to BRP's baseline |

## 4.2. Steps – Scenarios

Scenario Name: No. 1 - Day Ahead

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 a | FR availability | Availability of Flexibility resources | FR Owner, through the app developed in the demo, communicates the availability of its resources to the Aggregator, for the day after | CREATE | FR Owner | Aggregator Platform | I - 12 | |
| 2 a | Users involved | List of flexible customer - step 1 | The Aggregator shares the flexible resources list with the SCD | CREATE | Aggregator Platform | SCD | I - 02 | |
| 3 a | Active POD | List of flexible customer - step 2 | The DSOTP acquires from SCD the list of POD involved | CREATE | SCD | DSO Technical Platform | I - 02 | |
| 4 a | DSO forecasts for day after | DSO Data acquisition | The DSO Technical Platform acquires the data from the SCD and from the field sensors (like V&C sensors and LV3G), through the Operational Systems, and runs the forecast tool to evaluate the production and the consumption | CREATE | Operation Systems | DSO Technical Platform | I-18 / I-01 | |
| 5 a | DSO simulates the grid for day after | Day Ahead grid assessment | The DSO Technical Platform runs the state estimation tool to assess the grid for the day after | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 6 a | Congestion | Congestion localization | If the DSO Technical Platform detects a congestion, it sends an alert to the DSO operator | CREATE | DSO Technical Platform | DSO | I - 10 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 a | Using of solutions in the DSO premises | Grid management | The DSO first tries to solve the issues, using its own technical solutions. | CREATE | DSO | Operational systems | I - 11 | |
| 8 a | Involving of the FR | Active Grid Management | The DSO Technical Platform checks further amount of flexibility that is required to solve the congestion and detects the location of the flexibility resources connected to distribution system, that can contribute to eliminate the issue | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 9 a | Flexibility Procurement | Flexibility requests | The DSO communicates the flexibility requests (Volumes, time frame) to the market | CREATE | DSO Technical Platform | Market Platform | I - 06 | |
| 10 a | Market session | Requests Acquisition | The market Platform acquires and stores the DSO Day Ahead Requests | CREATE | Market Platform | Market Platform | | |
| 1 b | Data acquisition | Data FR Acquisition | The Aggregator, once known the available resources, acquires their measurements from the Shared Customer Database | GET | SCD | Aggregator Platform | I - 01 | |
| 2 b | Customer flexibility | Provision of flexibility from FR | The Aggregator calculates the baseline and the energy flexibility for every customer in its premises | Execute | Aggregator Platform | Aggregator Platform | | |
| 3 b | Definition of the offer | Offering | The Aggregator arranges the offers for PODs defining the flexibility to be offered | CREATE | Aggregator Platform | Aggregator Platform | | |
| 4 b | Offers providing | Offers sending | The Aggregator sends the scheduling (max. volumes, time frame and price) per POD to the market | CREATE | Aggregator Platform | Market Platform | I - 05 | |
| 5 b | Market session | Offers Acquisition | The Market Operator acquires and stores the Aggregator Day Ahead Bids | GET | Market Platform | Market Platform | | |
| 1 c | TSO flexibility requests for day after | TSO requests | The TSO acquires from SCD the list of flexible resources that can contribute to eliminate the congestion at transmission level | CREATE | SCD | TSO Simulator | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 c | Procurement of flexibility | Flexibility requests | The TSO communicates the requests (Volumes, time frame) of flexibility to the market | CREATE | TSO Simulator | Market | I - 06 | |
| 3 c | Market session | Requests Acquisition | The Market Operator acquires and stores the TSO Day Ahead Requests | CREATE | Market Platform | Market | | |
| 11 a | Selection of the cheapest requests for the DSO | Economic market clearing | The Market Operator solves the DSO requests, selecting the best offers located in the distribution network area subjected to congestion. To increase the reliability, the Market Platform also selects some additional offers beyond the requests | REPEAT | Market Platform | Market Platform | | |
| 12 a | Selection of the cheapest requests for the TSO | Economic market clearing | The Market Operator uses the remaining flexibility to clear the TSO requests | REPEAT | Market Platform | Market platform | | |
| 13 a | Preliminary list of auctioned offers | Economical Auctioned offers | The Market Operator gathers and orders the list of auctioned offers and sends it to the DSO | REPORT | Market Platform | DSO | I - 08 | |
| 14 a | Grid constraints assessment | Technical assessment | The DSO receives from the Market the list of auctioned offers and assesses the grid constraints | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 15 a | Final list of auctioned offers | Auctioned offers | The DSO sends the list of approved offers to the Market | REPORT | DSO Technical Platform | Market Platform | I - 07 | |
| 16 a | Market outcomes | Market Day Ahead outcomes | The DSO, TSO and Aggregator receive Market Day Ahead outcomes from the Market Operator | REPORT | Market Platform | DSO/ TSO/ Aggregator Platform | I - 08 | |
| 17 a | Available resources | Resource Planning | FR Owner receives the detail of the service to be provide for the day after | REPORT | Aggregator Platform | FR Owner | I - 13 | |

Scenario Name: No. 2 - Real Time

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 a | DSO forecast for the next hours | DSO Data acquisition | DSO Technical Platform acquires the data from SCD and from the field sensors (V&C sensors and LV3G), through the Operational Systems and runs the forecast tool, to evaluate the production and the consumption | CREATE | Operational Systems | DSO Technical Platform | I-18 / I-01 | |
| 2 a | DSO simulate the grid for the next hours | Real Time grid assessment | DSO Technical Platform run the state estimation tool to assesses the grid for the next four hours | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 3 a | Congestion | Congestion Localization | If the DSO Technical Platform detect a congestion sends an alert to DSO Operator | CREATE | DSO Technical Platform | DSO | I - 10 | |
| 4 a | Using of solution in premises of DSO | Grid management | DSO tries first to solve the issue, using its own technical solutions. | CREATE | DSO | Operational Systems | I - 11 | |
| 5 a | Involving of the customer | Active Grid Management | DSO Technical Platform assess the amount of flexibility that is required to solve the congestion and decides the location of the flexibility resources connected to distribution system, that can contribute to eliminate the issue | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 6 a | Flexibility Procurement | Flexibility requests | DSO communicates the requests (Volumes, time frame) of flexibility | CREATE | DSO Technical Platform | Market Platform | I - 06 | |
| 7 a | Open market session | Requests publishing | Market Platform acquires and stores the DSO Real time Requests | CREATE | DSO Technical Platform | Market Platform | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 c | Flexibility Procurement | Flexibility requests | TSO communicates the further requests (Volumes, time frame) of flexibility to market | CREATE | TSO Simulator | Market Platform | I-06 | |
| 2 c | Open market session | Requests publishing | Market Platform Acquires and stores the TSO Real time Requests | CREATE | TSO Simulator | Market Platform | | |
| 8 a | Select of the cheaper requests for DSO | Economic market clearing | Market Platform solves the DSO requests, selecting the best offers located in the distribution network area subjected to congestion. To increase the reliability Market Platform select also some additional offers beyond the requests | REPEAT | market platform | Market Platform | | |
| 9 a | Select of the cheapest requests for TSO | Economic market clearing | The Market Platform uses the remaining flexibility to clear the TSO requests | REPEAT | market platform | Market Platform | | |
| 10 a | Preliminary list of auctioned offers | Economical Auctioned offers | The Market Platform gathers and orders the list of all auctioned offers and sends it to DSO Technical Platform | REPORT | market platform | DSO Technical Platform | I - 08 | |
| 11 a | Grid constraints assessment | Technical assessment | DSO Technical Platform receives from Market Operator the list of auctioned offers and assesses the grid constraints | CREATE | DSO Technical Platform | DSO Technical Platform | | |
| 12 a | Finally list of auctioned offers | Auctioned offers | DSO Technical Platform sends the list of all approved offers to Market | REPORT | DSO technical Platform | Market Platform | I -07 | |
| 13 a | Market outcomes | Market Real Time outcomes | DSO, TSO and Aggregator receives Market Real Time outcomes from the Market Operator | REPORT | Market Platform | DSO/TSO/ Aggregator Platform | I - 08 | |
| 14 a | Available resources | Resources planning | FR Owner receives the detail on the service to provide in the Real Time | REPORT | Aggregator Platform | FR Owner | I-13 | |

Scenario Name: No. 3 - Activation

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 a | The DSO needs to solve a congestion | DSO Flexibility order | The DSO Technical Platform sends the order to move flexibility to the market operator | CREATE | DSO Technical Platform | Market Platform | I-09 | |
| 1 b | The TSO needs to solve a congestion | TSO Flexibility order | The TSO sends the order to move flexibility to the market operator | CREATE | TSO Simulator | Market Platform | I-09 | |
| 2 a | Order transmission | Forwarding the set point - step 1 | The Market Platform receives and sends the order to the DSO Technical Platform, the SCD and the Aggregator | CREATE | Market Platform | DSO Technical Platform/ SCD/ Aggregator | I-09 | |
| 3 a | Order transmission | Forwarding the of set point - step 2 | The DSO receives from the Market the scheduling and sends the set points to Light Nodes | CREATE | DSO Technical Platform | Light Nodes | I-09 | |
| 4 a | Order available | Delivering of set point | The Light Node receives and makes available the set point to the EMS (it can be BMS or HMS) and FR | CREATE | Light Node | EMS / FR | I-09 | |
| 5 a | Moving of flexibility | Activation | Energy Management System acquires the set point and selects the correct scenario for electrical appliances (it can be also EV or storage), and/or suggests the right behavior for the customers (e.g. through an alert); | CREATE | EMS / FR | Smart Appliance / EV / Storage | I-14 | |
| 6 a | Use of Blockchain Access Layer | Data Certification | The Light Node forwards the set point and the measurements (in Blockchain | CREATE | Light Nodes | Blockchain Access Platform | I-04 / I-09 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 a | Flexibility Certification | Blockchain outcomes | The Blockchain sends the certification data to the SCD | CREATE | Blockchain Access Platform | Shared Customer Database | I-04 / I-09 | |
| 8 a | Measurement of flexibility | Energy Monitoring | Light Node measures the electrical quantities for calculating the flexibility and sends them to the SCD | CREATE | Light Node | Shared Customer Database | I-04 / I-09 | |

Scenario Name: No. 4 - Settlement

| **Step No.** | **Event.** | **Name of Process/ Activity** | **Description of Process/ Activity.** | **Service** | **Information Producer (Actor)** | **Information Receiver (Actor)** | **Information Exchanged** | **Requirements, R-ID** |
|---|---|---|---|---|---|---|---|---|
| 1 | Baseline Definition | Market Baseline | The BRP defines the production and/or consumption programs for all the resources involved in the local flexibility market, and sends it to the SCD | CREATE | BRP | SCD | I-03 | |
| 2 | Energy moved after a flexibility request | Flexibility measurements | The light node sends the measurements to the SCD | CREATE | Light Node | SCD | I-04 | |
| 3 | Gathering of data | Settlement - step 1 | The Market Platform acquires the data from the SCD | CREATE | SCD | Market Platform | I-04 | |
| 4 | Flexibility evaluation | Settlement - step 2 | The Market Operator performs the settlement comparing the metering data with the BRP baseline | CREATE | Market Platform | Market Platform | | |
| 5 | Settlements outcomes | Settlement - step 3 | The Market Operator communicates the settlements outcomes to the DSO, TSO and Aggregator | CREATE | Market Platform | DSO / TSO / Aggregator Platform | I -15 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | Payment of Energy provided | Payment | The DSO pays the Energy provided for flexibility to Aggregator | CREATE | DSO | Aggregator Platform | I -16 | |
| 7 | Customer payment | Payment | The Aggregator shares the revenues with the flexibility resources under their jurisdiction | CREATE | Aggregator Platform | FR Owner | I -17 | |

5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | Quarterly measures | The data measurements (active power, energy consumption, energy production, etc.) stored in the SCD. These measures have a 15-minute granularity | |
| I-02 | Customer list | The list of customers available to provide flexibility services for the day after | |
| I-03 | BRP Baseline | The BRP defines for every POD the day after load profile, in compliance with the day ahead market | |
| I-04 | Near real time measures | This information contains for every POD involved in the flexibility market, the active power measured every 4 seconds | |
| I-05 | Data for Offer | The flexibility offer contains the volume, the time frame and the price provided by the FR involved in the group | |
| I-06 | Data for Requests | The flexibility request contains the needs of flexibility (volume and time frame) localized in specific nodes of the grid | |
| I-07 | Technical Validation | This information contains the assessment of the local grid constraints | |
| I-08 | Market Outcomes | This information contains the list of offers arranged in economic order and in compliance with the grid constraint | |
| I-09 | Order | The TSO and the DSO send a signal of activation to move the FR involved in the service | |
| II-10 | Congestion localization | The DSO technical platform defines a list of grid nodes subject to congestions | |
| I-11 | Grid configuration | The DSO technical platform detects the possible grid configuration to solve the issue | |
| I-12 | FR status | This information contains the customer availability to move its own FR | |

| | | | |
|---|---|---|---|
| I-13 | FR planning | This information contains the time frame and the power that the customer has to provide during the activation | |
| I-14 | Activation Signal | The EMS sends the signal of activation to smart load | |
| I-15 | Settlement outcomes | This information contains for every offer the energy moved and the payment | |
| I-16 | DSO payment | It is the payment realized by the DSO for the energy provided | |
| I-17 | Aggregator payment | It is the remuneration that the aggregator recognizes to the customer | |
| I-18 | Technical Measurement | Electrical quantities coming from the field sensors (Voltage and current sensors or Low Voltage circuit breakers embedded with IED) | |

## 6. Requirements

## 7. Common Terms and Definitions

| Term | Definition |
|---|---|
| | |

## 8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

## A.2 Detailed Greek Demo UCs

### A.2.1 UC-GR-1 Functions of the State Estimation tool given conventional measurements

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-GR-1 | Area: Energy system<br>Domains: Distribution, DER, Customer Premises<br>Zones: Station, Operation | Functions of SE tool given conventional measurements |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 17th June 2020 | Themistoklis Xygkis, Panagiotis Pediaditis, Stavroula Tzioka, Eleni Daridou, Dimitris Stratogiannis | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | The scope of the UC is to investigate whether a high quality estimative of the network state will be acquired via the state estimation tool in real-time conditions under various network operating scenarios. The estimated network state will be used as an input to distribution management applications. |
| **Objective(s)** | *To improve confidence in actual measurement data obtained throughout the network as well as available load forecasts.<br>*To capture the real-time operational network state. |
| Related business case(s) | |

1.4. Narrative of Use Case

**Short description**

The UC investigates the capability of the state estimation tool to filter the available measurement data, comprising actual measurements obtained from active metering devices and pseudo-measurements, i.e. data derived from load forecasting or RES scheduling for network observability accomplishment, in order to identify measurements with gross errors (bad data), to suppress measurement errors, to reconcile inconsistent data and, ultimately, to estimate the actual operational network state.

The goal is to ensure that high quality estimative of the network state will be acquired via the state estimation tool in real-time conditions under various network operating scenarios. The estimated network state will be used as an input to distribution management applications.

**Complete description**

The DSO operates the distribution network. A measurement set, composed of actual and historical measurement data obtained from the dispersed metering devices (AMR, GIS, SCADA) installed throughout the network, is available for real-time operation purposes. The related measurements refer to power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, and load pseudo-measurements for aggregated consumer demand at MV/LV transformer level. Given that the network model (topology) is known with a good degree of certainty, the state estimation tool ensures that the network is observable based on the available measurement set and, subsequently, calculates the estimated state vector, that is, the voltage magnitudes and angles of all network buses.

## 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_GR_01 | Relative root mean square error (RRMSE) | This KPI measures a relative root mean square error (RRMSE) which is a unitless metric for the evaluation of state estimation accuracy in terms of bus voltage magnitudes. It captures the average 2-norm relative error in estimating bus voltage magnitudes. | |
| KPI_GR_02 | Relative percentage error (RPE) | This KPI measures a relative percentage error (RPE) which is unitless metric for the evaluation of state estimation accuracy in terms of bus voltage magnitudes. It captures the relative error in estimating voltage magnitude per individual bus. | |
| KPI_GR_03 | Accuracy metric for complex phasor voltage estimation (MaccV) | This KPI measures an accuracy metric for complex phasor voltage estimation (MaccV) which is a metric for the evaluation of state estimation accuracy in terms of complex phasor voltages. It captures the effect of both bus voltage magnitude and angle errors by combining them in a common 2-norm formula. | |
| KPI_GR_04 | Convergence metric in terms of objective function | This KPI measures the convergence metric which is a metric for the evaluation of the ability of state estimation algorithm to converge to a solution. It quantifies the relative change in objective function ($Mconv_{obj}$) which occurs at the final iteration. | |
| KPI_GR_05 | Convergence metric in terms of estimated voltage magnitude | This KPI measures a convergence metric in terms of estimated voltage magnitude (MconvV) which is a metric for the evaluation of the ability of state estimation algorithm to converge to a solution. It quantifies the maximum relative change in estimated voltage magnitudes which occur at the final iteration. | |
| KPI_GR_06 | Convergence metric in terms of estimated voltage angle | This KPI measures the convergence metric in terms of estimated voltage angle (Mconvδ) which is a metric for the evaluation of the ability of state estimation algorithm to converge to a solution. It quantifies the maximum change in estimated voltage angles which occur at the final iteration. | |

### 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| The network model (topology) is known with a good degree of certainty, DSO systems (e.g. AMR, GIS, SCADA) being operational | |

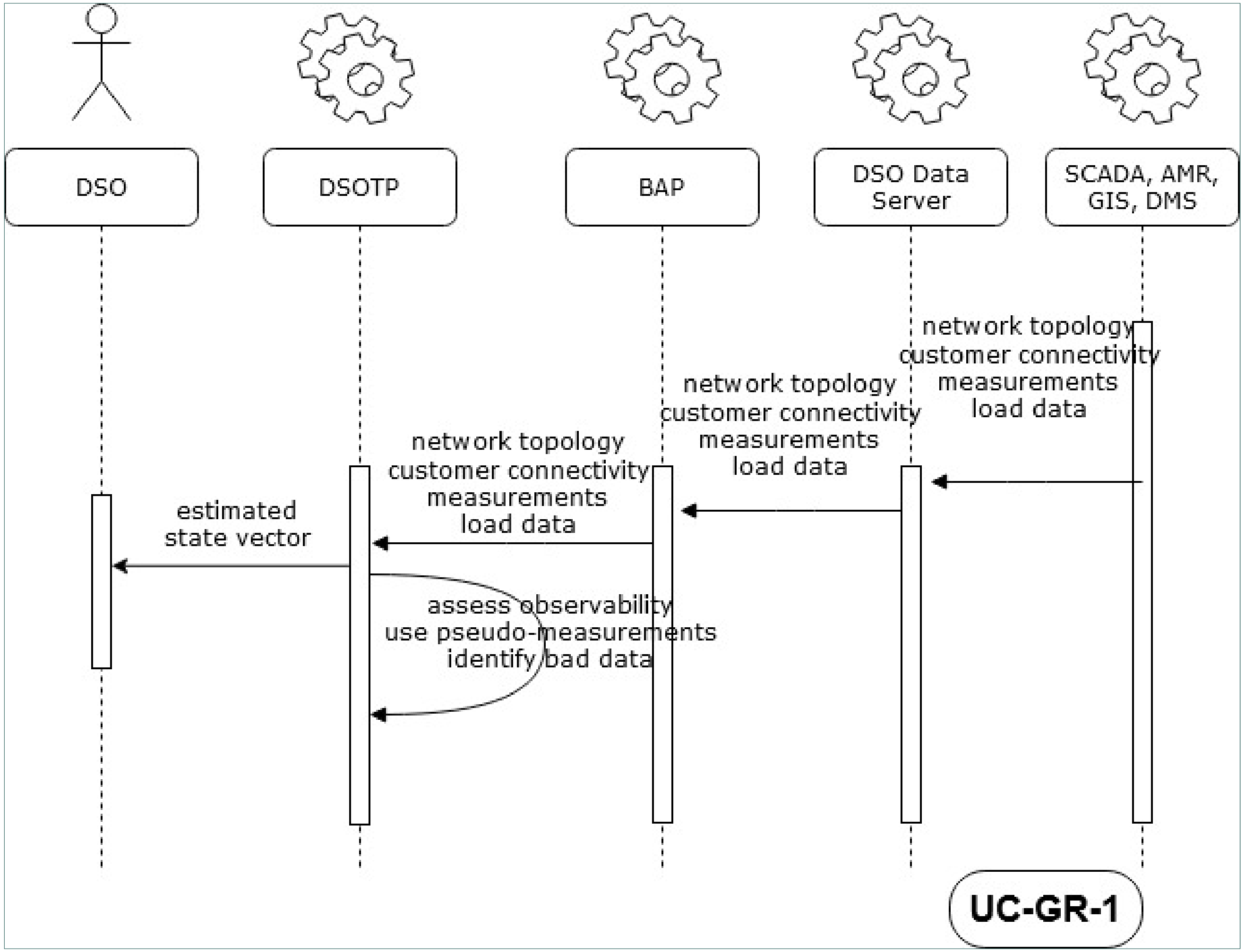
### 1.7. Further information to the use case for classification/mapping

| **Relation to other use cases** | |
|---|---|
| Level of depth | |
| Prioritization | |
| Generic, regional or national relation | |
| Nature of the use cases | |
| Further keywords for classification | |

### 1.8. General remarks

| General remarks |
|---|
| |

2. Diagrams of Use Case




Annex Figure 1: Sequence Diagram UC-GR-1

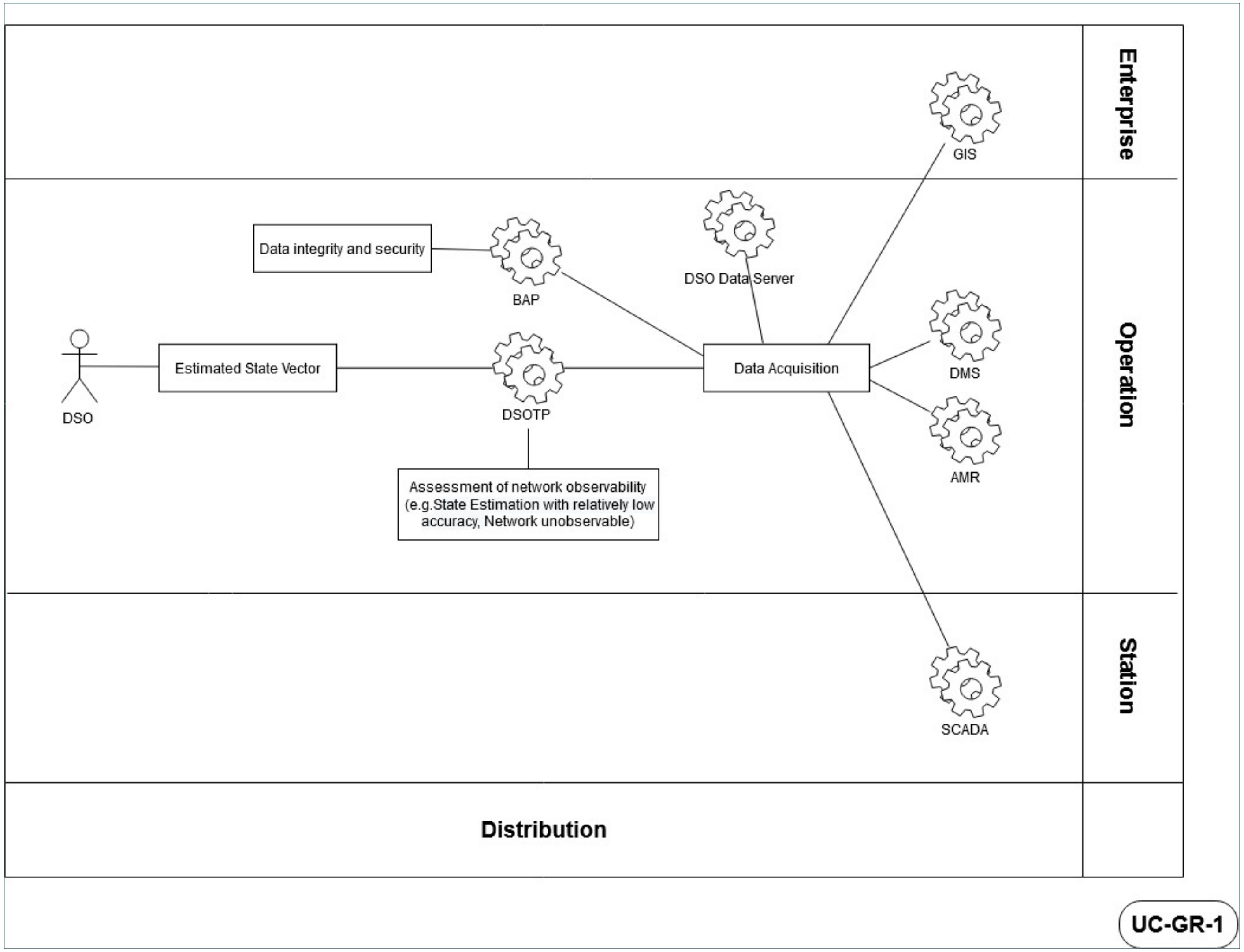



Figure 21: Use Case Diagram UC-GR-1

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| AMR | System | Automatic Meter Reading system | |
| DMS | System | Distribution Management System | |
| DSO | Person | Distribution System Operator, the entity responsible for the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; for procurement of flexibility services using optimization algorithms and the DSO Technical Platform. | |
| DSO Data Server | System | Database containing data from AMR, DMS & SCADA | |
| DSOTP | System | DSO Technical Platform | |
| GIS | System | Geographical Information System | |
| SCADA | Device | Supervisory Control And Data Acquisition system | |

### 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organization | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

## 4. Step by Step Analysis of Use Case

### 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Attainment of quality state estimation using accurate pseudo-measurements or indicating new measured points. | SCADA | State estimation accuracy below predefined threshold | State vector with relatively low accuracy | High-accuracy state vector |
| 2 | Fulfillment of observability using additional/alternative data to substitute for the missing ones. | SCADA | Initially missing or inconsistent measurements | Unobservable network | High-accuracy state vector |

## 4.2. Steps – Scenarios

Scenario Name: No. 1 - Attainment of quality state estimation

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 | Measurements from the Distribution Network | Data Acquisition | Various field measurements that reflect the network state are communicated | REPORT | SCADA,DMS,GIS,AMR | DSO Data Server | I-01 | |
| 2 | Measurements from the Distribution Network | Data Acquisition | Various field measurements that reflect the network state are communicated | REPORT | DSO Data Server | BAP | I-01 | |
| 3 | Measurements from the Distribution Network | Data Verification | All data received gets verified and secured via blockchain technology | EXECUTE | BAP | BAP | | |
| 4 | Measurements from the Distribution Network | Data Acquisition | Verified and secured data is delivered to the DSOTP | REPORT | BAP | DSOTP | I-03 | |
| 5 | Measurements from the Distribution Network | Observability assessment | A numerical observability method is used in order to determine observability status | EXECUTE | DSOTP | | I-03 | |
| 6 | Measurements from the Distribution Network | Calculation of state vector | State estimation algorithm is carried out | EXECUTE | DSOTP | DSOTP | I-02 | |
| 7 | State vector with low accuracy | Data Acquisition | New measurements/pseudo-measurements integrated in the State Estimation tool | CHANGE | DSO Data Server | DSOTP | I-01 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | Measurements from the Distribution Network | Calculation of state vector | State estimation algorithm is carried out | EXECUTE | DSOTP | DSOTP | I-02 | |
| 9 | Measurements from the Distribution Network | Output of State Estimation tool | Estimated state vector is communicated | REPORT | DSOTP | DSO | I-02 | |

Scenario Name: No. 2 - Fulfillment of observability

| **Step No.** | **Event.** | **Name of Process/ Activity** | **Description of Process/ Activity.** | **Service** | **Info. Producer (Actor)** | **Info. Receiver (Actor)** | **Info. Exchanged (IDs)** | **Req., R-ID** |
|---|---|---|---|---|---|---|---|---|
| 1 | Measurements from the Distribution Network | Data Acquisition | Various field measurements that reflect the network state are communicated | REPORT | SCADA,DMS,GIS,AMR | DSO Data Server | I-01 | |
| 2 | Measurements from the Distribution Network | Data Acquisition | Various field measurements that reflect the network state are communicated | REPORT | DSO Data Server | BAP | I-01 | |
| 3 | Measurements from the Distribution Network | Data Verification | All data received gets verified and secured via blockchain technology | EXECUTE | BAP | BAP | | |
| 4 | Measurements from the Distribution Network | Data Acquisition | Verified and secured data is delivered to the DSOTP | REPORT | BAP | DSOTP | I-03 | |
| 5 | Measurements from the Distribution Network | Observability assessment | A numerical observability method is used in order to determine observability status | EXECUTE | DSOTP | | I-03 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | Lack of observability | Data acquisition | Additional/alternative data to substitute for missing or inconsistent measurements, are integrated in the State Estimation tool | CHANGE | DSO Data Server | DSOTP | I-01 | |
| 7 | Measurements from the Distribution Network | Observability assessment | A numerical observability method is used in order to determine observability status | EXECUTE | DSOTP | | I-03 | |
| 8 | Measurements from the Distribution Network | Output of State Estimation tool | Estimated state vector is communicated | REPORT | DSOTP | DSO | I-02 | |

## 5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | Measurements | Measurements from the Distribution Network (voltage magnitudes, active and reactive power injections/flows) | TCP/IP, IP over GPRS |
| I-02 | State Vector | Voltage magnitudes and angles of all network buses | |
| I-03 | Observability status | The result of the observability assessment of the Distribution Network, i.e. whether the state estimation problem can be resolved or not | |

## 6. Requirements

## 7. Common Terms and Definitions

| Term | Definition |
|---|---|
| Pseudo-measurement | An injection whose value is obtained either from bus load forecasts or generation schedules. It is used as a substitute for a missing measurement in order to restore observability. |
| State vector | Voltage magnitudes and angles of all network buses |

## 8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

### A.2.2 UC-GR-2 PMU data integration into SE tool

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-GR-2 | Area: Energy system<br>Domains: Distribution, DER, Customer Premises<br>Zones: Station, Operation | PMU data integration into SE tool |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 17th June 2020 | Themistoklis Xygkis, Panagiotis Pediaditis, Stavroula Tzioka, Eleni Daridou, Dimitris Stratogiannis | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | The scope of the UC is the integration of measurement data obtained from PMUs into the State Estimation tool. |
| **Objective(s)** | * To reinforce network observability and controllability via improved state estimation performance.<br>* To ensure smooth incorporation of synchronized measurement data derived from PMUs into the preexisting system of conventional measurements. |
| **Related business case(s)** | |

1.4. Narrative of Use Case

**Short description**

Measurement data obtained from the installed PMUs are integrated in the State Estimation tool and used to enhance the network observability. The installation of PMUs at selected buses is sure to upgrade the overall metering infrastructure of the network, since they record synchronized measurements of bus voltage phasors as well as a number of line current phasors—all of which are independent of each other and count as individual measurements. Yet, their proper utilization via the SE tool is a challenging task due to a) the intense discrepancies in update rates between conventional and PMU measurements, b) the provision of current measurements which often lead to various numerical problems, and c) the contrast between the large weighting factors linked to PMU measurements compared to the much lower ones linked to pseudo-measurements, which usually raises ill-conditioning issues. The goal is to ensure that the integration of PMU data will be smooth and all the previously mentioned problems will be circumvented.

In this way, the overall performance of the SE tool will be enhanced; the network state will be calculated with increased precision and high quality real-time operational standards for distribution management applications, will be met.

**Complete description**

A measurement set, composed of actual and historical measurement data obtained from the dispersed metering devices (AMR, GIS, SCADA, PMUs) installed throughout the network, is available to the DSO for real-time operation purposes. The aforementioned data refer to a) synchronized measurements of bus voltage phasors and line current phasors (magnitude and angle) and b) conventional measurements of power flows and voltage magnitudes at the top of distribution feeders, power injections from distributed generation units, and load pseudo-measurements for aggregated consumer demand at MV/LV transformer level. Given that the network model (topology) is known with a good degree of certainty, the state estimation tool ensures that the network is observable based on the available measurement set, reconciles the PMU data with the conventional measurements, and, subsequently, calculates the estimated state vector, that is, the voltage magnitudes and angles of all network buses. Given the successful integration and use of the PMU data in the SE tool, the overall performance of the SE tool will be enhanced; the network state will be calculated with increased precision compared to conventional-measurements-only scenarios (uc-GR-1), and high quality real-time operational standards for distribution management applications will be met.

## 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_GR_01 | Relative root mean square error (RRMSE) | This KPI measures a relative root mean square error (RRMSE) which is a unitless metric for the evaluation of state estimation accuracy in terms of bus voltage magnitudes. It captures the average 2-norm relative error in estimating bus voltage magnitudes. | |
| KPI_GR_02 | Relative percentage error (RPE) | This KPI measures a relative percentage error (RPE) which is unitless metric for the evaluation of state estimation accuracy in terms of bus voltage magnitudes. It captures the relative error in estimating voltage magnitude per individual bus. | |
| KPI_GR_03 | Accuracy metric for complex phasor voltage estimation (MaccV) | This KPI measures an accuracy metric for complex phasor voltage estimation (MaccV) which is a metric for the evaluation of state estimation accuracy in terms of complex phasor voltages. It captures the effect of both bus voltage magnitude and angle errors by combining them in a common 2-norm formula. | |
| KPI_GR_04 | Convergence metric in terms of objective function | This KPI measures the convergence metric which is a metric for the evaluation of the ability of state estimation algorithm to converge to a solution. It quantifies the relative change in objective function ($Mconv_{obj}$) which occurs at the final iteration. | |
| KPI_GR_05 | Convergence metric in terms of estimated voltage magnitude | This KPI measures a convergence metric in terms of estimated voltage magnitude (MconvV) which is a metric for the evaluation of the ability of state estimation algorithm to converge to a solution. It quantifies the maximum relative change in estimated voltage magnitudes which occur at the final iteration. | |
| KPI_GR_06 | Convergence metric in terms of estimated voltage angle | This KPI measures the convergence metric in terms of estimated voltage angle (Mconvδ) which is a metric for the evaluation of the ability of state estimation algorithm to converge to a solution. It quantifies the maximum change in estimated voltage angles which occur at the final iteration. | |

### 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| The network model (topology) is known with a good degree of certainty | |
| DSO systems (e.g. AMR, GIS, SCADA) being operational | |
| PMUs are installed and PMU data is available for SE tool | |

### 1.7. Further information to the use case for classification/mapping

| Relation to other use cases | Associate with UC-GR-5 |
|---|---|
| Level of depth | |
| Prioritization | |
| Generic, regional or national relation | |
| Nature of the use cases | |
| Further keywords for classification | |

### 1.8. General remarks

| General remarks |
|---|
| |

## 2. Diagrams of Use Case

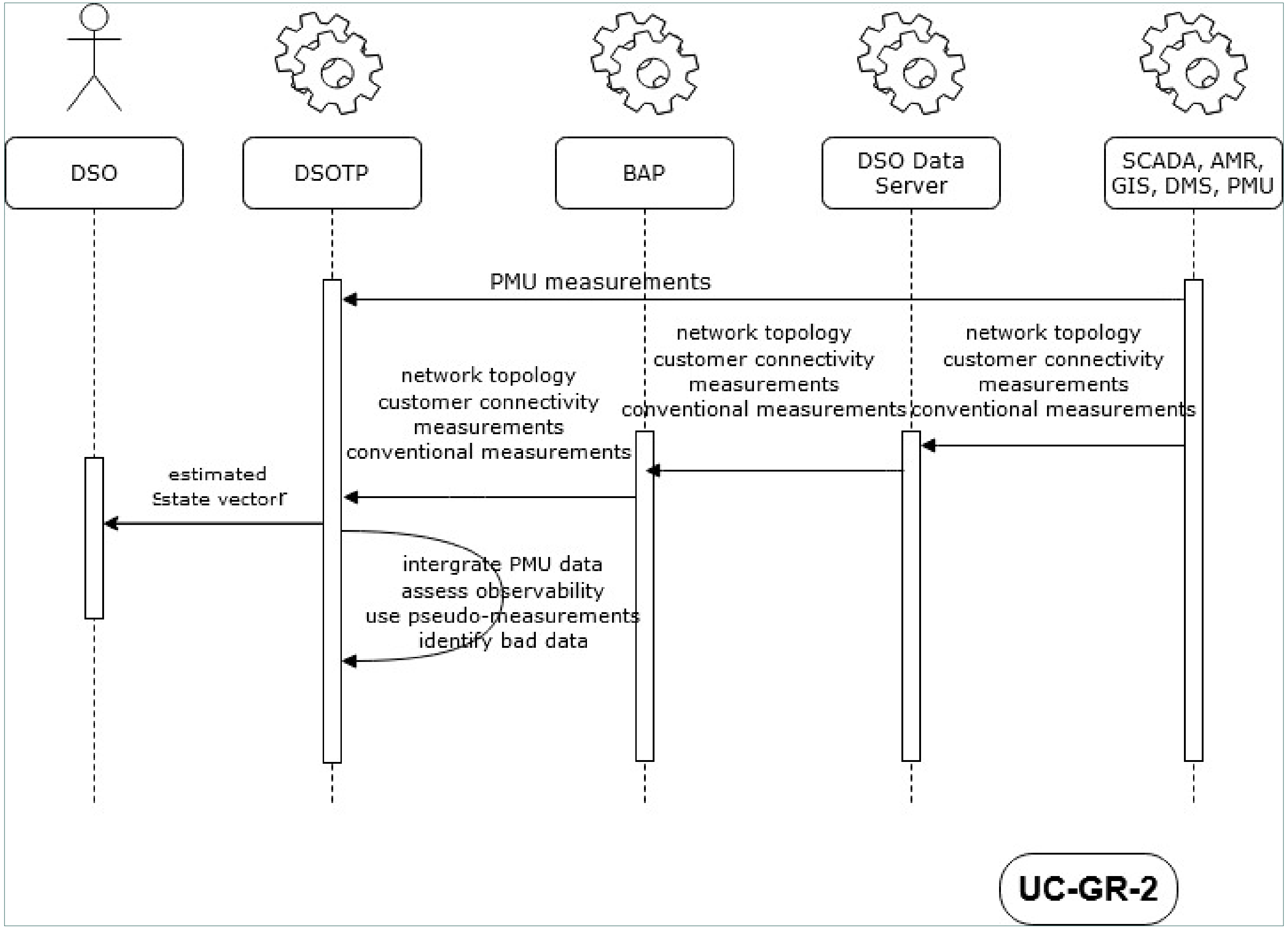



**Figure 22: Sequence Diagram UC-GR-2**

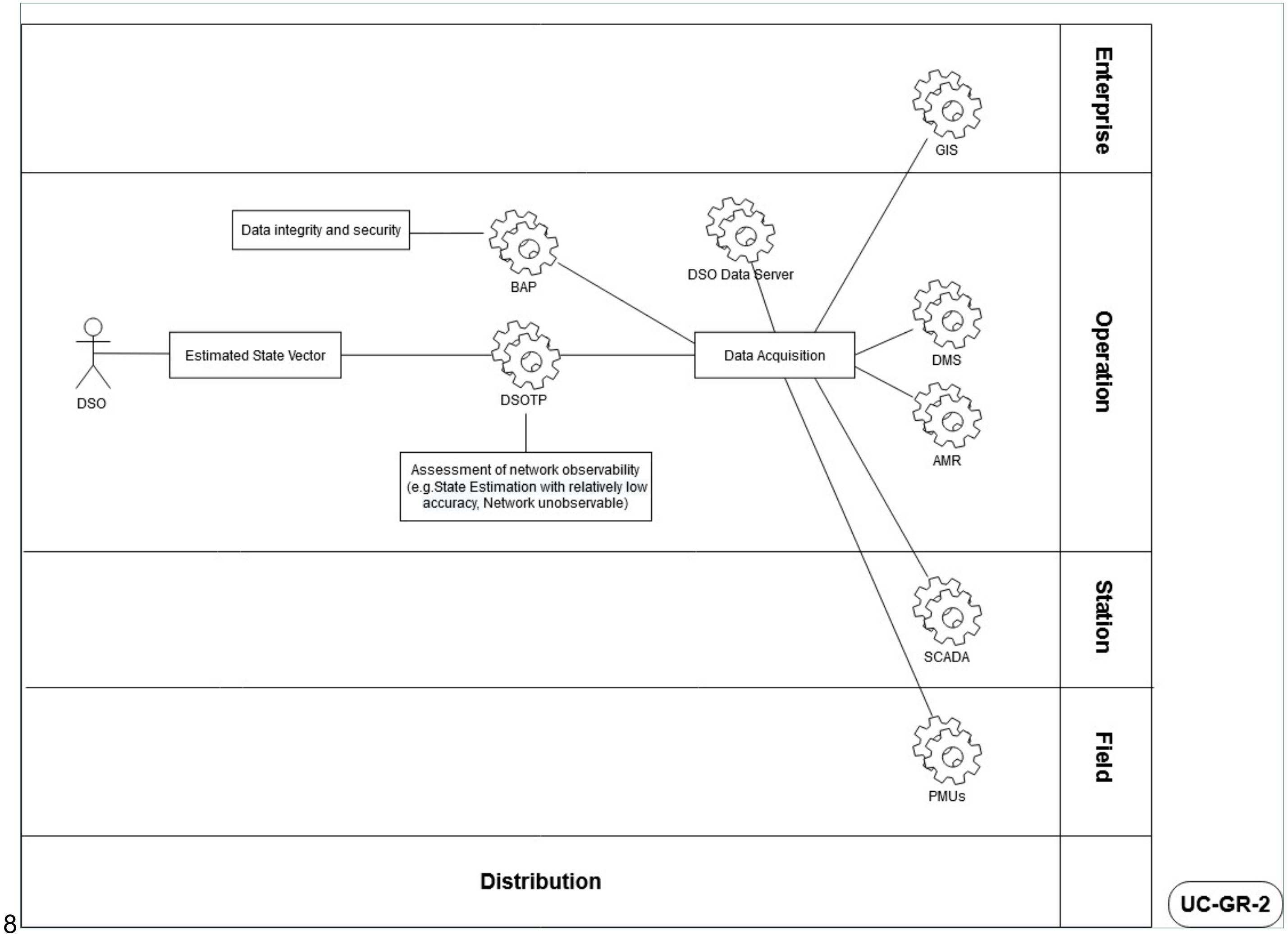



Figure 23: Use Case Diagram UC-GR-2

## . Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| AMR | System | Automatic Meter Reading system | |
| DMS | System | Distribution Management System | |
| DSO | Person | Distribution System Operator, the entity responsible for the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; for procurement of flexibility services using optimization algorithms and the DSO Technical Platform. | |
| DSO Data Server | System | Database containing data from AMR, DMS & SCADA | |
| DSOTP | System | DSO Technical Platform | |
| GIS | System | Geographical Information System | |
| PMU | Device | Phasor Measurement Unit | |
| SCADA | Device | Supervisory Control And Data Acquisition system | |

### 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organization | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

## 4. Step by Step Analysis of Use Case

### 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | PMU data integration | SCADA,PMU | State estimation accuracy to be improved | PMU field installation | High-accuracy state vector |

## 4.2. Steps – Scenarios

Scenario Name: No. 1 - PMU data integration

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 | Measurements from the Distribution Network | Data Acquisition | Various field measurements that reflect the network state are communicated | REPORT | SCADA,DMS,GIS,AMR, PMUs | DSO Data Server | I-01 | |
| 2 | Measurements from the Distribution Network | Data Acquisition | Various field measurements that reflect the network state are communicated | REPORT | DSO Data Server | BAP | I-01 | |
| 3 | Measurements from the Distribution Network | Data Verification | All data received gets verified and secured via blockchain technology | EXECUTE | BAP | BAP | | |
| 4 | Measurements from the Distribution Network | Data Acquisition | Verified and secured data is delivered to the DSOTP | REPORT | BAP | DSOTP | I-03 | |
| 5 | Measurements from the Distribution Network | PMU Data Acquisition | PMU measurements that reflect the network state are communicated | REPORT | PMU | DSOTP | I-04 | |
| 6 | Measurements from the Distribution Network | PMU data integration | PMU and conventional measurements integrated into a unified measurement set | EXECUTE | DSOTP | DSOTP | I-01 | |
| 7 | Measurements from the Distribution Network | Observability assessment | A numerical observability method is used in order to determine observability status | EXECUTE | DSOTP | DSOTP | I-03 | |
| 8 | Measurements from the Distribution Network | Calculation of the state vector | State estimation algorithm is carried out | EXECUTE | DSOTP | DSOTP | I-02 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | Measurements from the Distribution Network | Output of State Estimation tool | Estimated state vector is communicated | REPO RT | DSOTP | DSO | I-02 | |

## 5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | Measurements | Measurements from the Distribution Network (voltage magnitudes, active and reactive power injections/flows) | Ethernet TCP/IP, IP over GPRS |
| I-02 | State Vector | Voltage magnitudes and angles of all network buses | |
| I-03 | Observability status | The result of the observability assessment of the Distribution Network, i.e. whether the state estimation problem can be resolved or not | |
| I-04 | PMU Measurements | Measurements from PMUs (voltage phasors(angle and magnitude), current phasors(angle and magnitude)) | MQTT |

## 6. Requirements

PMU field installation

## 7. Common Terms and Definitions

| Term | Definition |
|---|---|
| Phasor measurements | Measurements of magnitude and phase angle of voltage or current signals, which are synchronized via the global positioning satellite (GPS) system. |
| Pseudo-measurement | An injection whose value is obtained either from bus load forecasts or generation schedules. It is used as a substitute for a missing measurement in order to restore observability. |
| State vector | Voltage magnitudes and angles of all network buses |

## 8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

## A.2.3 UC-GR-3 Distribution Network limit violation mitigation

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-GR-3 | Area: Energy system<br>Domains: Distribution, DER, Customer Premises/<br>Zones: Station, Operation | Distribution Network limit violation mitigation |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 17th June 2020 | Panagiotis Pediaditis, Themistoklis Xygkis, Dimitris Stratogiannis, Eleni Daridou, Stavroula Tzioka | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | The scope of the UC is to examine the operational use of flexibility tools in order to satisfy EN50160 in case of a voltage level limit violation in the distribution network and mitigate line congestion, especially in MV lines with flexible loads availability. |
| Objective(s) | *To use network tariffs in order to incentivize a more efficient operation of the network while respecting operation limits (voltages, lines) |
| Related business case(s) | |

1.4. Narrative of Use Case

**Short description**

Various types of flexible loads -aggregated for the scope of the Use Case- react to network tariffs sent by the DSO, so that a voltage/line thermal limit violation is mitigated. The DSO will examine the operation of tools and services for decision making support to mitigate voltage/thermal line limits violations, assuming that the grid state estimation has a good degree of certainty.

**Complete description**

Customers with flexible loads are connected to the distribution network and their loads are considered aggregated for the scope of the UCs regarding their management in the MV level. State of the network is known with a good degree of certainty based on the state vector that the state estimation tool produces using the available measurements and the topology data from the AMR, GIS, SCADA and PMUs. The DSO communicates network tariffs in a day-ahead context. These tariffs appropriately reflect the potential of the network exceeding its physical limits resulting in violations and/or curtailment of demand/generation. Compared to the business as usual scenario of the flat network tariffs, the DSO aims at reducing such negative effects by the use of variable day-ahead network tariffs, which incentivize the appropriate actions of the -assumed as- rational users of the distribution network.

## 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_GR_07 | Generation curtailment | The indicator compares the amount of energy from Renewable Energy Sources (RES) that is not injected to the grid (even though it is available) due to operational limits of the grid, between the flexible network tariff scenario and the Business as Usual scenario. | |
| KPI_GR_08 | Demand curtailment | The indicator compares the amount of energy consumption that needs to be curtailed due to operational limits of the grid, between the flexible network tariff and the Business as Usual scenario. | |
| KPI_GR_09 | Generation curtailment occurrences | The metric compares the number of occurrences of generation curtailment for the mitigation of network limit violations between the flexible network tariff scenario and the Business as Usual scenario. | |
| KPI_GR_10 | Demand curtailment occurrences | The metric compares the number of occurrences of demand curtailment for the mitigation of network limit violations between the flexible network tariff scenario and the Business as Usual scenario. | |
| KPI_GR_11 | Network limit violation occurrences | This indicator evaluates the difference between the number of network limit violation occurrences under a 24-hour timeframe in the flexible network tariff scenario and the equivalent one in the Business-as-Usual scenario. | |

## 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| Customers' consent required for participation in the flexibility mechanism, Customers are rational, Part of the load is flexible, State of the network is known with a good degree of certainty | Dynamic network charging is allowed, Smart metering is installed, Smart appliances can perform load shifting, DSO systems (e.g. AMR, GIS, SCADA) being operational |

## 1.7. Further information to the use case for classification/mapping

| Relation to other use cases | include uc-GR-1 and uc-GR-2 |
|---|---|
| Level of depth | detailed |
| Prioritization | obligatory |
| Generic, regional or national relation | generic |
| Nature of the use cases | technical, market |
| Further keywords for classification | |

### 1.8. General remarks

| **General remarks** |
| --- |
| |

## 2. Diagrams of Use Case

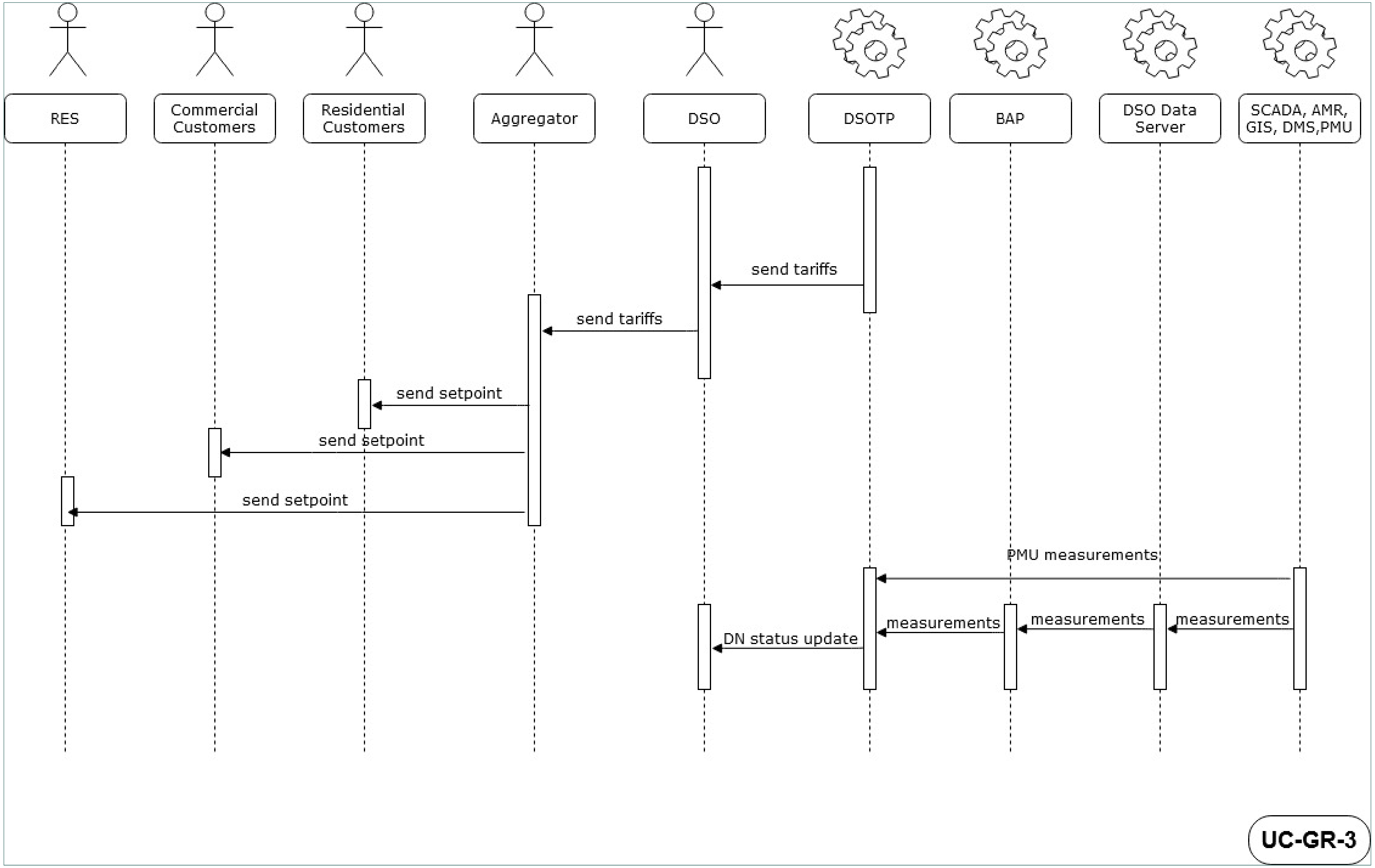



Figure 24: Sequence Diagram UC-GR-3

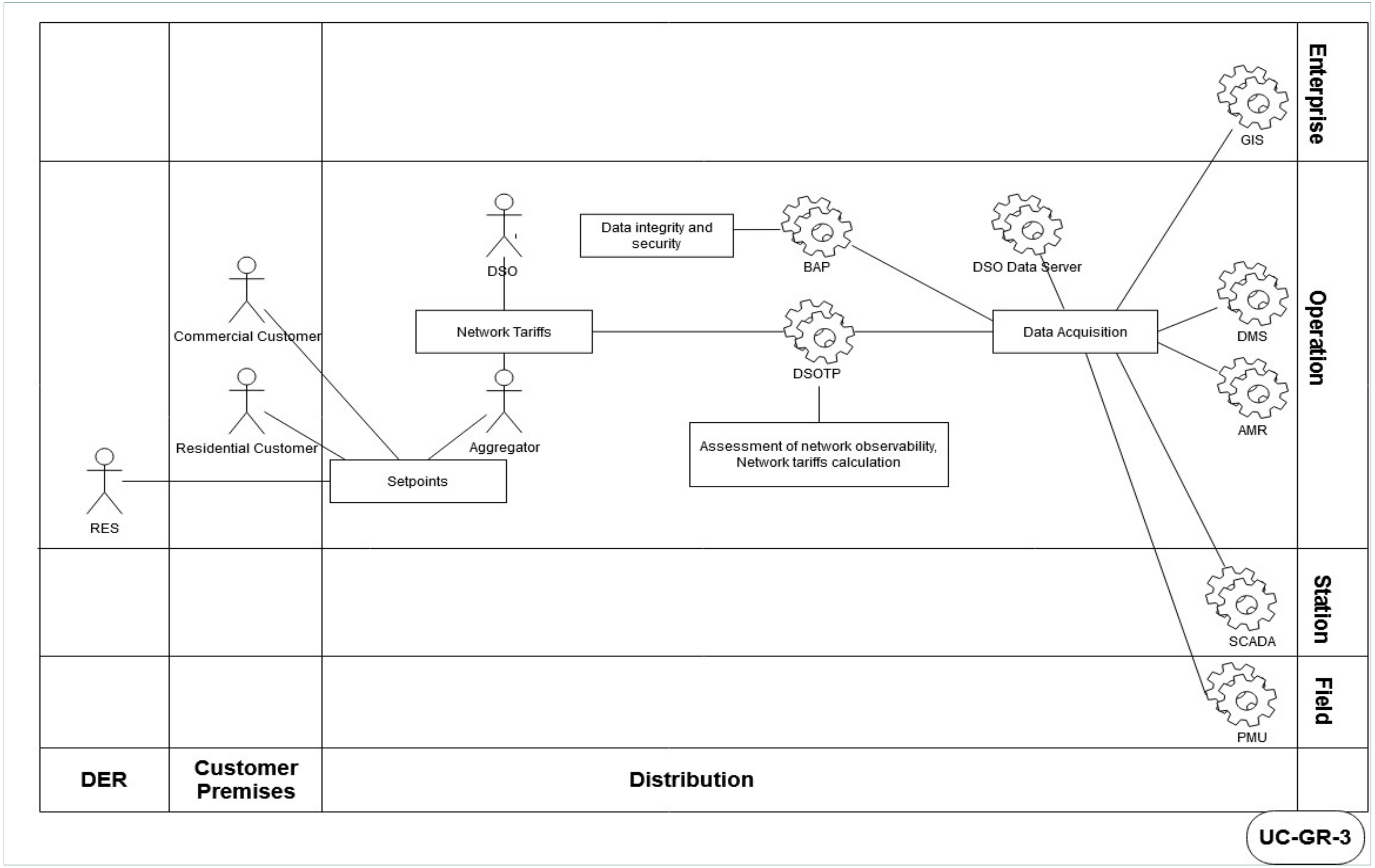



Figure 25: Use Case Diagram UC-GR-3

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| Aggregator | Person | | |
| AMR | System | Automatic Meter Reading system | |
| Commercial customer | Person | Final end user to denote a typical commodity commercial consumption with capability of neither generation nor storage. | |
| DMS | System | Distribution Management System | |
| DSO | Person | Distribution System Operator, the entity responsible for the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; for procurement of flexibility services using optimization algorithms and the Platone DSO Technical Platform. | |
| DSO Data Server | System | Database containing data from AMR, DMS & SCADA | |
| DSOTP | System | DSO Technical Platform | |
| GIS | System | Geographical Information System | |
| PMU | Device | Phasor Measurement Unit | |
| RES | System | Renewable Energy Source | |
| Residential customer | Person | Final end user to denote a typical commodity residential consumption with capability of neither generation nor storage. | |
| SCADA | Device | Supervisory Control And Data Acquisition system | |

### 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organization | Link |
|---|---|---|---|---|---|---|
| 1 | Standard | EN50160 Voltage characteristics of electricity supplied by public distribution systems | | CENELEC | | |

## 4. Step by Step Analysis of Use Case

### 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Network limit violations mitigation by the use of day-ahead network tariffs | none | none | Distribution network observability | Network limit violation mitigated |

### 4.2. Steps – Scenarios

Scenario Name: No. 1 - Network limit violations mitigation by the use of day-ahead network tariffs

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 | none-daily process | Tariffs retrieval | Day-ahead tariffs that reflect the expected state of the network sent to the DSO | CREATE | DSOTP | DSO | I-06 | |
| 2 | Tariffs retrieval | Tariffs communication | Tariffs are communicated to the Aggregator | REPORT | DSO | Aggregator | I-06 | |
| 3 | Tariffs communication | Setpoint sent to Residential Customer | Sending setpoint to the flexibility load | CREATE | Aggregator | Residential consumer | I-07 | |
| 4 | Tariffs communication | Setpoint sent to Commercial Customer | Sending setpoint to the flexibility load | CREATE | Aggregator | Commercial consumer | I-07 | |
| 5 | Tariffs communication | Setpoint sent to RES | Sending setpoint to the RES producer | CREATE | Aggregator | RES | I-07 | |
| 6 | none | Data Acquisition | New Distribution Network state (Distribution Network state updated following the Aggregator's response) | REPORT | PMU | DSOTP | I-04 | |
| 7 | none | Data Acquisition | New Distribution Network state (Distribution Network state updated following the Aggregator's response) | REPORT | SCADA,DMS,GIS,AMR | DSO Data Server | I-01 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | New Distribution Network state | Data Acquisition | New Distribution Network state | REPORT | DSO Data Server | BAP | I-01 | |
| 9 | New Distribution Network state | Data Verification | All data received gets verified and secured via blockchain technology | EXECUTE | BAP | BAP | | |
| 10 | New Distribution Network state | Data Acquisition | Verified and secured data is delivered to the DSOTP | REPORT | BAP | DSOTP | I-03 | |
| 11 | New Distribution Network state | Data Acquisition | New Distribution Network state | REPORT | DSOTP | DSO | I-02 | |

## 5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | Measurements | Measurements from the Distribution Network (voltage magnitudes, active and reactive power injections/flows) | Ethernet TCP/IP, IP over GPRS |
| I-02 | State Vector | Voltage magnitudes and angles of all network buses | |
| I-03 | Measurement data provision | Sensors located at secondary substation, BESS and households push measurement data to EMS | PMU: MQTT or IEC61850<br>Household energy storage: MQTT or HTTP<br>BESS: MODBUS/TCP or IEC VPN 608770 |
| I-04 | Sending of setpoint (t) or setpoint schedule (t+1) from EMS to BESS, household energy storages and flexible loads | Setpoint to increase or decrease demand/generation as static value [P] or relative value [%] or [SOC] | Household energy storage: MQTT or HTTP<br>BESS: MODBUS/TCP or IEC VPN 608770 |

## 6. Requirements

## 7. Common Terms and Definitions

| Term | Definition |
|---|---|
| | |

8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

## A.2.4 UC-GR-4 Frequency support by the distribution network

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-GR-04 | Area: Energy system/ Domains: Distribution, Transmission, DER, Customer Premises/ Zone: Station, Operation | Frequency support by the distribution network |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 17th June 2020 | Panagiotis Pediaditis, Stavroula Tzioka, Eleni Daridou, Dimitris Stratogiannis, Themistoklis Xygkis | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | The scope of the UC is to examine the operational use of flexibility tools in order to reduce the possibility of negative effects on the distribution in the case of a frequency support request by the transmission system. |
| Objective(s) | To keep the distribution network within physical limits (line and voltage) with appropriate actions in the case of a frequency restoration reserve activation request by the TSO |
| Related business case(s) | - |

1.4. Narrative of Use Case

**Short description**

Various types of flexible loads -aggregated for the scope of the Use Case- react to network tariffs sent by the DSO, so that frequency restoration request from the TSO is adequately handled. More in detail, customers with flexible loads will respond to such requests and the DSO will use flexibility tools to coordinate their response aiming at achieving the frequency support objective while ensuring distribution network operational safety. As in the previous Use Cases, the state of the system is provided by the state estimation tool.

**Complete description**

Customers with flexible loads are connected to the distribution network and their loads are considered aggregated for the scope of the UCs regarding their management in the MV level. State of the network is known with a good degree of certainty based on the available measurements and the topology via the AMR, GIS and SCADA data. A frequency support activation request from the TSO arrives at the customers with flexible loads. The request is also communicated to the DSO technical platform via an API and the information is shared with the appropriate tools and services. The DSO calculated and communicated to the customers the appropriate network tariffs that reflect the situation of the network. The flexible loads react to these tariffs and respond to the frequency support request appropriately.

## 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_GR_12 | Frequency support not provided | This indicator evaluates the difference between the power deficit between the TSO's request for the frequency support and customers' response, due to operational limits of the grid in the flexible network tariff scenario and the Business as Usual scenario. | |

## 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| Customers' consent required for participation in the flexibility mechanism, Customers are rational, Part of the load is flexible, State of the network is known with a good degree of certainty | Simulation of TSO, Dynamic network charging is allowed, Smart metering is installed, Smart appliances can perform load shifting, DSO systems (e.g. AMR, GIS, SCADA) being operational |

## 1.7. Further information to the use case for classification/mapping

| Relation to other use cases | include uc-GR-1 and potentially uc-GR-2 |
|---|---|
| Level of depth | detailed |
| Prioritisation | |
| Generic, regional or national relation | |
| Nature of the use cases | technical, market, test |
| Further keywords for classification | |

## 1.8. General remarks

| General remarks |
|---|
| |

## 2. Diagrams of Use Case

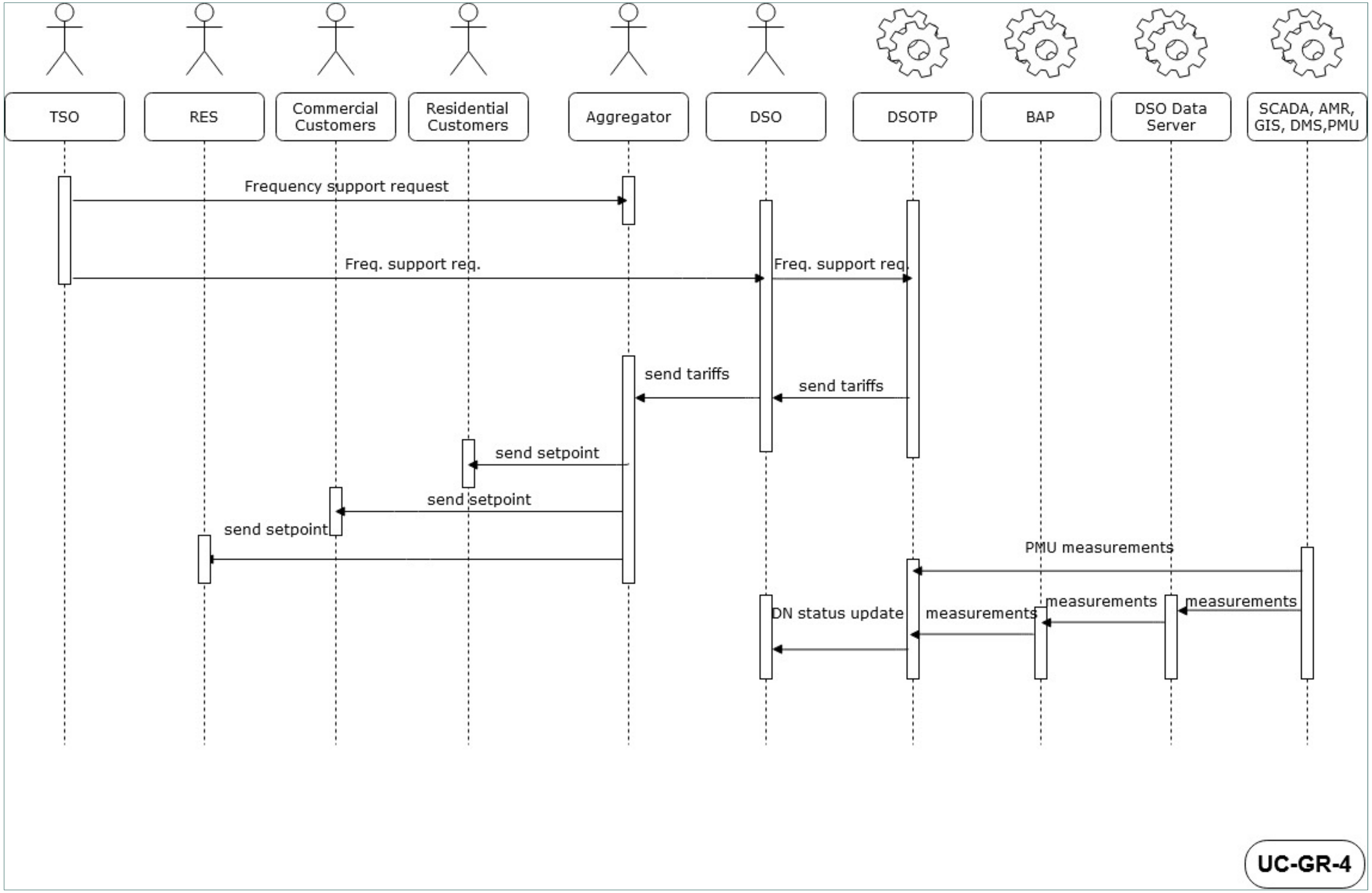



**Figure 26: Sequence Diagram UC-GR-4**

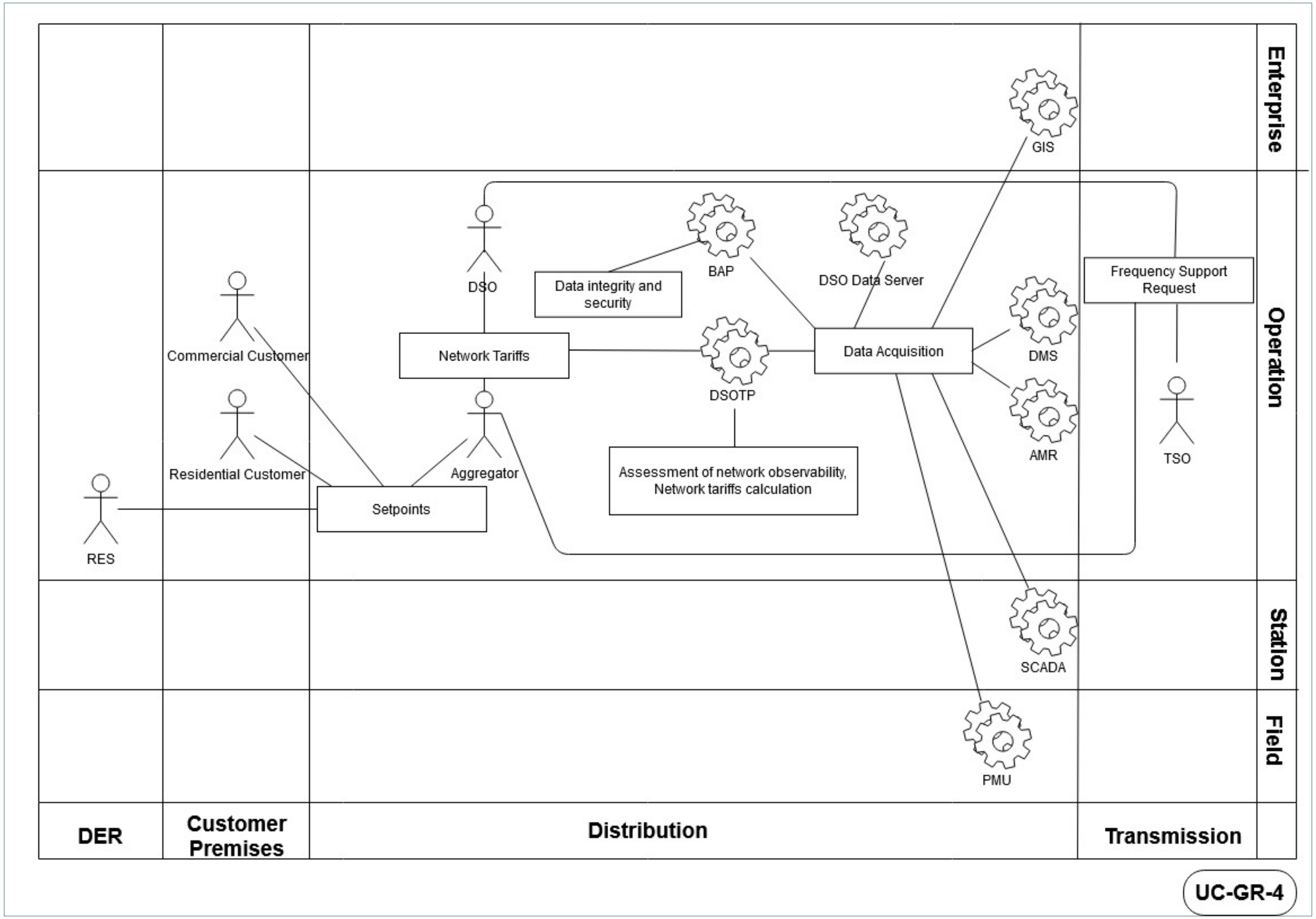



Figure 27: Use Case Diagram UC-GR-4

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| Aggregator | Person | | |
| AMR | System | Automatic Meter Reading system | |
| Commercial customer | Person | Final end user to denote a typical commodity commercial consumption with capability of neither generation nor storage. | |
| DMS | System | Distribution Management System | |
| DSO | Person | Distribution System Operator, the entity responsible for the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; for procurement of flexibility services using optimization algorithms and the Platone DSO Technical Platform. | |
| DSO Data Server | System | Database containing data from AMR, DMS & SCADA | |
| DSOTP | System | DSO Technical Platform | |
| GIS | System | Geographical Information System | |
| PMU | Device | Phasor Measurement Unit | |
| RES | System | Renewable Energy Source | |
| Residential customer | Person | Final end user to denote a typical commodity residential consumption with capability of neither generation nor storage. | |
| SCADA | Device | Supervisory Control and Data Acquisition system | |
| TSO | Person | Transmission System Operator | Simulated entity to trigger the use case |

### 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organisation | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

# 4. Step by Step Analysis of Use Case

## 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Frequency support request resolved | TSO | TSO sending a frequency support request | Distribution network observability | Frequency support request resolved |

## 4.2. Steps – Scenarios

Scenario Name: No. 1 - Frequency support request resolved

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchange d | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 | TSO needs frequency support | Frequency support request | Frequency support request sent to the Aggregator | CREATE | TSO | Aggregator | I-08 | |
| 2 | TSO needs frequency support | Frequency support request | Frequency support request communicated to the DSO | CREATE | TSO | DSO | I-08 | |
| 3 | DSO receives frequency support request from TSO | Frequency support request | Frequency support request sent to the DSOTP | REPORT | DSO | DSOTP | I-08 | |
| 4 | Frequency support request received by DSOTP | Tariffs retrieval | Tariffs are sent to the DSO | CREATE | DSOTP | DSO | I-06 | |
| 5 | Tariffs retrieval | Tariffs communicatio n | Tariffs are communicated to the Aggregator | REPORT | DSO | Aggregator | I-06 | |
| 6 | Tariffs communication | Setpoint sent to Residential Customer | Sending setpoint to the flexibility load | CREATE | Aggregator | Residential consumer | I-07 | |
| 7 | Tariffs communication | Setpoint sent to Commercial Customer | Sending setpoint to the flexibility load | CREATE | Aggregator | Commercia l consumer | I-07 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | Tariffs communication | Setpoint sent to RES | Sending setpoint to the RES producer | CREATE | Aggregator | RES | I-07 | |
| 9 | none | Data Acquisition | New Distribution Network state (Distribution Network state updated following the Aggregator's response) | REPORT | PMU | DSOTP | I-04 | |
| 10 | none | Data Acquisition | New Distribution Network state (Distribution Network state updated following the Aggregator's response) | REPORT | SCADA,DMS,GIS,AMR | DSO Data Server | I-01 | |
| 11 | New Distribution Network state | Data Acquisition | New Distribution Network state | REPORT | DSO Data Server | BAP | I-01 | |
| 12 | New Distribution Network state | Data Verification | All data received gets verified and secured via blockchain technology | EXECUTE | BAP | BAP | | |
| 13 | New Distribution Network state | Data Acquisition | Verified and secured data is delivered to the DSOTP | REPORT | BAP | DSOTP | I-03 | |
| 14 | New Distribution Network state | Data Acquisition | New Distribution Network state | REPORT | DSOTP | DSO | I-02 | |

## 5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | Measurements | Measurements from the Distribution Network (voltage magnitudes, active and reactive power injections/flows) | TCP/IP, IP over GPRS |
| I-02 | State Vector | Voltage magnitudes and angles of all network buses | |
| I-04 | PMU Measurements | Measurements from PMUs (e.g. voltage magnitudes, voltage phasors, current phasors) | MQTT |
| I-06 | Network tariffs | Network tariffs that reflect the Distribution Network state | IP |
| I-07 | Setpoint | Setpoint for adjustment of flexible load/RES production | IP |
| I-08 | Frequency support request | Frequency support request from the TSO | IP |

6. Requirements

7. Common Terms and Definitions

| Term | Definition |
|---|---|
| | |

8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

### A.2.5 UC-GR-5 PMU integration and Data Visualization for Flexibility Services Management

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-GR-5 | Area: Energy system<br>Domains: Distribution/ Zone: Station, Operation | PMU integration and Data Visualization for Flexibility Services Management |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 17th June 2020 | Dimitris Stratogiannis, Panagiotis Pediaditis, Stavroula Tzioka, Eleni Daridou, Themistoklis Xygkis | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | The scope of the UC is to examine the integration and operational use of low-cost PMUs in order to increase network observability collecting measurement data such as voltage, current and phases in various points of the distribution network. More in detail, the DSO will use the data collected to improve the operation of the tools and services developed within the project by exploiting increased data granularity. Furthermore, the data coming from various sources and systems of the DSO should be integrated in the DSO Technical Platform having first passed through the Blockchain Access Platform developed in the project to provide data access security and data integrity. In addition, all the available data should be further delivered for use by tools and services developed in order to support flexibility mechanisms. All the appropriate communication protocols should be integrated and tested to develop a unique point of data delivery to various actors involved in the project and a User Interface (UI) should be developed to allow the DSO personnel to use the available tools and services. |
| Objective(s) | * To increase network observability.<br>* To integrate data coming from different sources in the DSO Technical Platform. |

| | |
|---|---|
| Related business case(s) | - |

## 1.4. Narrative of Use Case

**Short description**

PMUs are installed in critical network nodes to increase network observability. PMU measurements along with other DSO data (network topology, customer loads, etc.) are integrated in the DSO Technical Platform to be visualised in a User Interface (UI), so that DSO can make use of tools and services developed in the project. Aforementioned data is going through the Blockchain Access Platform developed in the project to ensure data access security and data integrity.

**Complete description**

The DSO operates the distribution network and handles the data sources coming from various systems such as SCADA/DMS, AMR, GIS etc. Data coming from various sources get integrated into the Open DSO Technical Platform providing an adequate level of network observability. Low cost PMUs are deployed in Mesogia area in critical network points and nodes where there is limited observability or a requirement to have an increased awareness such as DER and prosumers bidirectional power flows. Also, PMU data are integrated in the DSO Technical Platform following a data collection plan that serves the functionalities of the flexibility tools and services. Measurements from PMUs enhance network awareness in terms of data granularity and number of nodes observed in a cost-effective manner. Also, the open DSO Technical Platform performs the correlation of the data coming from different sources and systems during real time, providing to the DSO the technical capacity for flexibility mechanisms support and a User Interface (UI) where the aforementioned is visualised. All data is verified and secured by the use of blockchain technology to be developed in the Blockchain Access Platform of the project.

## 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_GR_13 | PMUs field installation and integration | This KPI indicates the number of PMUs actually installed in the field and integrated in the DSO Technical Platform. | |
| KPI_GR_14 | Data visualization | This KPI indicates the number of data sources (AMR, GIS, SCADA, DMS, DSO data server) that will be visualized in the open DSO Technical Platform. | |
| KPI_GR_15 | Visualized outputs of tools and services and network response handling | This KPI indicates the number of tools and services visualised, outputs of which, allow the DSO to operate the distribution network more efficiently by the use of the DSO Technical Platform. | |

## 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| PMUs are provided for deployment in Mesogia area | |

## 1.7. Further information to the use case for classification/mapping

| Relation to other use cases | Include all other UC-GR |
|---|---|
| Level of depth | generic |
| Prioritisation | |
| Generic, regional or national relation | |
| Nature of the use cases | |
| Further keywords for classification | technical (IT) |

## 1.8. General remarks

| General remarks |
|---|
| |

## 2. Diagrams of Use Case

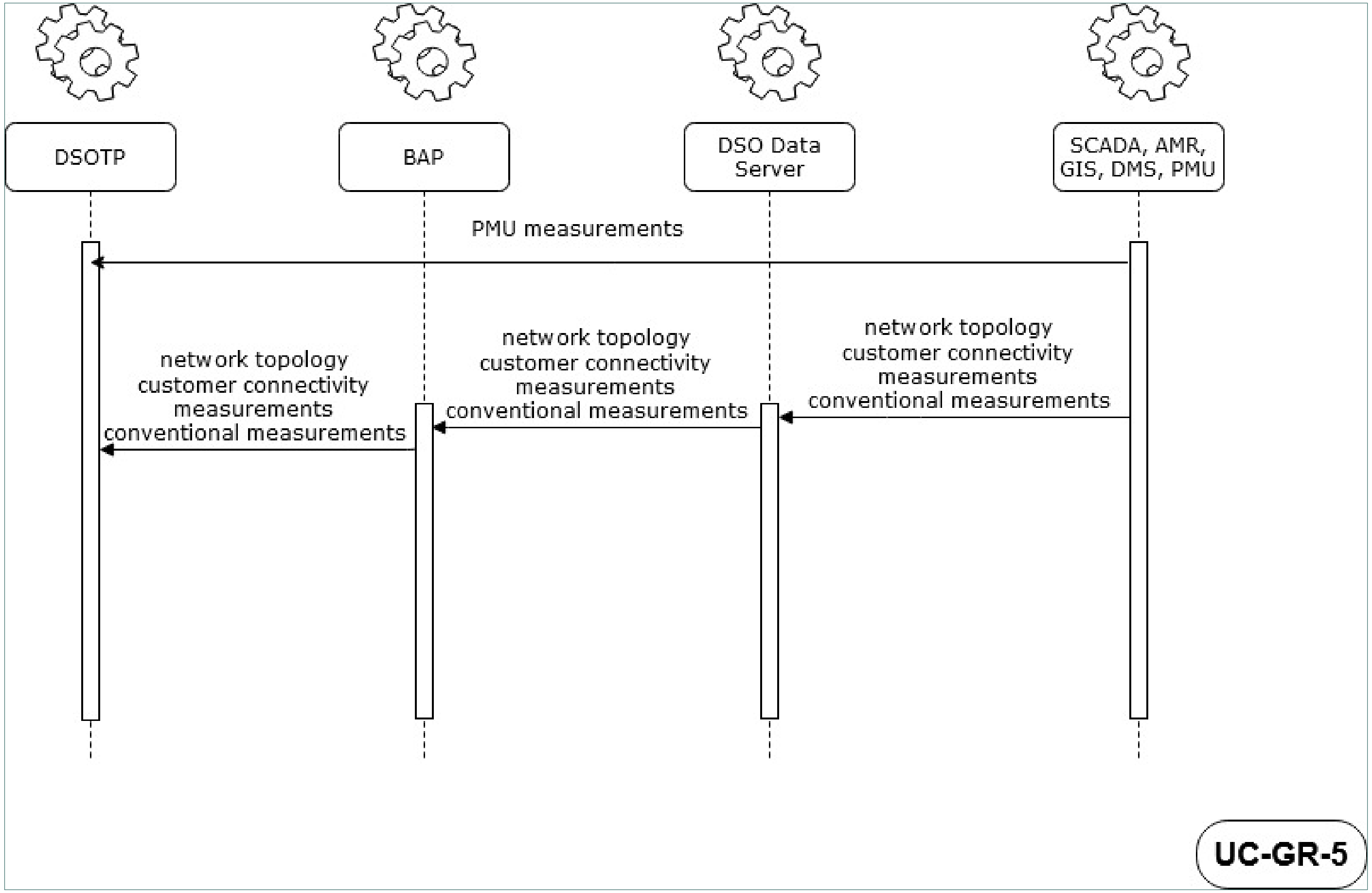



Figure 28: Sequence Diagram UC-GR-5

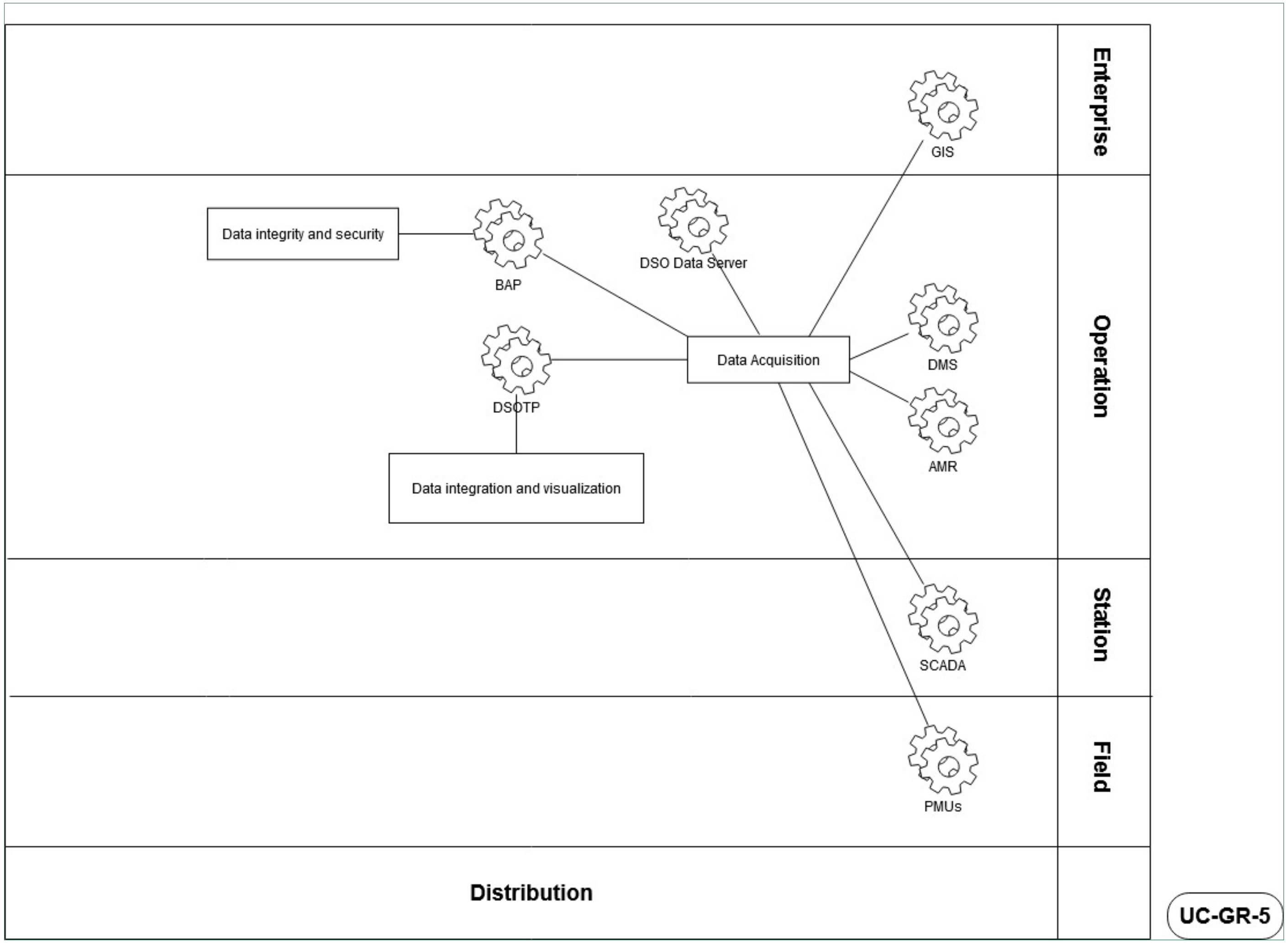



Figure 29: Use Case Diagram UC-GR-5

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| AMR | System | Automatic Meter Reading system | |
| DMS | System | Distribution Management System | |
| DSOTP | System | DSO Technical Platform | The system that integrates data from various DSO sources as well as the PMUs installed in Mesogia and allows use of tools and services developed within the project |
| DSO Data Server | System | Database containing data from AMR, DMS & SCADA | |
| GIS | System | Geographical Information System | |
| SCADA | Device | Supervisory Control and Data Acquisition system | |
| BAP | System | Blockchain Access Platform | |

### 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organisation | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

## 4. Step by Step Analysis of Use Case

### 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Data integration and visualisation in the DSOTP (User Interface) | none | none | none | Data from various data sources as well as services' outcomes integrated and visualised in the DSOTP |

## 4.2. Steps – Scenarios

Scenario Name: No. 1 - Data integration and visualisation in the DSOTP (User Interface)

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 | none -continuous process | Data acquisition | Various field measurements that reflect the network state are communicated | REPORT | SCADA, DMS, GIS, AMR | DSO Data Server | I-01 | |
| 2 | None - continuous process | Data Acquisition | PMU data are retrieved by and integrated in the DSOTP | REPORT | PMUs | DSOTP | I-04 | |
| 3 | None - continuous process | Data Acquisition | Various field measurements that reflect the network state are communicated | REPORT | DSO Data Server | BAP | I-01 | |
| 4 | none-continuous process | Data Verification | All data received gets verified and secured via blockchain technology | EXECUTE | BAP | BAP | I-01 | |
| 5 | None - continuous process | Data Acquisition | Verified and secured data is delivered to the DSOTP | REPORT | BAP | DSOTP | I-01 | |
| 6 | None - continuous process | Data Visualisation | Data and services' outcomes are visualised (User Interface) | EXECUTE | DSOTP | DSOTP | - | |

## 5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | Measurements | Measurements from the Distribution Network (voltage magnitudes, active and reactive power injections/flows) | TCP/IP, IP over GPRS |
| I-04 | PMU Measurements | Measurements from PMUs (e.g. voltage magnitudes, voltage phasors, current phasors) | MQTT |

## 6. Requirements

## 7. Common Terms and Definitions

| Term | Definition |
|---|---|

| | |
|---|---|
| | |

8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

# A.3 Detailed German Demo UCs

## A.3.1 UC-DE-1 Island Mode

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-DE-1 | Area: Energy system<br>Domain: Distribution, Customer Premise, Field, DER<br>Zones: Operation, Enterprise, Process | Islanding |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 1st June 2020 | Thorsten Gross | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | The scope of the UC is the implementation of an EMS that operates a specific low voltage network in virtual island mode, i.e. minimization of the power exchange with the connected medium voltage feeder by utilizing available flexibility (local energy storage systems and controllable loads). The UC focuses on a local energy community.<br>Networks: LV<br>Markets: None |
| Objective(s) | - Maximize consumption of local generation/Minimize demand satisfied by public grid<br>- Islanding of local grid by making use of flexible loads and storages<br>- Maximizing duration of islanding operation |
| Related business case(s) | - |

1.4. Narrative of Use Case

**Short description**

The use case “Islanding” aims to balance generation and demand of a local energy community in such a way that the load flow across the connecting MV/LV transformer is reduced to a minimum. The balancing is enabled by an energy management system (EMS) called Avacon Local Flex Controller

(ALF-C). The EMS monitors the power flow across the transformer and controls a battery energy storage system (BESS) connected directly to the LV-terminal of the substation. Generated energy surplus will be stored in the BESS and released at times of a generation deficit. Private households equipped with batteries and controllable electric heaters can be dispatched to increase the degree of self-sufficiency further.

**Complete description**

The field test trial and application of UC1 will take place in a bounded rural LV network consisting of family houses, agricultural buildings and a large amount of installed generation capacities provided by roof top photovoltaic systems. A local Energy Management System (EMS) named Avacon Local Flex Controller (ALF-C) will monitor local generation, demand and storage capacities and control available flexibilities in such a way that the consumption of the locally generated energy will be maximized, and the energy demanded from the MV grid will be minimized. The application of UC 1 will be triggered by an operator from Avacon via a user interface (UI).

In times when the local generation exceeds the local demand, surplus energy will automatically be stored in local storages and the consumption of available flexible loads will be increased. When local consumption is exceeding local generation, stored electrical energy in local batteries will be discharged. The optimization of self-consumption targets to minimize the load exchange with the MV grid along the MV/LV grid connection point up to a level at which the community is virtually islanded. In cases in which generation and demand cannot be balanced due to a lack of available storage capacity or flexibility, the residual load will be exported or imported.

A sensor located at the grid connection will measure the power exchange of all 3 phases between the medium voltage and the low voltage grid. The measured values indicate the real time residual load demand or surplus of generation. Measurement data by sensors is provided to the EMS. Based on the provided information the EMS will increase or decrease the load demand of individual storages or flexible loads in order to balance the grid. Additionally, customer households provide flexible load and storage capacities for steering. Flexible assets in the field are equipped with sensors and controllers for steering to increase or decrease demand and to command charging or discharging of the local large Battery Energy Storage System and private customer household storages. Vendors of flexible assets provide a cloud data management platform from which measurement data is accessible for EMS via a backend. The interface also provides data to estimate the state of charge of batteries, flexible loads and potential available storage capacity. Historical measurement data and weather forecasts provided by external service providers enable the EMS to predict energy generation and consumption to maximize self-sufficiency.

Controllers in the field enable to switch on or off flexible loads and trigger charge or discharge of batteries in order to increase total consumption or generation of the community. Flexible load may be provided by storage heaters and heat pumps. Storage capacities will be provided by a local BESS and battery storages from private households. In order to avoid customers to sacrifice comfort due to a decrease of room heating, steering of loads will be limited.

The communication between sensors, controllers and EMS will be web based, via LTE or DSL and open protocols. The EMS and sensors will be fully integrated into the communication infrastructure of the Platone framework. The Blockchain Access Platform (BAP) will provide encryption functionalities where the Platone DSO Technical Platform (DSOTP) will act as a middle ware enabling connection to sensors in the field and providing services to the EMS.

### 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_DE_01 | Reduction of energy demand | UC 1 is targeting to maximize consumption of locally generated energy and minimize consumption of energy provided by the feeding MV grid to avoid an exchange of energy along the MV / LV feeder within a defined period. | |

| | | | |
|---|---|---|---|
| | provided by MV-grid | This KPI measures the success of avoiding consumption from the feeding grid by measuring the deviation of energy consumption in times of UC 1 application and times UC 1 is not applied. | |
| KPI_DE_02 | Reduction of power recuperation peaks | Use Case 1 is targeting the reduction of power peaks along the MV/LV grid connection point. A coordinated control of a local BESS, household energy storages and flexible loads enables the avoidance of power peak at grid connection point. This KPI measures the relative reduction of the maximum power value within a defined period of time. | |
| KPI_DE_03 | Increase of self-consumption | UC 1 is targeting the reduction of power exchanges along the MV/LV grid connection point. The balancing algorithm shall maximize the consumption of locally generated energy by storing generated surplus in local battery storages (BESS and household energy storages) and make use of stored energy in times of higher demand. This KPI measures the increase of self -consumption in times of UC 1 is applied by comparing the energy export in the period dt with the application of UC 1 and in the period dt without the application of UC 1. | |
| KPI_DE_04 | Maximization of Islanding Duration | Use Case 1 is targeting to maximize the duration or number of times in which the load exchange along the grid connection point is zero or close to zero. This KPI measures the success pf maximizing the duration of time in which a load exchange along grid connection point can be avoided. | |

### 1.6. Use case conditions

| **Assumptions** | **Prerequisites** |
|---|---|
| Private Customer households with flexible loads and storages join a local energy community. | Participants of the energy communities incl. flexible loads and storages are connected to a single low voltage grid (feed by a single MV/LV transformer) and are monitored and steered by an EMS. |
| The energy community needs an operator for the “Islanding” EMS. | National regulations have to be clarified who can be the service providers and who can’t (TSO, DSO, Aggregator, Retailer, Energy Service provider) |

### 1.7. Further information to the use case for classification/mapping

| **Relation to other use cases** | |
|---|---|
| Level of depth | |
| Prioritisation | |
| Generic, regional or national relation | |
| Nature of the use cases | |
| Further keywords for classification | |

### 1.8. General remarks

| General remarks |
| --- |
| - Use case 1 is anticipated to emerge as a result of the Clean Energy Package, driven by the bottom-up demand of customers and local communities<br>- It is a prerequisite for the advanced use 2 - 4 |

## 2. Diagrams of Use Case

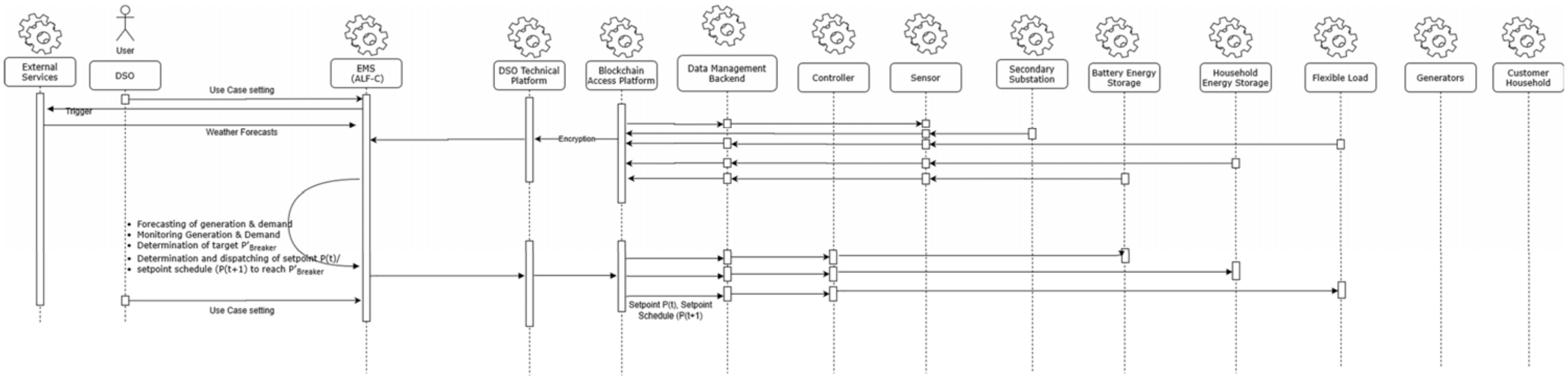



Figure 30: Sequence Diagram UC-DE-1

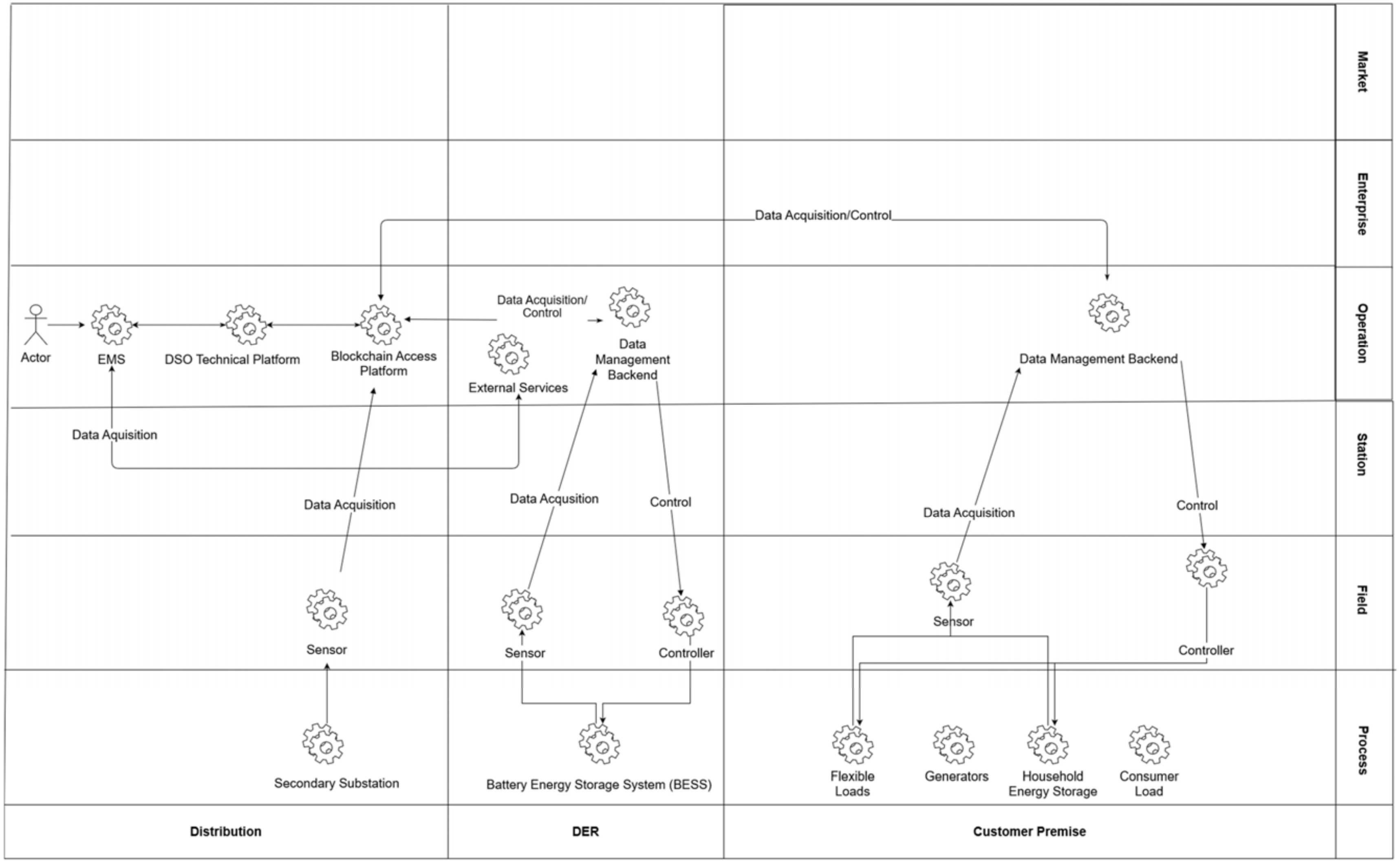



Figure 31: Use Case Diagram UC-DE-1

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| Consumer Load | System | Household with a standard load profile energy consumption of a single household or energy consumer with a standard load profile of an agricultural building. | No direct measurement of energy consumption, demand not controllable (passive user). |
| Generators | System | Roof Top photovoltaic system generating energy directly correlated with solar radiation at location. | Limited controllability (can be curtailed in extreme cases). Located on customers premise and can be operated in combination with a battery storage system, for optimization of own consumption. |
| Controller | Device | Summarises all devices that are able to receive setpoints or setpoint schedules and translate them into actionable steering commands for the flexible load or storage. | |
| Sensors | Device | Devices that measure voltage, current and angle of phase or SOE or SOC in case of storages and able to communicate to external systems or devices. | Retrofit (PMU or other) or integrated sensor. |
| Battery Energy Storage System (BESS) | System | Stores electrical energy | 300 kW/600 kWh, fully integrated in EMS and permanently available for UC. |
| Household Energy Storage | System | Stores electrical energy | Integrated in EMS and permanently available for UC. |
| Flexible Load | Device | Storage heater or heat pump used by household for generation of domestic heat. | Could be provided by customer households. |
| Weather Forecast Service Provider | External System | Provides weather forecasts for the next 24h of wind, solar radiation, cloudiness and temperature. | |
| BESS Data Management Backend | External System | Cloud service platform of BESS manufacturer for storing data and providing measurement data and forwarding setpoint to BESS. | |
| Sensor & Controller Data Management Backend | External System | Cloud service of assets vendor (can be individual for different assets) storing data, providing measurement data of asset and/or interface for transmission of setpoints to asset. | Assets with different vendors, requires connection to different vendor cloud platform and backends. |

| | | | |
|---|---|---|---|
| DSO Technical Platform | System | Central Platform providing services, e.g. data storage and state estimation. Used as middleware for data acquisition and setpoint delivery of assets and sensors in the field. | Provided by RWTH. |
| Blockchain Access Platform | System | Platform for encryption and verification of data flows along the way of communication from EMS (ALF-C) to sensors and Assets in the field. | Provided by Engineering |
| EMS (ALF-C) | Component | - Monitors local generation and demand<br>- monitors available flexibility and storages<br>- forecasts generation, demand and available flexibility via historic data and weather forecasts<br>- receives "Islanding" -Trigger from EMS Use Case Module and determines and dispatches setpoints for individual assets<br>- Calculates the setpoint or setpoint schedule for the EMS Controller | EMS named Avacon Local Flex Controller (EMS).<br><br>In a productive environment operator could be DSO, retailer, storage system operators or any other energy service provider. |
| Distribution System Operator (Avacon) | Person | Local grid operator (Avacon) setting use case | Only in field-test trial. In future done by DSO, TSO, marketer, or energy service providers |

## 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organisation | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

## 4. Step by Step Analysis of Use Case

### 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Local generation exceeds local demand | • Generators<br>• EMS (EMS)<br>• Consumer Load<br>• Energy Storage<br>• Flexible Load<br>• BESS<br>• DSO | Measured load flow (export) at grid connection point | • Sensors and controllers are connected with EMS<br>• Enough flexible loads and storages capacity are available for balancing | $P_{Breaker} = P'_{Breaker}$ |
| 2 | Local demands exceed local generation | • Generators<br>• EMS (EMS)<br>• Consumer Load<br>• Energy Storage<br>• Flexible Load<br>• BESS<br>• DSO | Measured Load Exchange at grid connection | • Sensors and controllers are connected with EMS<br>• Enough flexible loads and storages capacity are available for balancing | Charging power of local flexible loads and storages will be decreased in order to balance generation and demand. |
| 3 | Faulty Situation | EMS | Faulty values<br>System Alerts | BMS of BESS and sensors are connected to EMS | Termination of UC |

### 4.2. Steps – Scenarios

Scenario Name: No. 1 - Local generation exceeds local demand
No. 2 - Local demands exceed local generation
No. 3 - Faulty Situation

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 | Initiating of UC 1 | Trigger Event | Operator sets EMS (ALF-C) mode of operation to UC 1 and defines target setpoint ($P'_{Breaker}$) for load exchange and the duration (t) | REPORT | DSO | EMS | I-01 | |
| 2 | External service provider | Transmitting the data | An external service provider sends weather data and weather forecast values. | GET | External System | EMS | I-03 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | sends weather forecasts | | | | | | | |
| 3 | EMS receives forecasting values | Forecasting of generation and demand | The EMS forecasts local generation and demand:<br>- Generation based on weather forecasts<br>Load – based on weather forecast and load profiles from historic measurement data | CREATE | EMS | EMS | | |
| 4 | Sensor (grid connection point in secondary substation) provides values | Transmitting the data | The local sensor located at secondary substation measures the residual power export and sends data to EMS.<br><br>If Applicable (to be clarified):<br>The communication will take place from the sensor via the sensor data management backend to the Blockchain Access Platform (BAP). The BAP acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the EMS.<br><br>After the trigger for provision of measurement data, the<br>Then data will be pushed by the sensor to the EMS every 10 seconds. | CHANGE | Sensor | EMS | I-05 | |
| 5 | Local sensors provide data via Data Management Backend. | Transmitting the data | Local sensors provide measurements values and data via sensor data management backend to the EMS.<br><br>If Applicable (to be clarified):<br>The communication will take place from the sensor via the sensor data management backend to the Blockchain Access Platform (BAP). The BAP acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform | CHANGE | Sensor | EMS | I-05 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | acting as second level middleware from where the signal is sent to the EMS.<br><br>After the trigger for provision of measurement data, the<br>Then data will be pushed by the sensor to the EMS every 15 minutes. | | | | | |
| 6 | All data collected | Evaluation and determination of control strategy and setpoints | Based on provided measurement data, asset key data. EMS calculates the power bandwidth of each asset available for steering ($P_{Flex}$).<br><br>The EMS determines for each asset a setpoint ($P'_{Asset}$) to reach $P'_{Breaker}$. The determination of setpoints is repeated every 10 seconds for BESS and every 15 minutes for flexible loads and household energy storages. | CREATE | EMS | EMS | | |
| 7 | Individual setpoints determined | Transmitting setpoints to controllers | The EMS sends setpoints via a data management backend to controllers to increase, decrease consumption assets (battery energy storage, household energy storage and flexible load) located in the field to increase consumption.<br>If Applicable (to be clarified):<br>The communication will take place from the EMS along the Blockchain Access Platform. The Blockchain Access Platform acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the Data Management Backend of the controller.<br>This signal is sent every ten seconds to the BESS Management Backend and every 15 minutes to loads located at customer premise | EXECUTE | EMS | Controllers | I-06 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | and replaces the default signal until the EMS calculates a setpoint. | | | | | |
| 8 | Setpoint send to controller | Verification of setpoint execution | The EMS compares measured values comparison of $P_{Breaker}$ from the grid connection point with the target values $P'_{Breaker}$. In case of deviation the setpoint are redefined by walking through step numbers 2 to 10. The process is continuously repeated until the end of use case. | CREATE | Sensor | EMS | | |
| 9 | End of Use Case 1 | End of Use Case 1 | The use case ends, when a user triggers another use case, or in a case of lack of flexibility to reach $P'_{Breaker}$. | REPORT/ CREATE | DSO or ALF-C | EMS | I-01 | |

5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | Signal from DSO via GUI | DSO triggers the use case via a GUI to the EMS to apply islanding. The trigger signal is:<br>0 = stop current use case<br>1 = application of UC 1<br>2 = application of UC 2<br>3 = application of UC 3<br>4 = application of UC 4<br><br>Based on the UC 1 trigger the EMS sets the target setpoint for the load - exchange along the grid connection point to zero (P'Breaker = 0). | HTTPS |
| I-02 | Weather forecasts | - Solar radiation (t + 24h)<br>- Cloudiness (t + 24 h)<br>- Temperature (t + 24 h)<br>- Humidity (t + 24 h)<br>- Windspeed (t + 24 h) | Rest API |
| I-03 | Measurement data provision | Sensors located at secondary substation, BESS and households push measurement data to EMS | PMU: MQTT or IEC61850<br>Household energy storage: MQTT or HTTP |

| | | | |
|---|---|---|---|
| | | | BESS: MODBUS/TCP or IEC VPN 608770 |
| I-04 | Sending of setpoint (t) or setpoint schedule (t+1) from EMS to BESS, household energy storages and flexible loads | Setpoint to increase or decrease demand/generation as static value [P] or relative value [%] or [SOC] | Household energy storage: MQTT or HTTP BESS: MODBUS/TCP or IEC VPN 608770 |

6. Requirements

7. Common Terms and Definitions

| Term | Definition |
|---|---|
| | |

8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

### A.3.2 UC-DE-2 Third Party Flex Request

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-DE-2 | **Area:** Energy system<br>**Domain:** Distribution, Customer Premise, DER<br>**Zones:** Operation, Enterprise, Process, Field | Flexibility Provision |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 1st April 2020 | Thorsten Gross | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | Communities with a high penetration of photovoltaic systems and correspondingly high installed generation capacity can be expected to generate an energy surplus during times of peak generation and low local demand, and vice versa to run into an energy deficit during seasons of low generation. Surplus energy can be stored and shifted to times of low generation in order to satisfy temporary demand and hence increase the degree of self-sufficiency. Use Case 2 demonstrates how the flexibility |

| | |
|---|---|
| | required to enable a local balancing mechanism could temporarily be allocated to other uses, for example the provision of flexibility to a third party, e.g. the connecting grid operator. Use Case 2 uses the available flexibility in a given local energy community to maintain an externally defined non-zero setpoint at the point of connection.<br>Networks: LV<br>Markets: None |
| Objective(s) | • Maintain a fixed non-zero power exchange between energy community and the distribution network for a limited duration. |
| Related business case(s) | Integration of local energy communities in network management strategies for the stabilization and uniform utilization in distribution grid |

## 1.4. Narrative of Use Case

**Short description**

Local energy communities are likely to emerge in Europe in the near future but will most likely retain an interconnection to the distribution grid. These communities will require a large share of flexibility to enable their primary use case. Situations could arise that require the community to provide flexibility to third parties – driven by technical circumstances or following economic considerations (market incentives). Use Case 2 demonstrates the ability and practical feasibility of a local community to maintain constant non-zero power exchange with the distribution network for a previously defined duration.

**Complete description**

The community is consuming and/or generating energy. A user (in the case of the field trial the DSO) triggers the EMS to apply Use Case 2 and sets a target value (P'Breaker) for the power exchange at the grid connection. The EMS (ALF-C) processes weather forecasts and measurement values from the grid connection and flexible assets such as BESS, household energy storages and flexible loads located in the community. Based on the data and historic values the EMS forecasts the local generation and demands and determines the best strategy to reach (P'Breaker) by utilizing the available flexibility to keep the power flow constant for a pre-defined duration.

The EMS communicates with sensors through the Blockchain Access Platform and DSO Technical Platform and handles all data in a dedicated database. The DSO Technical Platform provides encryption and decryption in the whole IT infrastructure. Control signals are routed through the DSO technical platform and the Blockchain Access Platform to flexible devices, if applicable through a third-party backend that connects to the hardware.

## 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_PR_03 | Flexibility Availability | This KPI aims to measure the potential amount of flexibility that is available to the grid by flexible resources. | |

| | | | |
|---|---|---|---|
| KPI_PR_04 | Flexibility Effectiveness | This KPI is targeting to measure the effectiveness of flexibility provision. The KPI measures the sum of successfully provided flexibility in relation to the requested demand for flexibility. | |
| KPI_DE_05 | Responsiveness | This KPI focuses on assessment of response times to flex requests and latencies along the use case process. The promptness of the implementation of an external triggered setpoint into to a measureable signal is an important indicator of the value of flexibility provided by local network or energy communities. | |
| KPI_DE_06 | Accuracy of the achievement of a given setpoint | The accuracy of reaching and maintaining a defined setpoint is a quality feature of flexibility that can be provided by local networks and communities. The ability to achieve and maintain a setpoint exactly helps to avoid fluctuations of power in distribution network.<br>During the application of UC 2 the KPI shall measure the relative deviation between the measured load exchange along the grid connection point ($P_{Breaker}$) and the triggered target set point for load exchange ($P'_{Breaker}$). | |

## 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| Private Customer households with flexible loads and storages are organized in a local energy community with a central EMS. | Participants of the energy communities incl. flexible loads and storages are connected to a single low voltage grid (feed by a single MV/LV transformer) and are monitored and steered by an EMS. |
| The energy community needs an operator for the “Islanding” EMS. | National regulations have to be clarified who can be the service providers and who can’t (TSO, DSO, Aggregator, Retailer, Energy Service provider) |

## 1.7. Further information to the use case for classification/mapping

| Relation to other use cases | UC 1 as a prerequisite for islanding the community |
|---|---|
| Level of depth | Primary Use Case |
| Prioritisation | |
| Generic, regional or national relation | |
| Nature of the use cases | technical |
| Further keywords for classification | |

## 1.8. General remarks

| General remarks |
|---|
| - Use case 1 is anticipated to emerge as a result of the Clean Energy Package, driven by the bottom-up demand of customers and local communities. |

| |
|---|
| - It is a prerequisite for the advanced use 2 - 4 |

## 2. Diagrams of Use Case

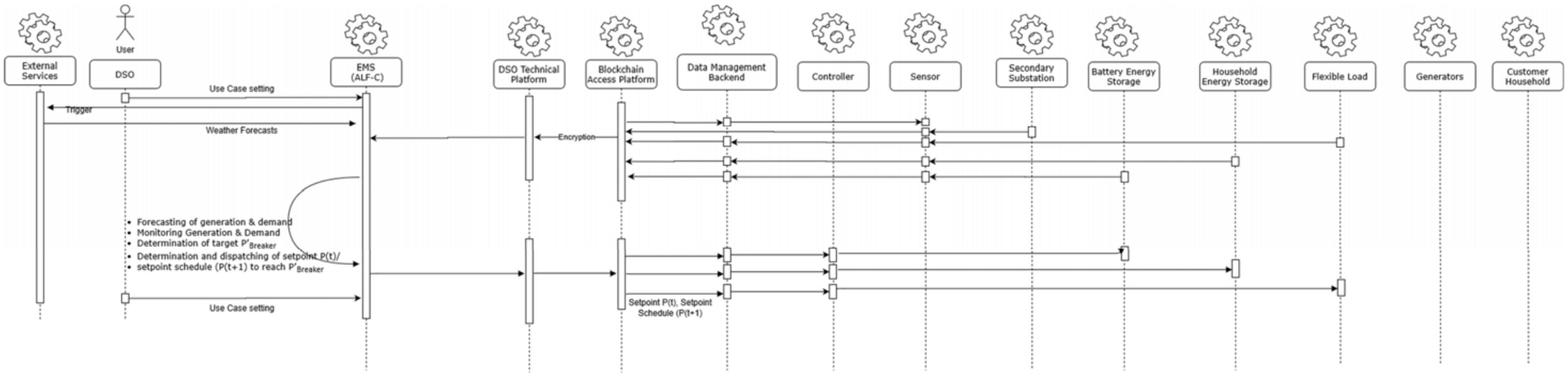



Figure 32: Sequence Diagram UC-DE-2

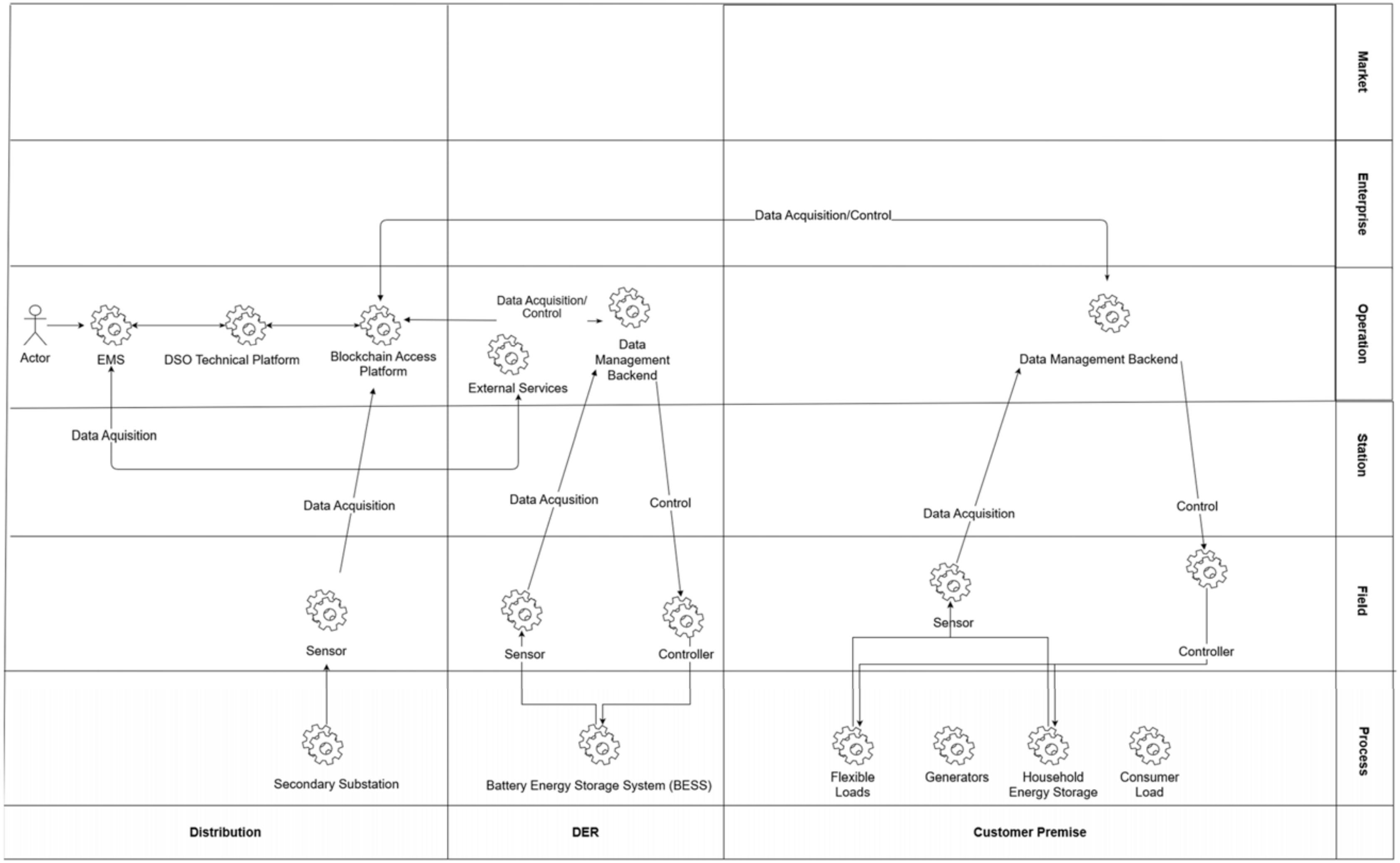



Figure 33: Use Case Diagram UC-DE-2

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| Consumer Load | System | Household with a standard load profile energy consumption of a single household or energy consumer with a standard load profile of an agricultural building. | No direct measurement of energy consumption, demand not controllable (passive consumer). |
| Generators | System | Rooftop photovoltaic system generating energy directly correlated with solar radiation at location. | Limited controllability (can be curtailed in extreme cases). Located on customers premise and can be operated in combination with a battery storage system, for optimization of own consumption. |
| Controller | Device | Summarises all devices that are able to receive setpoints or setpoint schedules and translate them into actionable steering commands for the flexible load or storage. | |
| Sensors | Device | Devices that measure voltage, current and angle of phase or SOE or SOC in case of storages and able to communicate to external systems or devices. | Retrofit (PMU or other) or integrated |
| Battery Energy Storage System (BESS) | System | System that are demanding, storing and feeding energy to the local grid/energy community. | 300 kW/600 kWh, fully integrated in EMS and full time available for UC. |
| Household Energy Storage | System | System that are demanding, storing and feeding energy to the local grid/energy community. | Integrated in EMS and full time available for UC. |
| Flexible Loads | System | Electrical heater or eat pump used by household for generation of domestic heat. | Could be provided by customer households. |
| Weather Forecast Service Provider | External System | Provides weather forecasts for the next 24h of wind, solar radiation, cloudiness and temperature. | |
| BESS Data Management Backend | External System | Data backend provided by BESS manufacturer for storing data and providing measurement data and forwarding setpoint to BESS. | |
| Sensor & Controller Data | External System | Cloud service of assets vendor (can be individual for different assets) storing data, providing measurement | Assets with different vendors, requires connection to different vendor cloud platform and backends. |

| | | | |
|---|---|---|---|
| Management Backend | | data of asset and/or interface for transmission of setpoints to asset. | |
| DSO Technical Platform | System | Central Platform providing services, e.g. data storage and state estimation. Used as middleware for data acquisition and setpoint delivery of assets and sensors in the field. | Provided by RWTH. |
| Blockchain Access Platform | System | Platform for encryption and verification of data flows along the way of communication from EMS (ALF-C) to sensors and Assets in the field. | Provided by Engineering |
| EMS (ALF-C) | Component | - Monitors local generation and demand<br>- Monitors available flexibility and storages<br>- Forecasts generation, demand and available flexibility via historic data and weather forecasts<br>- Accepts use case Trigger from EMS Use Case Module and determines and dispatches setpoints for individual assets<br>- Calculates the setpoint or setpoint schedule for the EMS Controller | EMS named Avacon Local Flex Controller (EMS). In a productive environment operator could be DSO, retailer, storage system operators or any other energy service provider. |
| Distribution System Operator (Avacon) | Person | Local grid operator (Avacon) setting use case and setting setpoint for load exchange along the grid connection point (P'Breaker) | Only in field-test trial. In future done by DSO, TSO, marketer or energy service providers |

## 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organisation | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

## 4. Step by Step Analysis of Use Case

### 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Local generation exceeds local demand | • Generators<br>• EMS (EMS)<br>• Consumer Load<br>• Energy Storage<br>• Flexible Load<br>• BESS<br>DSO | Measured load flow (export) at grid connection point | • Sensors and controllers are connected with EMS<br>• Enough flexible loads and storages capacity are available for balancing | $P_{Breaker} = P'_{Breaker}$ |
| 2 | Local demands exceed local generation | • Generators<br>• EMS (EMS)<br>• Consumer Load<br>• Energy Storage<br>• Flexible Load<br>• BESS<br>• DSO | Measured Load Exchange at grid connection | • Sensors and controllers are connected with EMS<br>• Enough flexible loads and storages capacity are available for balancing | Charging power of local flexible loads and storages will be decreased in order to balance generation and demand. |
| 3 | Faulty Situation | EMS | Faulty values<br>System Alerts | BMS of BESS and sensors are connected to EMS | Termination of UC |

### 4.2. Steps – Scenarios

Scenario Name: No. 1 - Local generation exceeds local demand
No. 2 - Local demands exceed local generation
No. 3 - Faulty Situation

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | Initiating of UC 2 | Trigger Event | Operator sets EMS (ALF-C) mode of operation to UC 2 and defines target setpoint ($P'_{Breaker}$) for load exchange and the duration (t) | REPORT | DSO | EMS | I-01 | |
| 2 | External service provider sends weather forecasts | Transmitting the data | An external service provider sends weather data and weather forecast values. | GET | External System | EMS | I-03 | |
| 3 | EMS receives forecasting values | Forecasting of generation and demand | The EMS forecasts local generation and demand:<br>- Generation based on weather forecasts<br>Load – based on weather forecast and load profiles from historic measurement data | CREATE | EMS | EMS | | |
| 4 | Sensor (grid connection point in secondary substation) provides values | Transmitting the data | The local sensor located at secondary substation measures the residual power export and sends data to EMS.<br><br>If Applicable (to be clarified):<br>The communication will take place from the sensor via the sensor data management backend to the Blockchain Access Platform (BAP). The BAP acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the EMS.<br><br>After the trigger for provision of measurement data, the<br>Then data will be pushed by the sensor to the EMS every 10 seconds. | CHANGE | Sensor | EMS | I-05 | |
| 5 | Local sensors provide data via Data Management Backend. | Transmitting the data | Local sensors provide measurements values and data via sensor data management backend to the EMS.<br><br>If Applicable (to be clarified):<br>The communication will take place from the sensor via the sensor data management backend to the Blockchain Access Platform (BAP). The BAP acts | CHANGE | Sensor | EMS | I-05 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the EMS.<br><br>After the trigger for provision of measurement data, the<br>Then data will be pushed by the sensor to the EMS every 15 minutes. | | | | | |
| 6 | All data collected | Evaluation and determination of control strategy and setpoints | Based on provided measurement data, asset key data. EMS calculates the power bandwidth of each asset available for steering ($P_{Flex}$).<br><br>The EMS determines for each asset a setpoint ($P'_{Asset}$) to reach $P'_{Breaker}$. The determination of setpoints is repeated every 10 seconds for BESS and every 15 minutes for flexible loads and household energy storages. | CREAT E | EMS | EMS | | |
| 7 | Individual setpoints determined | Transmitting setpoints to controllers | The EMS sends setpoints via a data management backend to controllers to increase, decrease consumption assets (battery energy storage, household energy storage and flexible load) located in the field to increase consumption.<br>If Applicable (to be clarified):<br>The communication will take place from the EMS along the Blockchain Access Platform. The Blockchain Access Platform acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the Data Management Backend of the controller.<br>This signal is sent every ten seconds to the BESS Management Backend and every 15 minutes to loads located at customer premise and replaces the default signal until the EMS calculates a setpoint. | EXECU TE | EMS | Controll ers | I-06 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | Setpoint send to controller | Verification of setpoint execution | The EMS compares measured values comparison of $P_{Breaker}$ from the grid connection point with the target values $P'_{Breaker}$. In case of deviation the setpoint are redefined by walking through step numbers 2 to 10. The process is continuously repeated until the end of use case. | CREATE | Sensor | EMS | | |
| 9 | End of Use Case 2 | End of Use Case 2 | The use case ends, when a user triggers another use case, or in a case of lack of flexibility to reach $P'_{Breaker}$. | REPORT/CREATE | DSO or ALF-C | EMS | I-01 | |

## 5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | User sets UC and variables | - DSO sets the use case via an UI the EMS (ALF-C) to apply UC 2. The trigger signal is:<br>0 = stop current use case<br>1 = application of UC 1<br>2 = application of UC 2<br>3 = application of UC 3<br>4 = application of UC 4<br><br>- DSO set via UI a target setpoint (P'Breaker) for the load - exchange along the grid connection point. | |
| I-03 | Weather forecasts provision | - Solar radiation (t + 24h)<br>- Cloudiness (t + 24 h)<br>- Temperature (t + 24 h)<br>- Humidity (t + 24 h)<br>Windspeed (t + 24 h) | |
| I-05 | Measurement data provision | Sensors located at secondary substation, BESS and households push measurement data to EMS | |
| I-06 | Sending of setpoint (t) or setpoint schedule (t+1) from EMS to BESS, household energy storages and flexible loads | Setpoint to increase or decrease demand/generation as static value [P] or relative value [%] or [SOC] | |

6. Requirements

7. Common Terms and Definitions

| Term | Definition |
|---|---|
| | |

8. Custom Information

| Key | Value | Refers to Section |
|---|---|---|
| | | |

### A.3.3 UC-DE-3 Energy Delivery

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-DE-3 | **Area:** Energy system<br>**Domain:** Distribution, Customer Premise, DER<br>**Zone:** Operation, Enterprise, Process, Field | Bulk energy supply |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 1st April | Thorsten Gross | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| Scope | Energy communities with a high proportion of self-generation and flexible consumers and storage can maximize the self-consumption of locally generated energy. These communities are unlikely to meet their own needs with locally generated energy throughout the year and will potentially run into energy-deficit in times of low local generation. Energy deficits could be compensated by the supplying distribution network. To reduce the stress on the mid-voltage feeder and reduce overall network cost, energy deficits occurring could be forecasted and delivered in discrete packages ahead of time at fixed time slots and be stored in local storages until demand arises.<br>Networks: LV, MV<br>Markets: None |
| **Objective(s)** | • Enabling temporary islanding even in times of energy deficit of the local community<br>• Forecasting of residual energy demand of an energy community<br>• Forecasting of residual energy generation of an energy community |

| | |
|---|---|
| | • Execution of power exchange schedule for the energy community for the grid connection point LV/MV (time and power of load exchange)<br>• Determination of a setpoint schedule for individual local asset to meet energy community setpoint schedule<br>• Execution of defined power exchange between energy community and the distribution network |
| **Related business case(s)** | Integration of local energy communities in network management and supply strategies for the stabilization and uniform utilization in distribution grid |

## 1.4. Narrative of Use Case

**Short description**

Local energy communities (LEC, CEC) are likely to emerge in Europe in the near future but will most likely retain an interconnection to the distribution grid. These communities will require a large share of flexibility to enable their primary use case (islanding).

In the absence of sufficient generation and storage, the community is unlikely to be self-sufficient at all times. When energy deficits occur, they must be provided by the distribution network. Instead of a real time energy supply by the connected distribution network, energy deficits could be forecast and supplied as an energy package with a defined time, duration and power value for the load exchange at the LV/ MV-grid connection point that connects the community with the distribution grid. The energy package shall be stored in local storages within the community and available for use, when the demand is rising. Outside of the defined periods of energy provision, no power exchange shall all the grid connection point shall take place, according to DE-UC1. This use case enables the DSO to reduce overall network costs, for example by gaining the ability to stagger the demand of multiple communities along a single feeder, thusly reducing the factor of coincidence of peak load and peak load level accordingly.

**Complete description**

An operator of Avacon triggers the EMS to apply Use Case 3 and sets a schedule of target value P'Breaker for the period (t+1) for the power exchange at the grid connection point. The schedule can be defined for a duration for the next 1 to 24 hours.

The schedule contains time slots for the import of energy in which P'Breaker ≠ 0 and time slots in which no power shall be exchanged along the grid connection point (P'Breaker = 0), following the principle of UC 1. During the application of UC 3 the total amount of imported energy shall meet the total amount of energy deficits that the community will have. The energy deficits will therefore have to be forecasted by the user. During the time of the energy package delivery, the energy package shall be stored in local battery storages. To maintain the given setpoint P'Breaker deficits shall be covered by energy provided by batteries located in the local network whereas generated surplus shall be buffered in available batteries.

After the user input has been confirmed the EMS begins with the application of UC 3. The EMS receives weather forecasts provided by an external service provider and measurement values provided by sensors located at the LV/MV grid connection point, flexible assets such as BESS, household energy storages and flexible loads as well as household grid connection points. Based on the received data and historic measurement values the EMS forecasts the local generation and demands and determines the best strategy to reach and maintain the setpoint schedule by utilizing the available flexibility for the pre-defined duration.

A sensor located at the grid connection will measure the power exchange of all 3 phases with the MV grid PBreaker and provide data to the EMS. Based on the information the EMS determines deviations between PBreaker and P'Breaker and dispatches setpoints to increase or decrease the load in the grid in order to reach P'Breaker. Additionally, sensors located in private customer households will provide measurements of energy consumption and SOC/SOE of storages and provide the data to the EMS. Historical measurement data and weather forecasts provided by external service providers enable the EMS to predict energy generation and consumption to maximize the duration of time of maintaining P'Breaker.

In case generation and demand cannot be balanced to reach (P'Breaker) due to a lack of available storage capacity or flexibility, the use case will be terminated.

## 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_PR_01 | Participants' recruitment | In relation with the total amount of customers contacted to participate in the demo. This indicator can be used to evaluate customer engagement plan. | |
| KPI_PR_02 | Active participation | This indicator measures the percentage of customers actively participating in the Platone demo with respect to the total customers that accepted the participation. This indicator can be used to evaluate customer engagement. | |
| KPI_PR_05 | Forecast reliability – customer profile | This KPI evaluates the reliability of the tool performing forecasting of power flows exchange by each Resource with the grid. The indicator is calculated for forecasted time range (next 24h or next 4h). | |
| KPI_PR_06 | Forecast reliability – grid profile | This KPI evaluates the reliability of the tool performing forecasting of power flow in significant assets of the grid. The indicator is calculated for forecasted time range (next 24h or next 4h). | |
| KPI_PR_07 | Distribution Network Hosting Capacity | This indicator measures the potential increase of hosting capacity for distributed energy resources with solutions proposed by Platone compared to the baseline scenario where DSO has no flexibility tools and services. The indicator gives a statement about the additional DERs that can be installed in the network thanks to innovative grid services without the need for conventional reinforcements (i.e. new grid lines). | |
| KPI_DE_07 | Success of package-based energy provision | During UC 3 application, the success of delivery of energy packages shall be documented. This KPI measures the success of package-based energy supply comparing total number of successful deliveries and triggered deliveries. | |
| KPI_DE_08 | Accuracy in forecasting deficits | A basic feature for the package based energy delivery approach is the forecast energy deficits of a local network, which will have to be delivered in advance. The KPI aims to measure the quality of forecasting by comparing the amount of energy imported into the local network/community or export of the local network in times UC 3 is applied and delivery of energy package is triggered. | |

## 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| Formation of energy communities in future distribution grid | The Clean Energy Package has to be implemented by national regulation and legislations, enabling the formation of energy communities. |

| | |
|---|---|
| Integration of battery storage in control mechanisms of the DSO | The local energy community has the ability to forecast net-energy deficit day ahead and can accept and follow power setpoints as defined by the DSO. |
| DSO supply mechanism for local energy communities | The DSO is enabled and capable to apply novel supply strategies to energy communities, moving away from real-time supply to a package-based philosophy. |

### 1.7. Further information to the use case for classification/mapping

| **Relation to other use cases** | **UC 3 requires UC 1 and UC 2 as a prerequisite** |
|---|---|
| Level of depth | Primary Use Case |
| Prioritisation | |
| Generic, regional or national relation | Germany |
| Nature of the use cases | Technical |
| Further keywords for classification | Medium Voltage Grid, Low Voltage Grid, Monitoring, Energy Communities, Islanding |

### 1.8. General remarks

| **General remarks** |
|---|
| |

## 2. Diagrams of Use Case

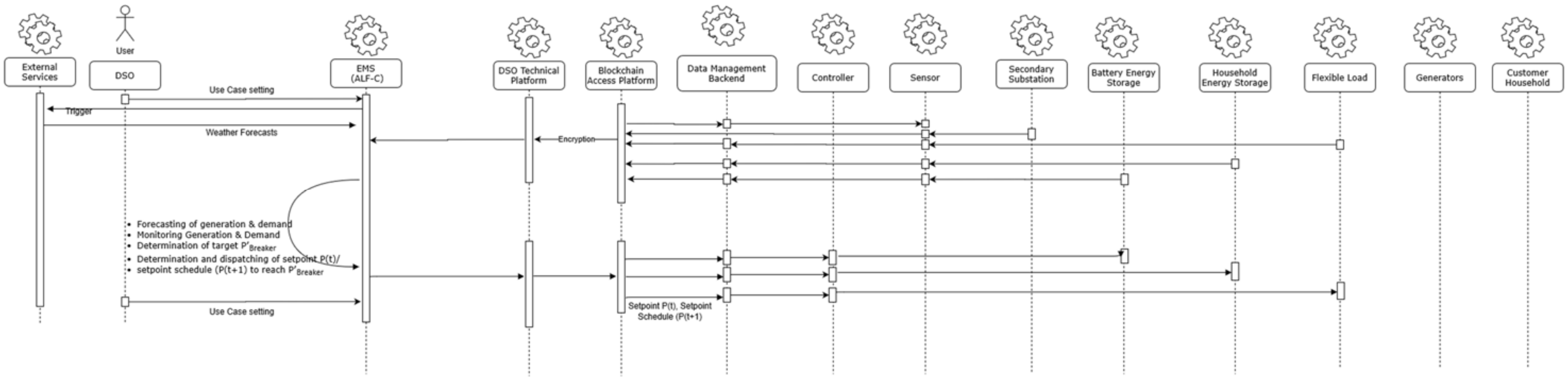



Figure 34: Sequence Diagram UC-DE-3

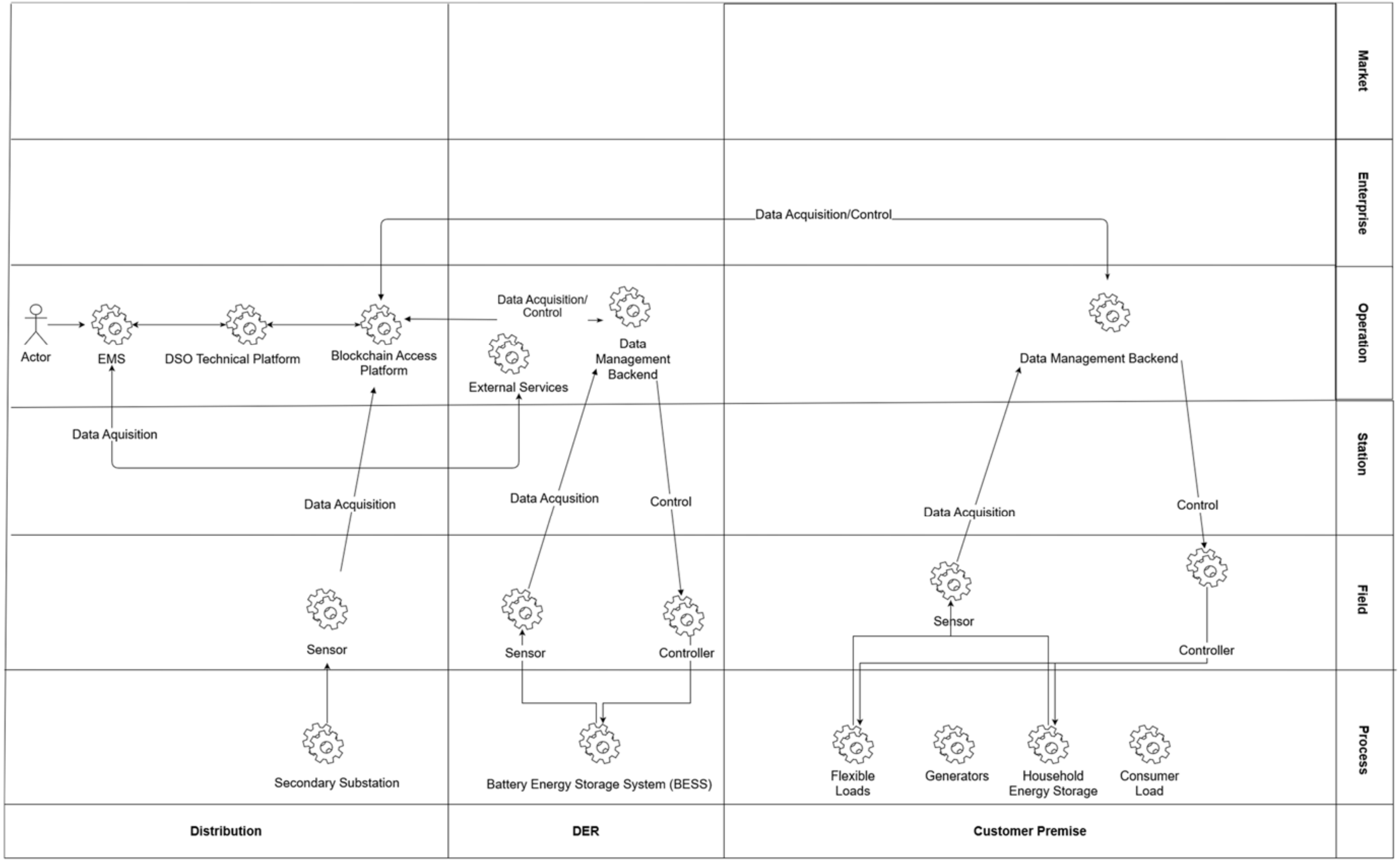



Figure 35: Use Case Diagram UC-DE-3

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| Consumer Load | System | Household with a standard load profile energy consumption of a single household or energy consumer with a standard load profile of an agricultural building. | No direct measurement of energy consumption, demand not controllable (passive user). |
| Generators | System | Roof Top photovoltaic system generating energy directly correlated with solar radiation at location. | Limited controllability (can be curtailed in extreme cases). Located on customers premise and can be operated in combination with a battery storage system, for optimization of own consumption. |
| Controller | Device | Summarises all devices that are able to receive setpoints or setpoint schedules and translate them into actionable steering commands for the flexible load or storage. | |
| Sensors | Device | Devices that measure voltage, current and angle of phase or SOE or SOC in case of storages and able to communicate to external systems or devices. | Retrofit (PMU or other) or integrated |
| Battery Energy Storage System (BESS) | System | System that are demanding, storing and feeding energy to the local grid/energy community. | 300 kW/600 kWh, fully integrated in EMS and full time available for UC. |
| Household Energy Storage | System | System that are demanding, storing and feeding energy to the local grid/energy community. | Integrated in EMS and full time available for UC. |
| Flexible Loads | System | Electrical heater or eat pump used by household for generation of domestic heat. | Could be provided by customer households. |
| Weather Forecast Service Provider | External System | Provides weather forecasts for the next 24h of wind, solar radiation, cloudiness and temperature. | |
| BESS Data Management Backend | External System | Data backend of BESS manufacturer for storing data and providing measurement data and forwarding setpoint to BESS. | |

| | | | |
|---|---|---|---|
| Sensor & Controller Data Management Backend | External System | Cloud service of assets vendor (can be individual for different assets) storing data, providing measurement data of asset and/or interface for transmission of setpoints to asset. | Assets with different vendors, requires connection to different vendor cloud platform and backends. |
| DSO Technical Platform | System | Central Platform providing services, e.g. data storage and state estimation. Used as middleware for data acquisition and setpoint delivery of assets and sensors in the field. | Provided by RWTH. |
| Blockchain Access Platform | System | Platform for encryption and verification of data flows along the way of communication from EMS (ALF-C) to sensors and Assets in the field. | Provided by Engineering |
| EMS (ALF-C) | Component | - Monitors local generation and demand<br>- monitors available flexibility and storages<br>- forecasts generation, demand and available flexibility via historic data and weather forecasts<br>- Accepts use case trigger and use case parameter - from EMS Use Case Module and determines and dispatches setpoints for individual assets<br>- Calculates the setpoint or setpoint schedule for the EMS Controller | EMS named Avacon Local Flex Controller (EMS).<br><br>In a productive environment operator could be DSO, retailer, storage system operators or any other energy service provider. |
| Distribution System Operator (Avacon) | Person | Local grid operator (Avacon) setting use case and setting setpoint for load exchange along the grid connection point (P'Breaker) | Only in field-test trial. n future done by DSO, TSO, marketer or energy service providers |

## 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organisation | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

## 4. Step by Step Analysis of Use Case

### 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Local generation exceeds local demand | • Generators<br>• EMS (EMS)<br>• Consumer Load<br>• Energy Storage<br>• Flexible Load<br>• BESS<br>DSO | Measured load flow (export) at grid connection point | • Sensors and controllers are connected with EMS<br>• Enough flexible loads and storages capacity are available for balancing | $P_{Breaker}$ = $P'_{Breaker}$ |
| 2 | Local demands exceed local generation | • Generators<br>• EMS (EMS)<br>• Consumer Load<br>• Energy Storage<br>• Flexible Load<br>• BESS<br>• DSO | Measured Load Exchange at grid connection | • Sensors and controllers are connected with EMS<br>• Enough flexible loads and storages capacity are available for balancing | Charging power of local flexible loads and storages will be decreased in order to balance generation and demand. |
| 3 | Faulty Situation | EMS | Faulty values<br>System Alerts | BMS of BESS and sensors are connected to EMS | Termination of UC |

### 4.2. Steps – Scenarios

Scenario Name: No. 1 - Local generation exceeds local demand
No. 2 - Local demands exceed local generation
No. 3 - Faulty Situation

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | Initiating of UC 3 | Trigger Event | Operator sets EMS (ALF-C) mode of operation to UC 3 and defines target setpoint ($P'_{Breaker}$) for load exchange and the duration (t) | REPORT | DSO | EMS | I-01 | |
| 2 | External service provider sends weather forecasts | Transmitting the data | An external service provider sends weather data and weather forecast values. | GET | External System | EMS | I-03 | |
| 3 | EMS receives forecasting values | Forecasting of generation and demand | The EMS forecasts local generation and demand:<br>- Generation based on weather forecasts<br>Load – based on weather forecast and load profiles from historic measurement data | CREATE | EMS | EMS | | |
| 4 | Sensor (grid connection point in secondary substation) provides values | Transmitting the data | The local sensor located at secondary substation measures the residual power export and sends data to EMS.<br><br>If Applicable (to be clarified):<br>The communication will take place from the sensor via the sensor data management backend to the Blockchain Access Platform (BAP). The BAP acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the EMS.<br><br>After the trigger for provision of measurement data, the<br>Then data will be pushed by the sensor to the EMS every 10 seconds. | CHANGE | Sensor | EMS | I-05 | |
| 5 | Local sensors provide data via Data Management Backend. | Transmitting the data | Local sensors provide measurements values and data via sensor data management backend to the EMS.<br><br>If Applicable (to be clarified): | CHANGE | Sensor | EMS | I-05 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | The communication will take place from the sensor via the sensor data management backend to the Blockchain Access Platform (BAP). The BAP acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the EMS.<br><br>After the trigger for provision of measurement data, the<br>Then data will be pushed by the sensor to the EMS every 15 minutes. | | | | | |
| 6 | All data collected | Evaluation and determination of control strategy and setpoints | Based on provided measurement data, asset key data. EMS calculates the power bandwidth of each asset available for steering ($P_{Flex}$).<br><br>The EMS determines for each asset a setpoint ($P'_{Asset}$) to reach $P'_{Breaker}$. The determination of setpoints is repeated every 10 seconds for BESS and every 15 minutes for flexible loads and household energy storages. | CREAT E | EMS | EMS | | |
| 7 | Individual setpoints determined | Transmitting setpoints to controllers | The EMS sends setpoints via a data management backend to controllers to increase, decrease consumption assets (battery energy storage, household energy storage and flexible load) located in the field to increase consumption.<br>If Applicable (to be clarified):<br>The communication will take place from the EMS along the Blockchain Access Platform. The Blockchain Access Platform acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the Data Management Backend of the controller.<br>This signal is sent every ten seconds to the BESS Management Backend and every 15 minutes to | EXECU TE | EMS | Controller s | I-06 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | loads located at customer premise and replaces the default signal until the EMS calculates a setpoint. | | | | | |
| 8 | Setpoint send to controller | Verification of setpoint execution | The EMS compares measured values comparison of $P_{Breaker}$ from the grid connection point with the target values $P'_{Breaker}$. In case of deviation the setpoint are redefined by walking through step numbers 2 to 10. The process is continuously repeated until the end of use case. | CREATE | Sensor | EMS | | |
| 9 | End of Use Case 3 | End of Use Case 3 | The use case ends, when a user triggers another use case, or in a case of lack of flexibility to reach $P'_{Breaker}$. | REPORT/CREATE | DSO or ALF-C | EMS | I-01 | |

## 5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Protocol |
|---|---|---|---|
| I-01 | User sets UC and variables | - DSO sets the use case via an UI the EMS to apply UC 3 “Energy Delivery”. The trigger signal is:<br>0 = stop current use case<br>1 = application of UC 1<br>2 = application of UC 2<br>3 = application of UC 3<br>4 = application of UC 4<br><br>- Set of time schedule:<br>DSO (user) sets via UI a time schedule for load exchange at grid connection point. The schedules define time (t) – earliest time for beginning of load exchange and duration for load exchange delivery (dt) – longest duration for delivery | |
| I-03 | Weather forecasts provision | - Solar radiation (t + 24h)<br>- Cloudiness (t + 24 h)<br>- Temperature (t + 24 h)<br>- Humidity (t + 24 h)<br>- Windspeed (t + 24 h) | |

| | | | |
|---|---|---|---|
| I-05 | Sensor measurement data provision | The sensor sends measurement values containing:<br>voltage (U), current (I) and angle of phase (Phi) values of all 3 phases measured in secondary substation.<br>Values indicate the residual power demand/generation as sum of demand or feed of BESS, household energy storage, flexible loads, generators and customer households and agricultural buildings. | |
| I-06 | Sending of setpoint (t) or setpoint schedule (t+1) | Setpoint to increase or decrease demand/generation as static value [P] or relative value [%] or [SOC] | |

## 6. Requirements

## 7. Common Terms and Definitions

| Term | Definition |
|---|---|
| | |

## 8. Custom Information

| Function | Description | Application in UC-DE-0 | Input | Output | Provided by |
|---|---|---|---|---|---|
| F-01 | Monitoring | 1,2,3,4 | I-03 | | ALF-C |
| F-02 | Data Storage | 1,2,3,4 | I-03 | historic data | ALF-C, BAP |
| F-03 | Analysis of Historic Data | 1,2,3,4 | historic data | load profiles | ALF-C, DSOTP |
| F-04 | State Estimation | 1,2,3,4 | I-02, I-03 | | ALF-C, DSOTP |
| F-05 | Forecasting Generation | 1,2,3,4 | I-03, I-02 asset data; load profiles | Generation forecast | ALF-C, DSOTP |
| F-06 | Forecasting Demand | 1,2,3,4 | I-03, I-02 asset data; load profiles | Load forecast | ALF-C, DSOTP |
| F-07 | Local Balancing | 1,2,3,4 | I-01, I-03, Generation forecast, Load forecast | Setpoint | ALF-C, DSOTP |
| F-08 | Setpoint Dispatching | 1,2,3,4 | Setpoint | I-06 | ALF-C |

### A.3.4 UC-DE-4 Energy Export in Discrete Packages

1. Description of the Use Case

1.1. Name of the Use Case

| ID | Area /Domain(s)/Zone(s) | Name of the Use Case |
|---|---|---|
| UC-DE-4 | **Area:** Energy system<br>**Domain:** Distribution, Customer Premise, DER<br>**Zones:** Operation, Enterprise, Process, Field | Bulk Energy Export |

1.2. Version Management

| Version No. | Date | Name of author(s) | Changes | Approval status |
|---|---|---|---|---|
| 0.1 | 1st April 2020 | Thorsten Gross | | Ready for D1.1 |

1.3. Scope and Objectives of Use Case

| | |
|---|---|
| **Scope** | Energy communities with a high proportion of self-generation and little amount flexible consumers, can make use of local storages to maximize the self-consumption of locally generated energy. These communities are unlikely to full consume locally generated energy throughout the year and will potentially run into generation of surplus in times of low demand. Energy surplus could be exported to the supplying distribution network. To reduce the stress on the mid-voltage feeder and reduce overall network cost, generation of surplus could be forecasted, be stored in local storages and exported delayed in discrete packages at fixed time slots.<br>Networks: LV, MV<br>Markets: None |
| **Objective(s)** | • Enabling temporary islanding even in times of energy deficit of the local community<br>• Forecasting of residual energy demand of an energy community<br>• Forecasting of residual energy generation of an energy community<br>• Execution of power exchange schedule for the energy community for the grid connection point LV/MV (time and power of load exchange)<br>• Determination of a setpoint schedule for individual local asset to meet energy community setpoint schedule<br>• Execution of defined power exchange between energy community and the distribution network |
| **Related business case(s)** | Integration of local energy communities in network management strategies for the stabilization and uniform utilization in distribution grid |

1.4. Narrative of Use Case

**Short description**

In the absence of sufficient generation and storage, the community is unlikely to be self-sufficient at all times. When surplus generation occurs, it must be exported into the distribution network. Instead of a real time energy export to the connected distribution network, energy surplus could be forecast and exported delayed as an energy package within a defined time, duration and power value for the load exchange at the LV/ MV-grid connection point. The generated energy surplus first shall be stored in local storages located within the community and be exported as an energy package delayed, when the load in the upper grid decreases. Outside of the defined periods of energy export, no power exchange shall take place, according to DE-UC1. This use case enables the DSO to reduce overall network costs, for example by gaining the ability to stagger the export of multiple communities along a single feeder, thusly reducing the factor of coincidence of peak load and peak load level accordingly.

**Complete description**

An operator of Avacon triggers the EMS to apply Use Case 4 and sets a schedule of target value $P'_{Breaker}$ for the period (t+1) for the power exchange at the grid connection point. The schedule can be defines for a duration for the next 1 to 24 hours.

The schedule contains time slots for the export of energy in which $P'_{Breaker} \neq 0$ and time slots in which no power shall be exchange along the grid connection point ($P'_{Breaker} = 0$), following the principle of UC 1. During the application of UC 4 the total amount of exported energy shall meet the total amount of the residual energy surplus that the community will generate. The generated surplus will therefore have to be forecasted by the user. In times $P'_{Breaker} = 0$ the generated surplus will have to be stored in local battery energy storages systems. In times $P'_{Breaker} \neq 0$, local batteries will be triggered to discharge in order to export generated surplus from LV into MV grid. To maintain the given setpoint $P'_{Breaker}$ deficits shall be covered by energy provided by batteries located in the local network whereas generated surplus shall be buffered in available batteries.

After the user input has been confirmed the EMS begins with the application of UC 4. The EMS receives weather forecasts provided by an external service provider and measurement values provided by sensors located at the LV/MV grid connection point, flexible assets such as BESS, household energy storages and flexible loads as well as household grid connection points. Based on the received data and historic measurements values the EMS forecasts the local generation and demands and determines the best strategy to reach and maintain the setpoint schedule by utilizing the available flexibility for the pre-defined duration.

A sensor located at the grid connection will measure the power exchange of all 3 phases with the MV grid $P_{Breaker}$ and provide data to the EMS. Based on the information the EMS determines deviations between $P_{Breaker}$ and $P'_{Breaker}$ and dispatches setpoints to increases or decreases the load in the grid in order to reach $P'_{Breaker}$. Additionally, sensors located in private customer households will provide measurements of energy consumption and SOC/SOE of storages and provide data to the EMS. With historical measurement data and weather forecast provided by external service providers enable the EMS to predict energy generation and consumption to maximize the duration of time of maintaining $P'_{Breaker}$.

In case generation and demand cannot be balanced to reach ($P'_{Breaker}$) due to a lack of available storage capacity or flexibility, the use case will be terminated.

## 1.5. Key Performance Indicators (KPI)

| ID | Name | Description | Reference to mentioned use case objectives |
|---|---|---|---|
| KPI_PR_01 | Participants' recruitment | Demo in relation with the total amount of customers contacted to participate in the demo. This indicator can be used to evaluate customer engagement plan. | |
| KPI_PR_02 | Active participation | This indicator measures the percentage of customers actively participating in the Platone demo with respect to the total customers that accepted the participation. This indicator can be used to evaluate customer engagement. | |

| | | | |
|---|---|---|---|
| KPI_PR_05 | Forecast reliability – customer profile | This KPI evaluates the reliability of the tool performing forecasting of power flows exchange by each Resource with the grid. The indicator is calculated for forecasted time range (next 24h or next 4h). | |
| KPI_PR_06 | Forecast reliability – grid profile | This KPI evaluates the reliability of the tool performing forecasting of power flow in significant assets of the grid. The indicator is calculated for forecasted time range (next 24h or next 4h). | |
| KPI_PR_07 | Distribution Network Hosting Capacity | This indicator measures the potential increase of hosting capacity for distributed energy resources with solutions proposed by Platone compared to the baseline scenario where DSO has no flexibility tools and services. The indicator gives a statement about the additional DERs that can be installed in the network thanks to innovative grid services without the need for conventional reinforcements (i.e. new grid lines). | |
| KPI_DE_07 | Success of package-based energy provision | During UC 4 application, the success of delivery of energy packages shall be documented. This KPI measures the success of package-based energy supply comparing total number of successful deliveries and triggered deliveries. | |
| KPI_DE_08 | Accuracy in forecasting deficits | A basic feature for the package based energy delivery approach is the forecast energy deficits of a local network, which will have to be delivered in advance. The KPI aims to measure the quality of forecasting by comparing the amount of energy imported into the local network/community or export of the local network in times UC 4 is applied and delivery of energy package is triggered. | |

## 1.6. Use case conditions

| Assumptions | Prerequisites |
|---|---|
| Private Customer households with flexible loads and storages are organized in a local energy community with a central EMS. | Participants of the energy communities incl. flexible loads and storages are connected to a single low voltage grid (feed by a single MV/LV transformer) and are monitored and steered by an EMS. |
| The energy community needs an operator for the "Islanding" EMS. | National regulations have to be clarified who can be the service providers and who can't (TSO, DSO, Aggregator, Retailer, Energy Service provider) |

## 1.7. Further information to the use case for classification/mapping

| Relation to other use cases | UC 1 as a prerequisite for islanding the community |
|---|---|
| Level of depth | Primary Use Case |
| Prioritisation | |
| Generic, regional or national relation | |
| Nature of the use cases | Technical |

| Further keywords for classification | |
|---|---|

## 1.8. General remarks

| General remarks |
|---|
| |

# 2. Diagrams of Use Case

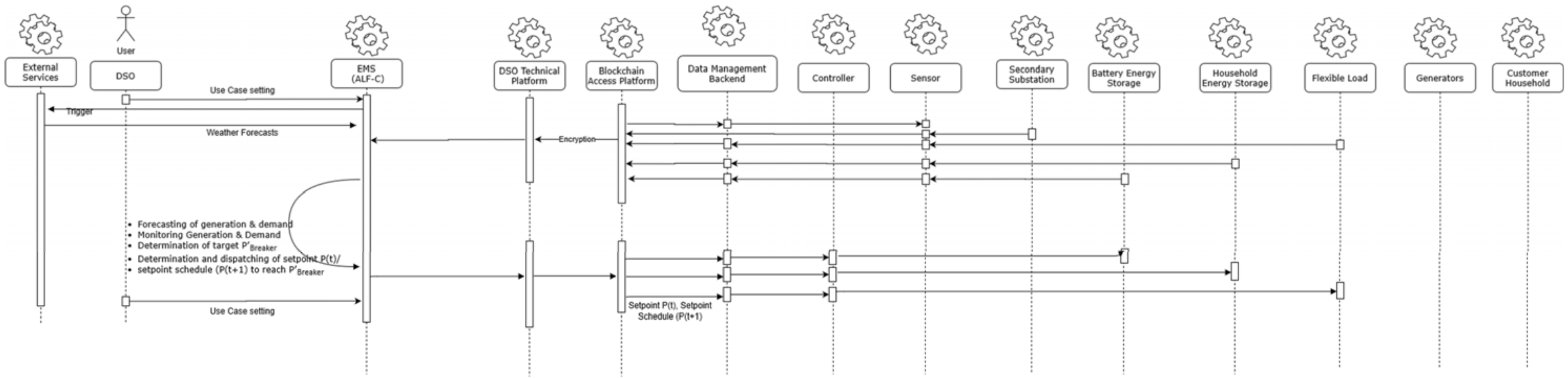



Figure 36: Sequence Diagram UC-DE-4

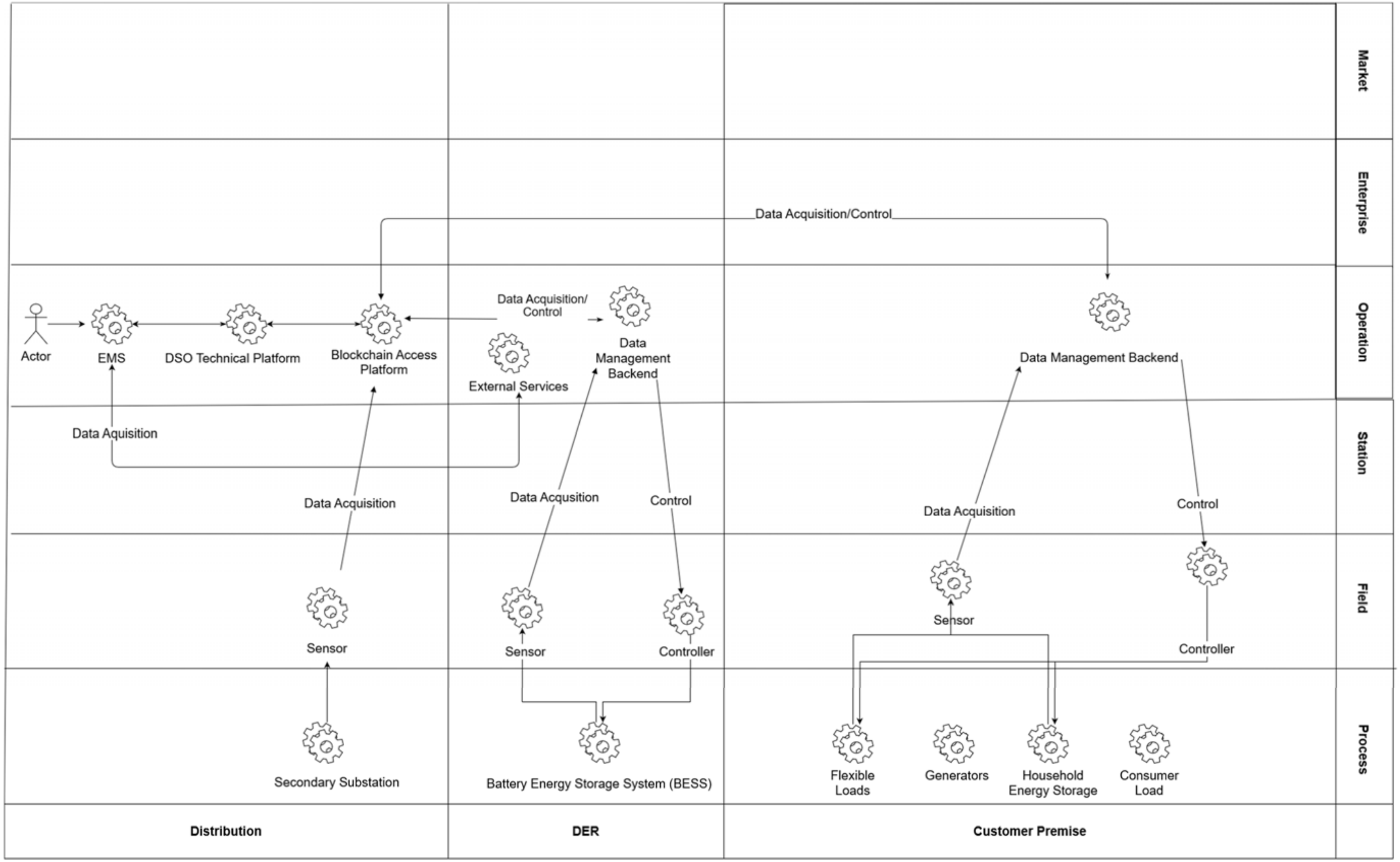



Figure 37: Use Case Diagram UC-DE-4

## 3. Technical Details

### 3.1. Actors

| Actor Name | Actor Type | Actor Description | Further information specific to this Use Case |
|---|---|---|---|
| Consumer Load | System | Household with a standard load profile energy consumption of a single household or energy consumer with a standard load profile of an agricultural building. | No direct measurement of energy consumption, demand not controllable (passive user). |
| Generators | System | Rooftop photovoltaic system generating energy directly correlated with solar radiation at location. | Limited controllability (can be curtailed in extreme cases). Located on customers premise and can be operated in combination with a battery storage system, for optimization of own consumption. |
| Controller | Device | Summarises all devices that are able to receive setpoints or setpoint schedules and translate them into actionable steering commands for the flexible load or storage. | |
| Sensors | Device | Devices that measure voltage, current and angle of phase or SOE or SOC in case of storages and able to communicate to external systems or devices. | Retrofit (PMU or other) or integrated |
| Battery Energy Storage System (BESS) | System | System that are demanding, storing and feeding energy to the local grid/energy community. | 300 kW/600 kWh, fully integrated in EMS and full time available for UC. |
| Household Energy Storage | System | System that are demanding, storing and feeding energy to the local grid/energy community. | Integrated in EMS and full time available for UC. |
| Flexible Loads | System | Electrical heater or eat pump used by household for generation of domestic heat. | Provided by customer households. |
| Weather Forecast Service Provider | External System | Provides weather forecasts for the next 24h of wind, solar radiation, cloudiness and temperature. | |
| BESS Data Management Backend | External System | Data backend provided by BESS manufacturer for storing data and providing measurement data and forwarding setpoint to BESS. | |

| | | | |
|---|---|---|---|
| Sensor & Controller Data Management Backend | External System | Cloud service of assets vendor (can be individual for different assets) storing data, providing measurement data of asset and/or interface for transmission of setpoints to asset. | Assets with different vendors, requires connection to different vendor cloud platform and backends. |
| DSO Technical Platform | System | Central Platform providing services, e.g. data storage and state estimation. Used as middleware for data acquisition and setpoint delivery of assets and sensors in the field. | Provided by RWTH. |
| Blockchain Access Platform | System | Platform for encryption and verification of data flows along the way of communication from EMS (ALF-C) to sensors and Assets in the field. | Provided by Engineering |
| EMS (ALF-C) | Component | - Monitors local generation and demand<br>- monitors available flexibility and storages<br>- forecasts generation, demand and available flexibility via historic data and weather forecasts<br>- Accepts use case Trigger from EMS Use Case Module and determines and dispatches setpoints for individual assets<br>- Calculates the setpoint or setpoint schedule for the EMS Controller | EMS named Avacon Local Flex Controller (EMS).<br><br>In a productive environment operator could be DSO, retailer, storage system operators or any other energy service provider. |
| Distribution System Operator (Avacon) | Person | Local grid operator (Avacon) setting use case and setting setpoint for load exchange along the grid connection point (P'Breaker) | Only in field-test trial. n future done by DSO, TSO, marketer or energy service providers |

## 3.2. References

| No. | References Type | Reference | Status | Impact on Use Case | Organiser / Organisation | Link |
|---|---|---|---|---|---|---|
| | | | | | | |

# 4. Step by Step Analysis of Use Case

## 4.1. Overview of Scenarios

| No. | Scenario Name | Primary Actor | Triggering Event | Pre-Condition | Post-Condition |
|---|---|---|---|---|---|
| 1 | Local generation exceeds local demand | • Generators<br>• EMS (EMS)<br>• Consumer Load<br>• Energy Storage | Measured load flow (export) at grid connection point | • Sensors and controllers are connected with EMS<br>• Enough flexible loads and storages capacity are available for balancing | $P_{Breaker} = P'_{Breaker}$ |

| | | | | | |
|---|---|---|---|---|---|
| | | • Flexible Load<br>• BESS<br>DSO | | | |
| 2 | Local demands exceed local generation | • Generators<br>• EMS (EMS)<br>• Consumer Load<br>• Energy Storage<br>• Flexible Load<br>• BESS<br>• DSO | Measured Load Exchange at grid connection | • Sensors and controllers are connected with EMS<br>• Enough flexible loads and storages capacity are available for balancing | Charging power of local flexible loads and storages will be decreased in order to balance generation and demand. |
| 3 | Faulty Situation | EMS | Faulty values<br>System Alerts | BMS of BESS and sensors are connected to EMS | Termination of UC |

## 4.2. Steps – Scenarios

Scenario Name: No. 1 - Local generation exceeds local demand
No. 2 - Local demands exceed local generation
No. 3 - Faulty Situation

| Step No. | Event. | Name of Process/ Activity | Description of Process/ Activity. | Service | Info. Producer (Actor) | Info. Receiver (Actor) | Info. Exchanged | Req., R-ID |
|---|---|---|---|---|---|---|---|---|
| 1 | Initiating of UC 4 | Trigger Event | Operator sets EMS (ALF-C) mode of operation to UC 4 and defines target setpoint ($P'_{Breaker}$) for load exchange and the duration (t) | REPORT | DSO | EMS | I-01 | |
| 2 | External service provider sends weather forecasts | Transmitting the data | An external service provider sends weather data and weather forecast values. | GET | External System | EMS | I-03 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | EMS receives forecasting values | Forecasting of generation and demand | The EMS forecasts local generation and demand:<br>- Generation based on weather forecasts<br>Load – based on weather forecast and load profiles from historic measurement data | CREATE | EMS | EMS | | |
| 4 | Sensor (grid connection point in secondary substation) provides values | Transmitting the data | The local sensor located at secondary substation measures the residual power export and sends data to EMS.<br><br>If Applicable (to be clarified):<br>The communication will take place from the sensor via the sensor data management backend to the Blockchain Access Platform (BAP). The BAP acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the EMS.<br><br>After the trigger for provision of measurement data, the<br>Then data will be pushed by the sensor to the EMS every 10 seconds. | CHANGE | Sensor | EMS | I-05 | |
| 5 | Local sensors provide data via Data Management Backend. | Transmitting the data | Local sensors provide measurements values and data via sensor data management backend to the EMS.<br><br>If Applicable (to be clarified):<br>The communication will take place from the sensor via the sensor data management backend to the Blockchain Access Platform (BAP). The BAP acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the EMS.<br><br>After the trigger for provision of measurement data, the<br>Then data will be pushed by the sensor to the EMS every 15 minutes. | CHANGE | Sensor | EMS | I-05 | |
| 6 | All data collected | Evaluation and determina | Based on provided measurement data, asset key data. EMS calculates the power bandwidth of each asset available for steering ($P_{Flex}$). | CREATE | EMS | EMS | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | tion of control strategy and setpoints | The EMS determines for each asset a setpoint ($P'_{Asset}$) to reach $P'_{Breaker}$. The determination of setpoints is repeated every 10 seconds for BESS and every 15 minutes for flexible loads and household energy storages. | | | | | |
| 7 | Individual setpoints determined | Transmitting setpoints to controllers | The EMS sends setpoints via a data management backend to controllers to increase, decrease consumption assets (battery energy storage, household energy storage and flexible load) located in the field to increase consumption.<br>If Applicable (to be clarified):<br>The communication will take place from the EMS along the Blockchain Access Platform. The Blockchain Access Platform acts as middleware for data encryption. From there the data will be forwarded to the DSO Technical Platform acting as second level middleware from where the signal is sent to the Data Management Backend of the controller.<br>This signal is sent every ten seconds to the BESS Management Backend and every 15 minutes to loads located at customer premise and replaces the default signal until the EMS calculates a setpoint. | EXECUTE | EMS | Controllers | I-06 | |
| 8 | Setpoint send to controller | Verification of setpoint execution | The EMS compares measured values comparison of PBreaker from the grid connection point with the target values P'Breaker. In case of deviation the setpoint are redefined by walking through step numbers 2 to 10. The process is continuously repeated until the end of use case. | CREATE | Sensor | EMS | | |
| 9 | End of Use Case 4 | End of Use Case 4 | The use case ends, when a user triggers another use case, or in a case of lack of flexibility to reach P'Breaker. | REPORT/CREATE | DSO or ALF-C | EMS | I-01 | |

## 5. Information Exchanged

| Information exchanged ID | Name of Information | Description of Information Exchanged | Requirements to information data |
|---|---|---|---|
| I-01 | User sets UC and variables | - DSO sets the use case via an UI the EMS (ALF-C) to apply UC 2.<br>The trigger signal is:<br>0 = stop current use case<br>1 = application of UC 1 | |

| | | | |
|---|---|---|---|
| | | 2 = application of UC 2<br>3 = application of UC 3<br>4 = application of UC 4<br>- DSO set via UI a target setpoint (P'Breaker) for the load - exchange along the grid connection point. | |
| I-03 | Weather forecasts provision | - Solar radiation (t + 24h)<br>- Cloudiness (t + 24 h)<br>- Temperature (t + 24 h)<br>- Humidity (t + 24 h)<br>- Windspeed (t + 24 h) | |
| I-05 | Measurement data provision | Sensors located at secondary substation, BESS and households push measurement data to EMS | |
| I-06 | Sending of setpoint (t) or setpoint schedule (t+1) from EMS to BESS, household energy storages and flexible loads | Setpoint to increase or decrease demand/generation as static value [P] or relative value [%] or [SOC] | |

## 6. Requirements

## 7. Common Terms and Definitions

| Term | Definition |
|---|---|
| | |

## 8. Custom Information

| Function | Description | Application in UC-DE-0 | Input | Output | Provided by |
|---|---|---|---|---|---|
| F-01 | Monitoring | 1,2,3,4 | I-03 | | ALF-C |
| F-02 | Data Storage | 1,2,3,4 | I-03 | historic data | ALF-C, BAP |
| F-03 | Analysis of Historic Data | 1,2,3,4 | historic data | load profiles | ALF-C, DSOTP |
| F-04 | State Estimation | 1,2,3,4 | I-02, I-03 | | ALF-C, DSOTP |
| F-05 | Forecasting Generation | 1,2,3,4 | I-03, I-02 asset data; load profiles | Generation forecast | ALF-C, DSOTP |
| F-06 | Forecasting Demand | 1,2,3,4 | I-03, I-02 asset data; load profiles | Load forecast | ALF-C, DSOTP |

| | | | | | |
|---|---|---|---|---|---|
| F-07 | Local Balancing | 1,2,3,4 | I-01, I-03, Generation forecast, Load forecast | Setpoint | ALF-C, DSOTP |
| F-08 | Setpoint Dispatching | 1,2,3,4 | Setpoint | I-06 | ALF-C |

# Annex B Platone Actors

The following Table 18 gives an overview of the actors in Platone.

The actors are of type Person, System or Device, which follows the IEC 62559-2 standard.

| ***Short Name*** | ***Actor Name*** | ***Actor Type*** | ***In UC?*** | ***Domain*** | ***Zone*** |
|---|---|---|---|---|---|
| AMR | Automatic Metering Reading | Device | GR1,2,3,4 IT1, IT2 | Distribution | Field |
| Agg | Aggregator/ Flexibility operator | Person | GR3,4,5 IT1, IT2 | n/a | n/a |
| AP | Aggregator Platform | System | GR3,4,5 IT1, IT2 | Distribution | Operation |
| AgBuild | Agricultural Buildings | System | DE1-4 | Customer Premises | Process |
| BRP | Balance Responsible Party | Person | IT1, IT2 | Distribution | Operation |
| BAP | Blockchain Access Platform | System | DE1-4 GR1-5 | Distribution | Operation |
| BAP_Ita | Italian Blockchain Access Platform | System | IT1, IT2 | Distribution | Operation |
| BESS | Battery Energy Storage System | System | DE1-4 | DER | Station |
| BESS_Backend | BESS Data Management Backend | System | DE1-4 | Distribution | Operation |
| BMS | Building Management System (BMS) | System | IT1, IT2 | Customer Premises | Field |
| CL | Consumer Load | System | DE1 | Customer Premises | Process |
| CC | Commercial consumer | Person | GR3,4,5 | n/a | n/a |
| DM_Backend | Data Management Backend | System | DE1-4 | Distribution | Operation |
| DMS | Distribution Management System | System | GR1,2,3,4 | Distribution | Operation |
| DSODS | DSO Data Server | System | GR1,2,3,4 | Distribution | Operation |
| DSO | Distribution System Operator | Person | DE1-4 GR1,2,3,4,5 IT1, IT2 | n/a | n/a |
| DSOTP | DSO Technical Platform | System | DE1-4 GR1,2,3,4 | Distribution | Operation |

| | | | | | |
|---|---|---|---|---|---|
| DSOTP_Ita | Italian DSO Technical Platform | System | IT1, IT2 | Distribution | Operation |
| EMS | Energy Management System | System | DE1-4 | Customer Premises | Field |
| EV | EV charging station | Device | IT1, IT2 | Customer Premises | Process |
| FL | Flexible Loads | System | DE1-4 | Distribution | Operation |
| FR | Flexibility Resource | Device | IT1, IT2 | Customer Premises | Process |
| FRO | FR Owner | Person | IT1, IT2 | n/a | n/a |
| Gen | Generator | System | DE1-4 | Customer Premises | Process |
| GIS | Geographic Information System | System | GR1,2,3,4 | Distribution | Enterprise |
| HES | Household Energy Storage | System | DE1-4 | Customer Premises | Field |
| LN | Light Node | System | IT1, IT2 | Distribution | Field |
| LVCB | LV Circuit breaker | System | IT1, IT2 | Distribution | Enterprise |
| MP | Market Platform | System | IT1, IT2 | Distribution | Operation |
| MO | Market Operator | Device | IT1, IT2 | n/a | n/a |
| OS | Operational Systems | System | IT1, IT2 | Distribution | Field |
| PMU | Phasor Measurement Unit | Device | DE1-4 GR2,3,4 IT1, IT2 | Distribution | Station |
| RES | Renewable Energy Source | Device | GR3,4,5 | Distribution | Process |
| RC | Residential consumer | Person | GR3,4,5 IT1, IT2 | n/a | n/a |
| SCADA | Supervisory Control and Data Acquisition | System | GR1,2,3,4 | Distribution | Field |
| SCD | Shared Customer Database | System | DE1-4 | Customer Premises | Enterprise |
| SCD_Ita | Italian Shared Customer Database | System | IT1, IT2 | Distribution | Operation |
| Sensor | Sensor | Device | DE1-4, IT1, IT2 | Distribution | Station |

| | | | | | |
|---|---|---|---|---|---|
| StoHeat | Storage heater | Device | DE1, DE2 | Customer Premises | Process |
| SSBS | Small Scale Battery Storage | Device | DE1-4 | Customer Premises | Process |
| SA | Smart Appliance | Device | IT1, IT2 | Customer Premises | Process |
| StHouse | Standard Household | Device | DE1, DE2 | Customer Premises | Process |
| SS | Storage System | Device | IT1, IT2 | Customer Premises | Process |
| TSO | Transmission System Operator | Person | GR4,5 IT1, IT2 | n/a | n/a |
| TSOsim | TSO simulator | System | IT1, IT2 | Distribution | Operation |
| V&C Sensor | Voltage and current sensors | Device | IT1, IT2 | Distribution | Station |
| WFS | Weather Forecast Service | System | DE1-4 | Distribution | Enterprise |

**Table 18: Actors in Platone**

# Annex C SGAM Analysis on Use Case Level

This Annex contains diagrams for the individual UCs in the Italian, Greek and German demos. The Component, Function, Communication and Information Layers are illustrated. This per-UC SGAM analysis complements the overall SGAM analysis of chapter 4. A per-UC analysis of the Business Layer is already given in chapter 4.6 above.

## C.1.1 Italian Demo UC-level SGAM Analysis

The similarity of Italian UC-1 and UC-2 means that a single diagram covers both UCs in the Component, Function, Communication, and Information Layers.

### C.1.1.1 Component Layer

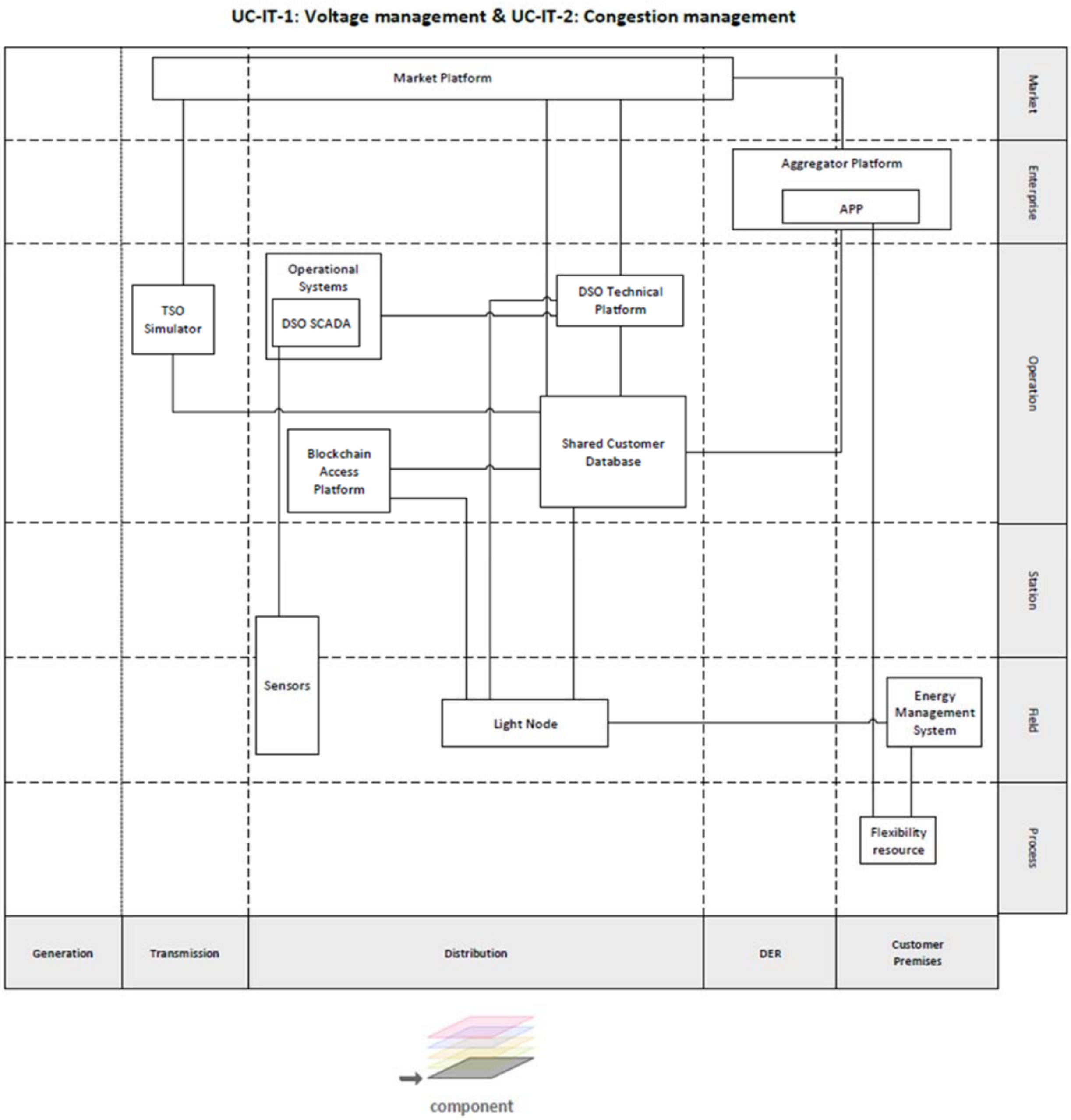



Figure 38: Italian Demo Component Layer for UC-IT-1 and UC-IT-2

### C.1.1.2 Function Layer

**UC-IT-1: Voltage management & UC-IT-2: Congestion management**

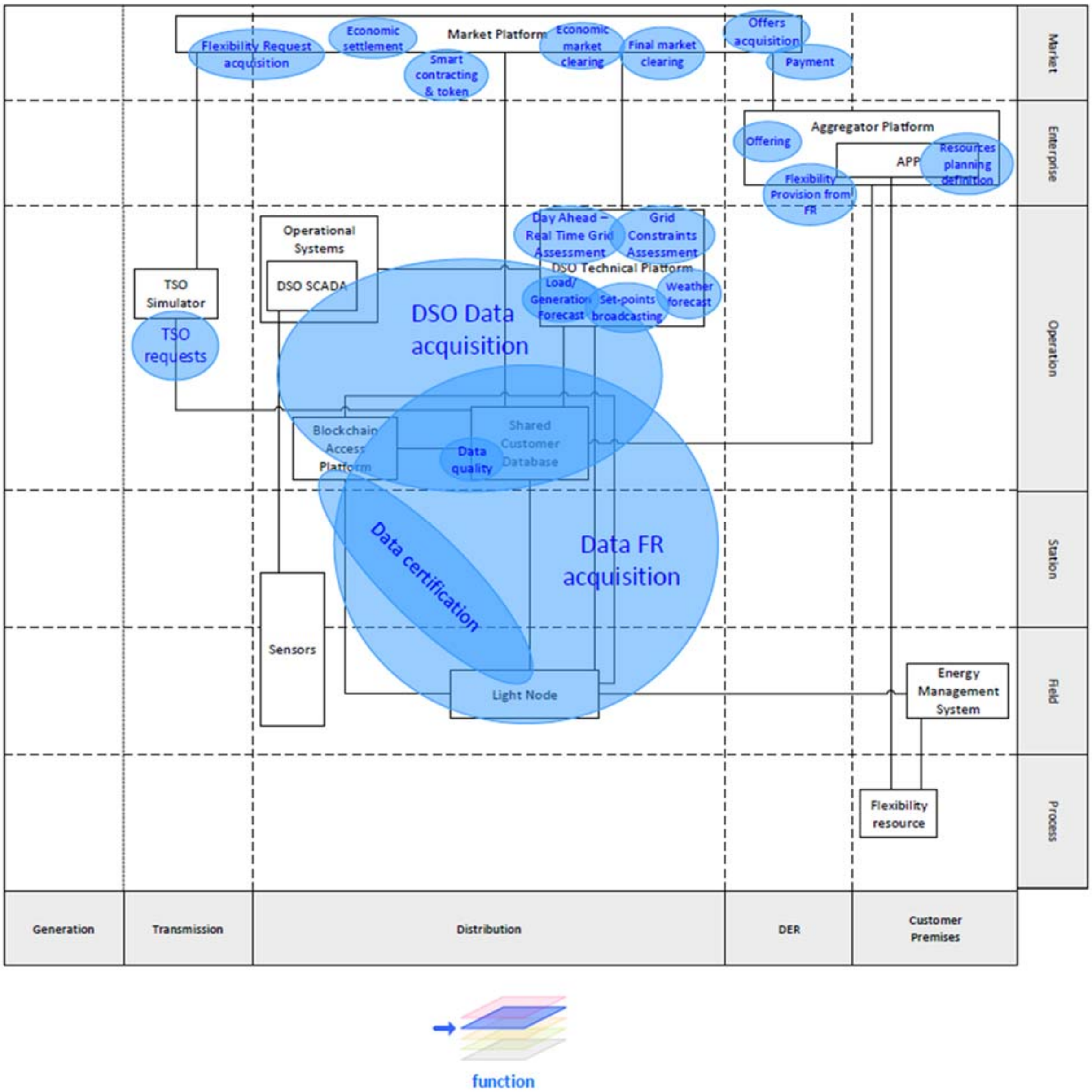



Figure 39: Italian Demo Function Layer for UC-IT-1 and UC-IT-2

### C.1.1.1 Communication Layer

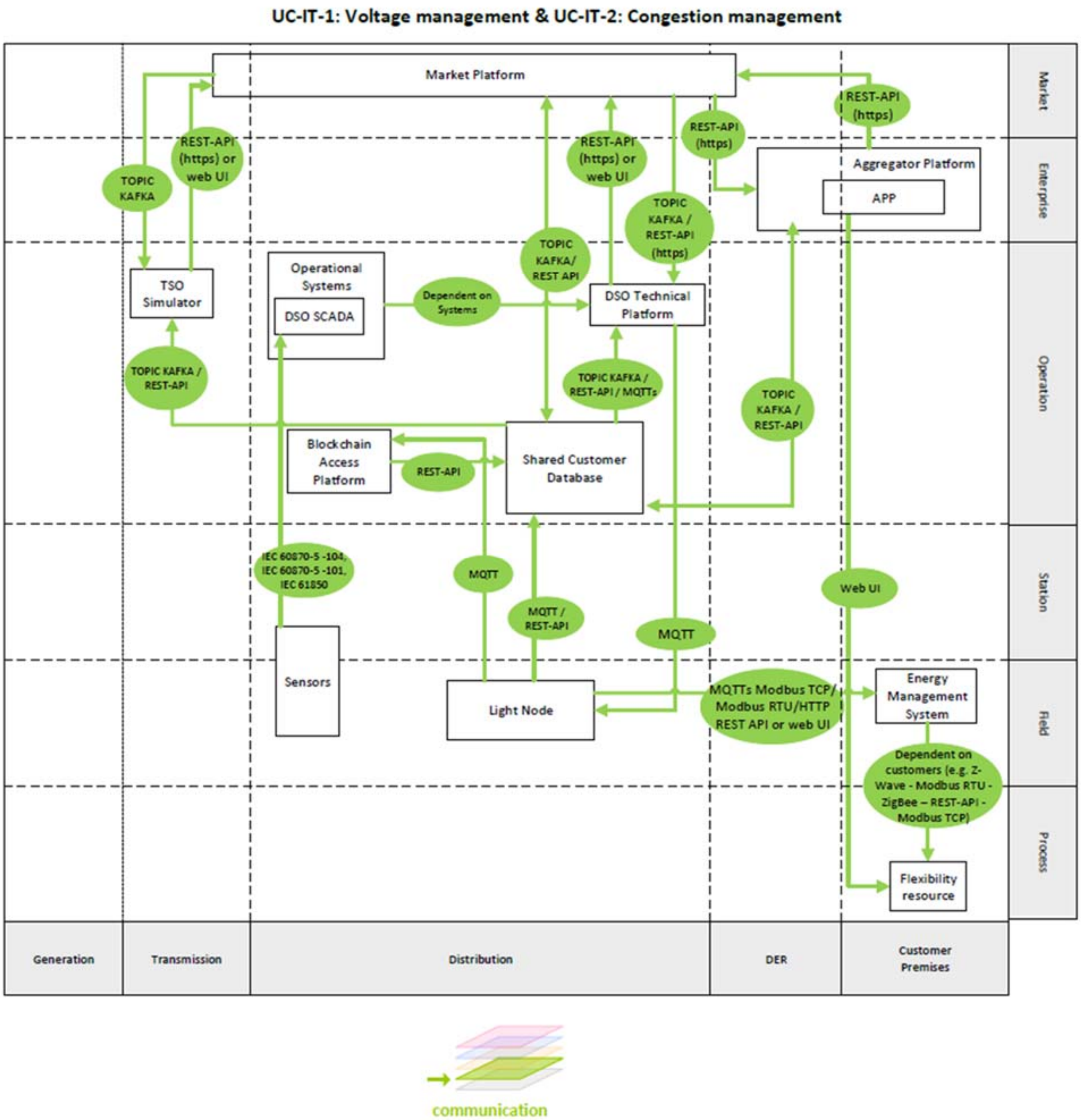



Figure 40: Italian Demo Communication Layer for UC-IT-1 and UC-IT-2

### C.1.1.2 Information Layer

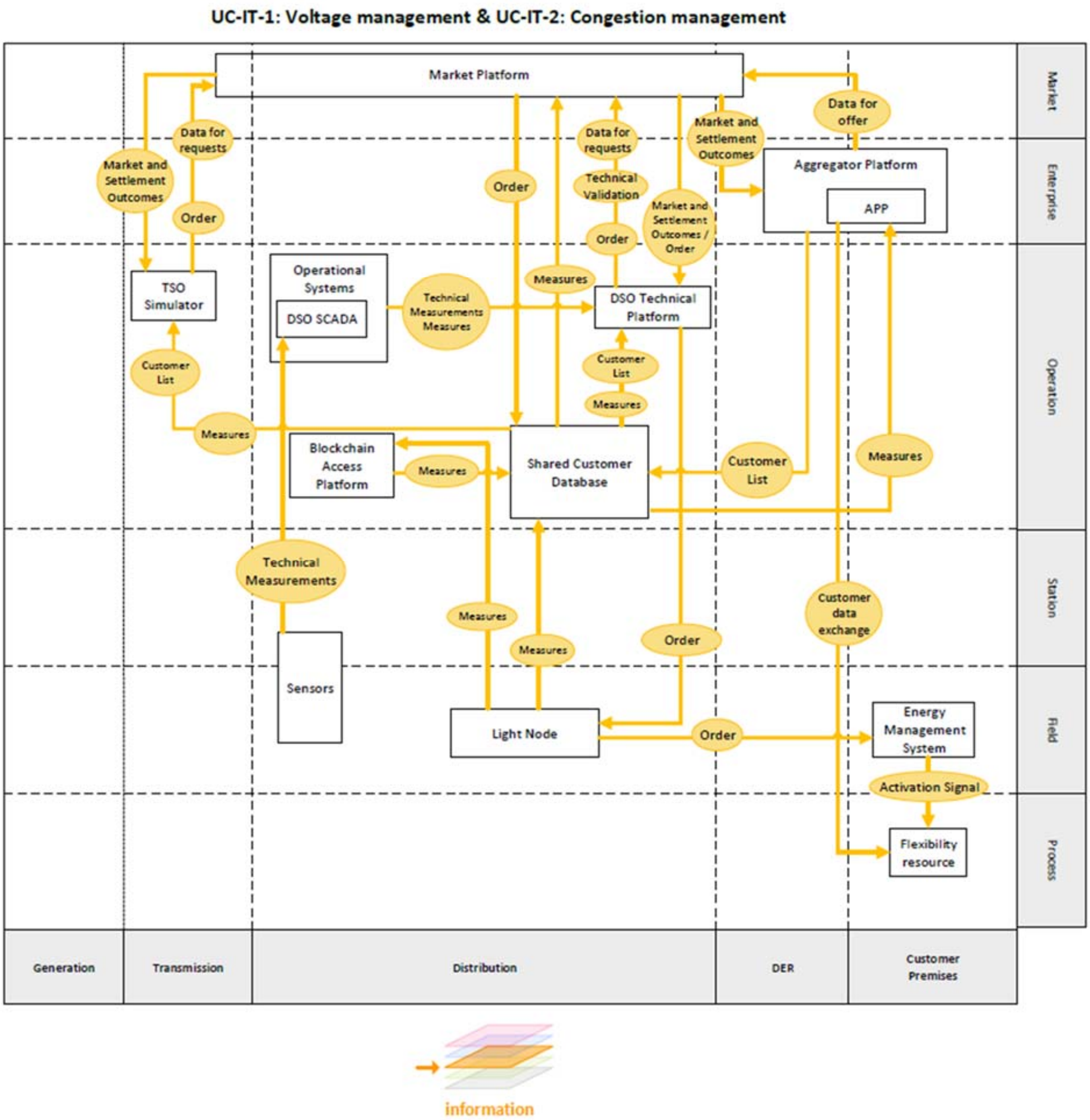



Figure 41: Italian Demo Information Layer for UC-IT-1 and UC-IT-2

## C.1.2 Greek Demo UC-level SGAM Analysis

### C.1.2.1 UC GR-1: Functions of the State Estimation tool given conventional measurements

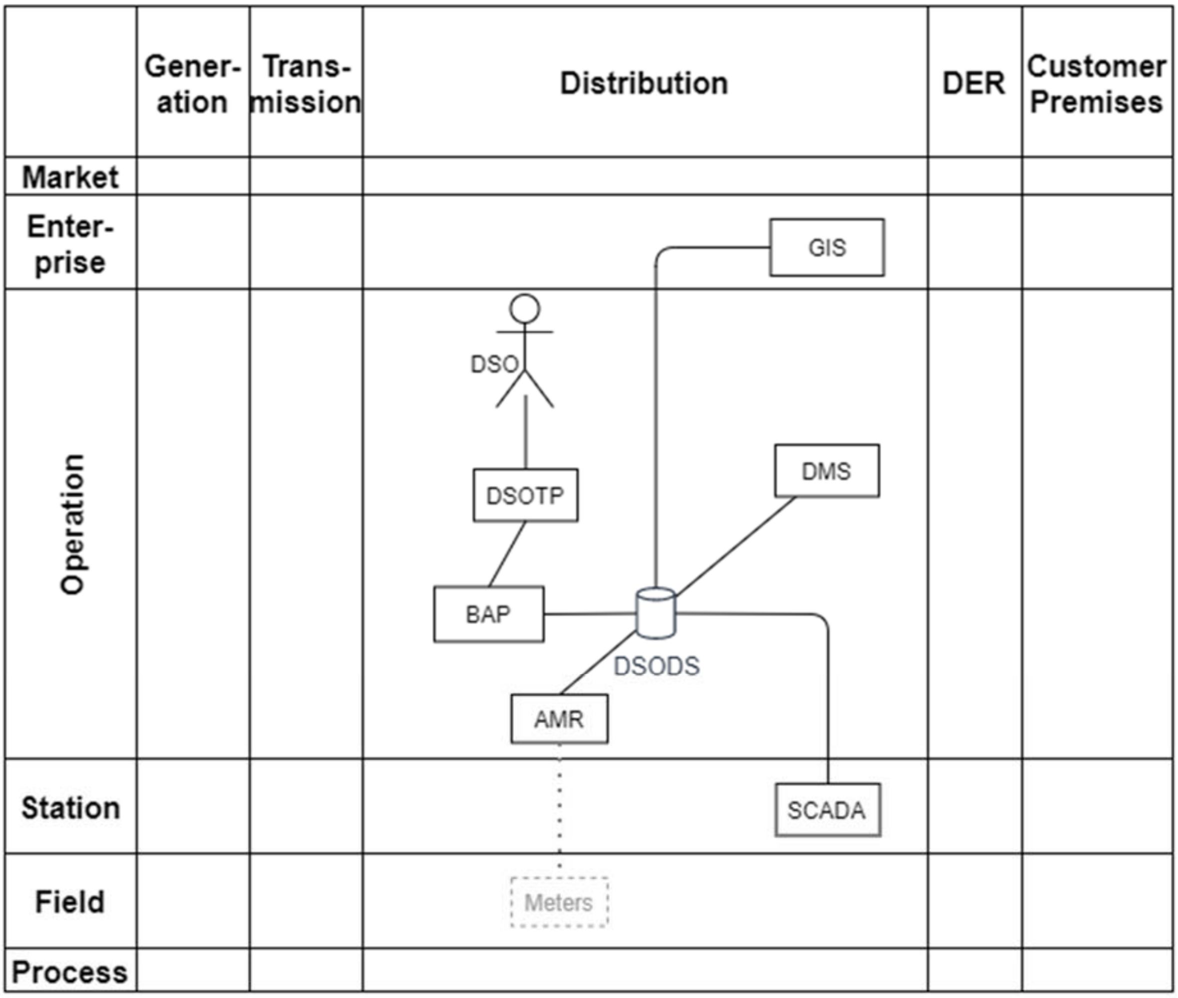



Figure 42: Component Layer for UC-GR-1

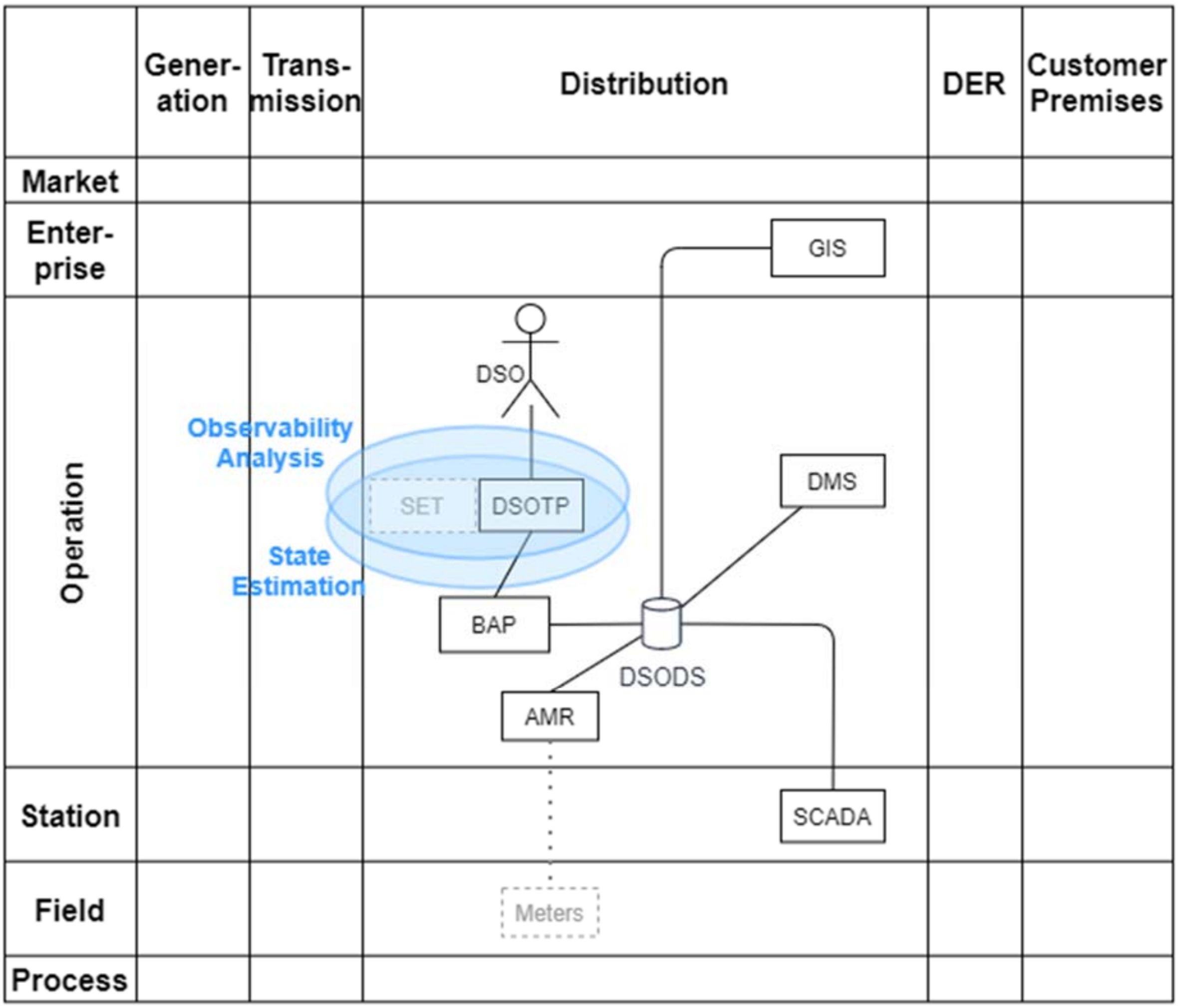



Figure 43: Function Layer for UC-GR-1

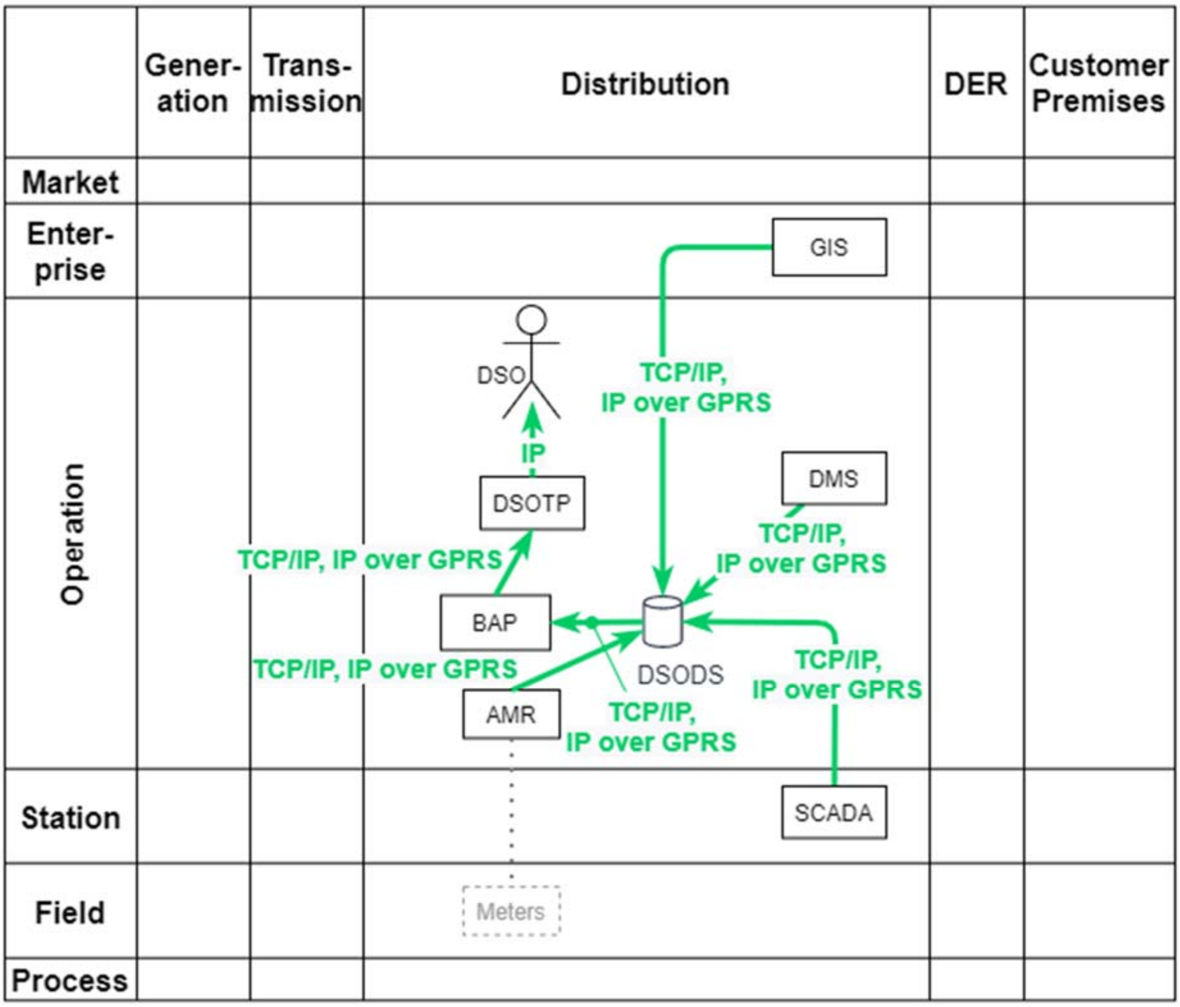



Figure 44: Communication Layer for UC-GR-1

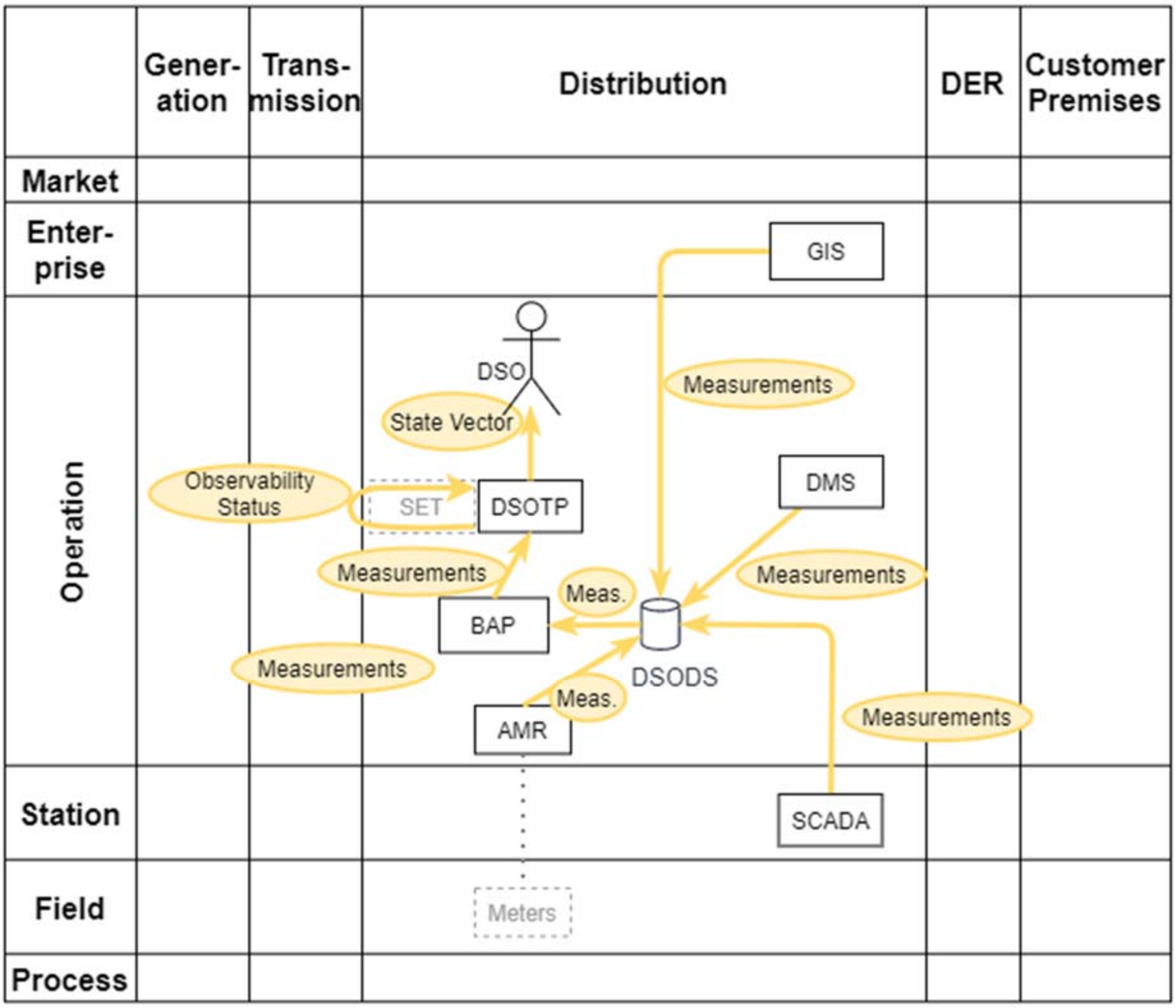



Figure 45: Information Layer for UC-GR-1

### C.1.2.2 UC GR-2: PMU data integration into SE tool

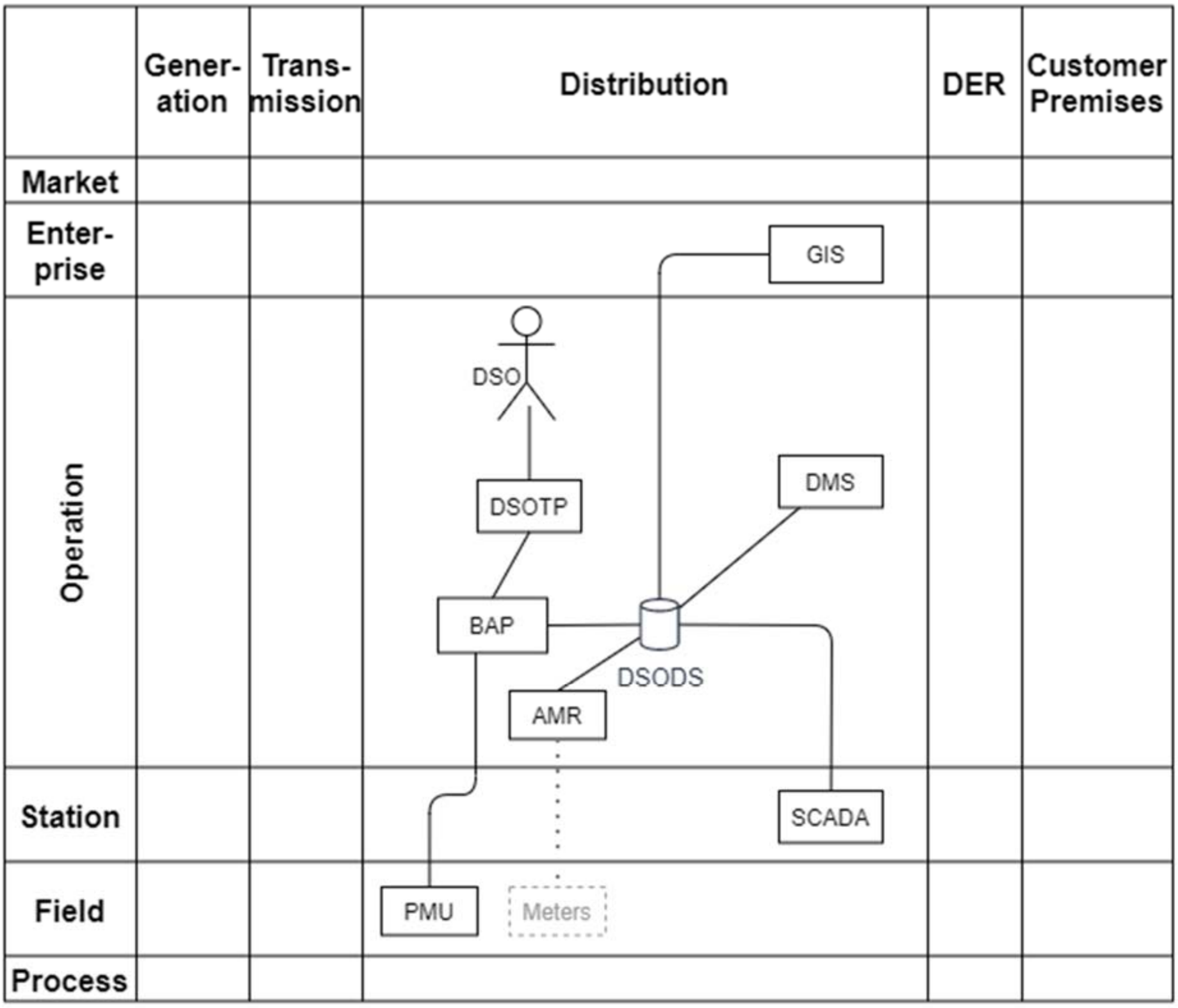



Figure 46: Component Layer for UC-GR-2

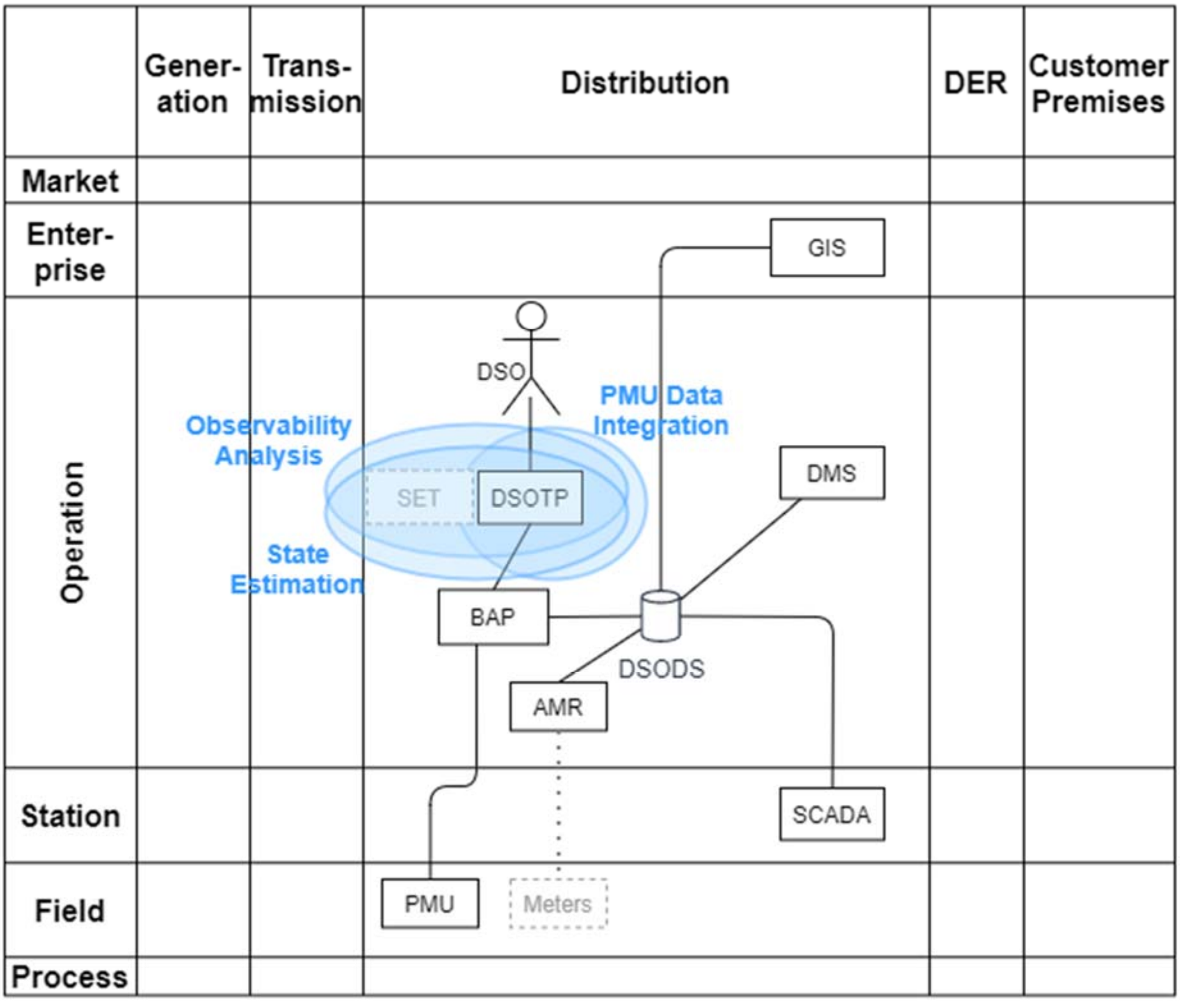



Figure 47: Function Layer for UC-GR-2

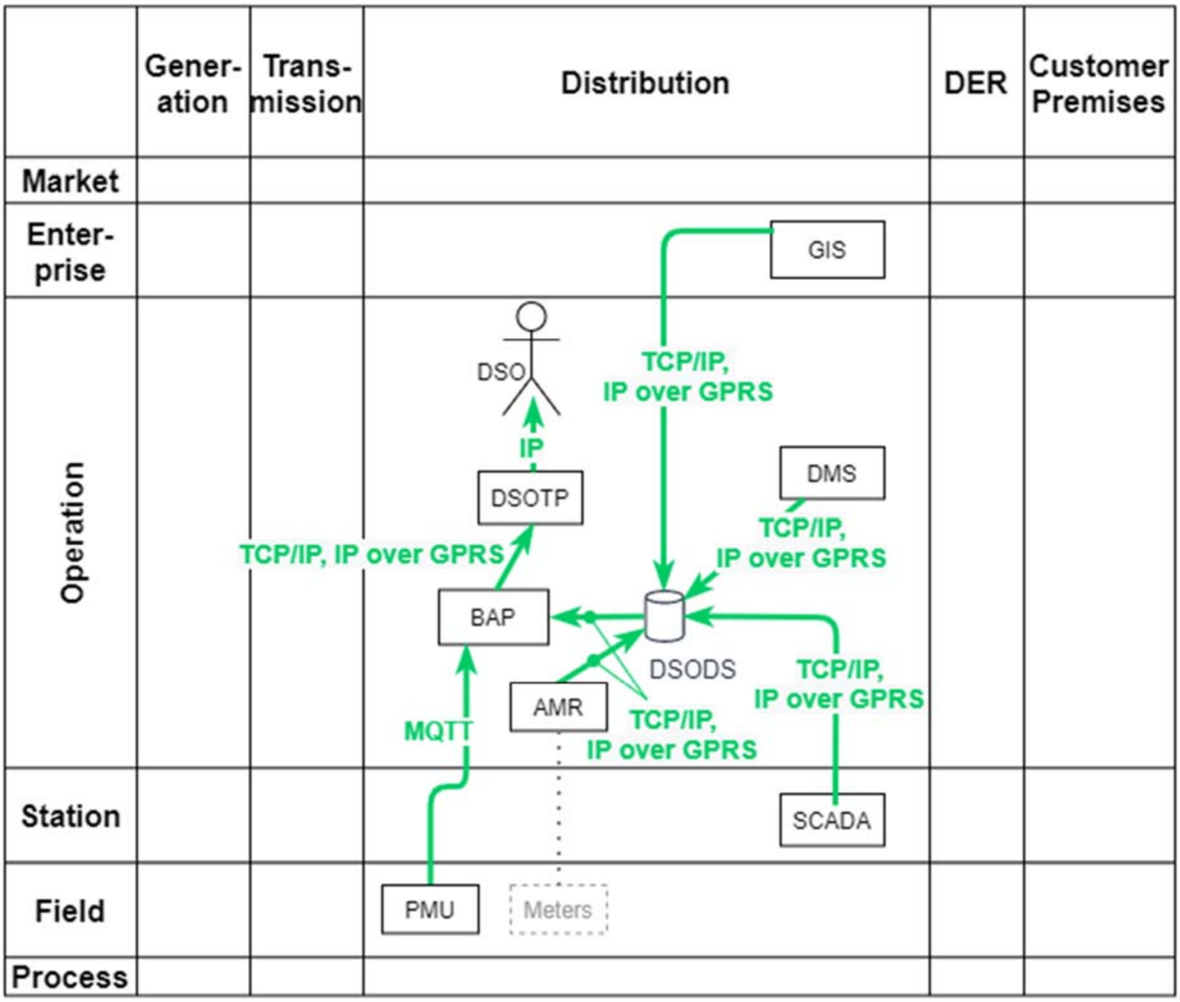



Figure 48: Communication Layer for UC-GR-2

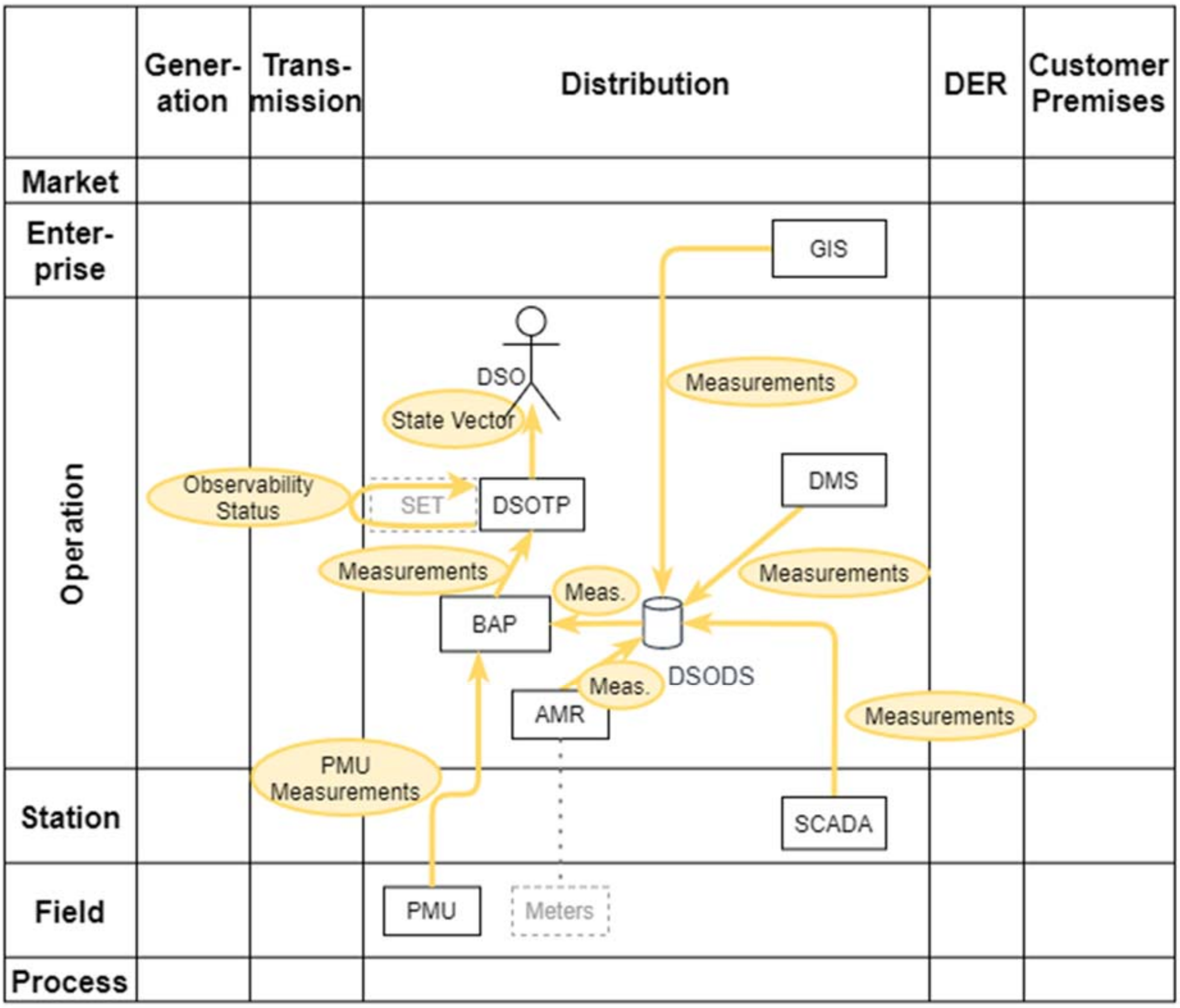



Figure 49: Information Layer for UC-GR-2

### C.1.2.3 UC GR-3: Distribution Network limit violation mitigation

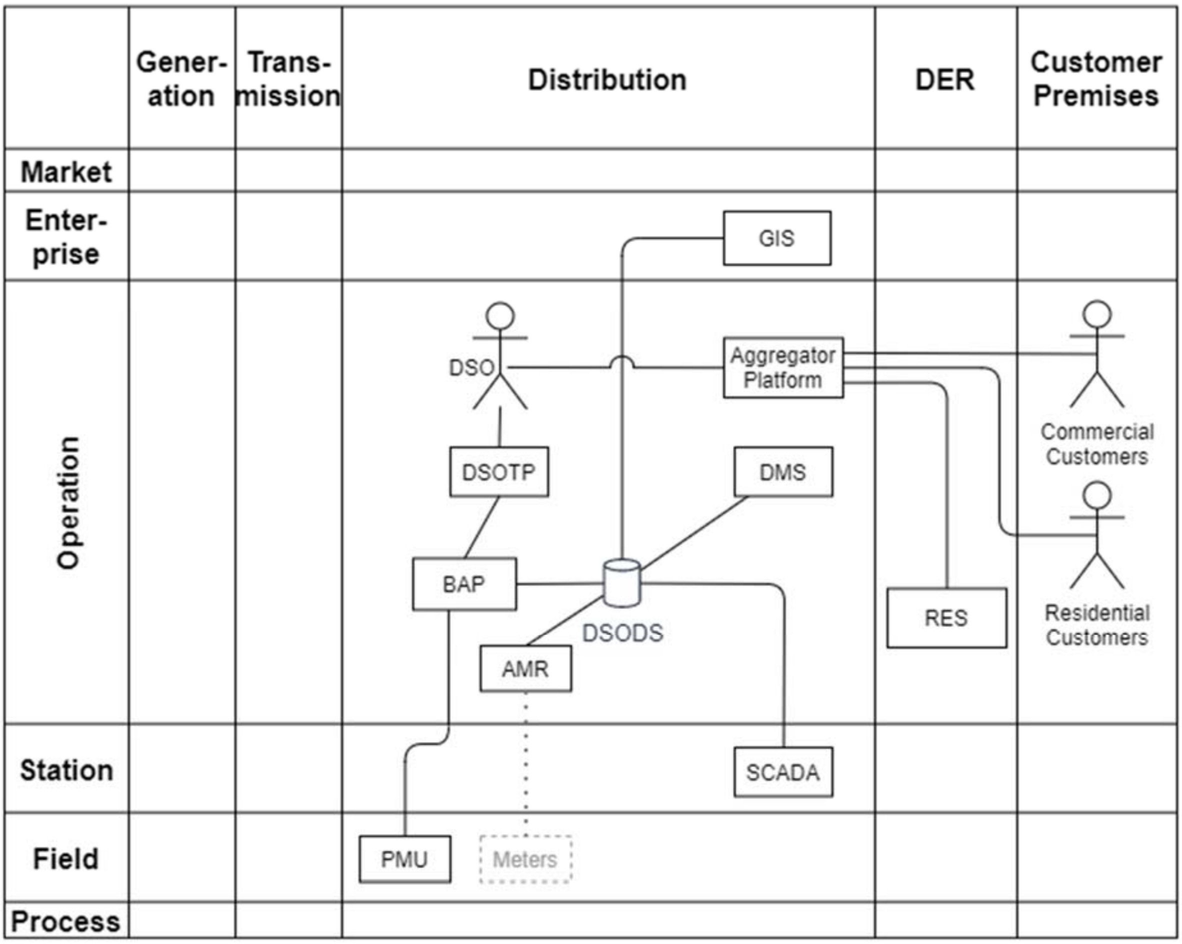



Figure 50: Component Layer for UC-GR-3

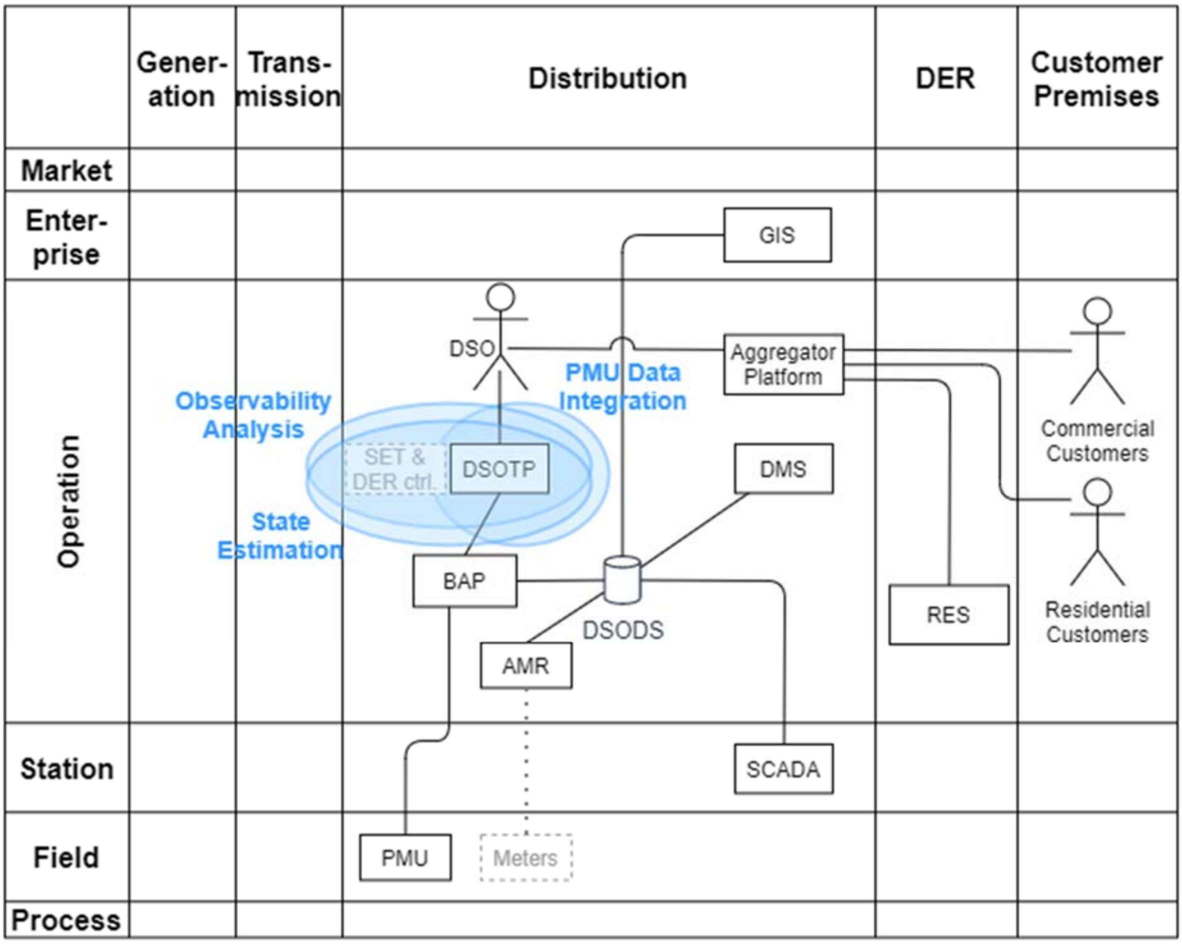



Figure 51: Function Layer for UC-GR-3

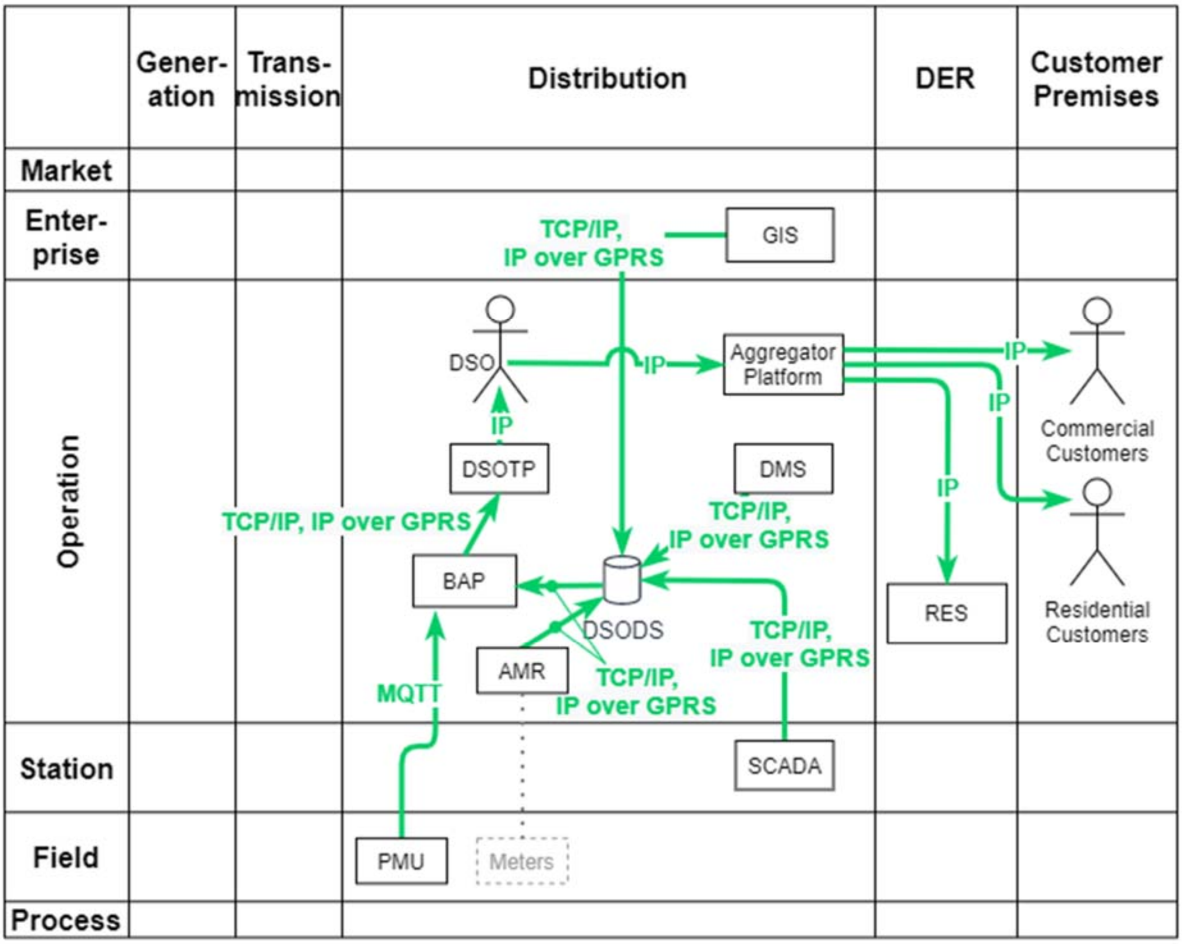



Figure 52: Communication Layer for UC-GR-3

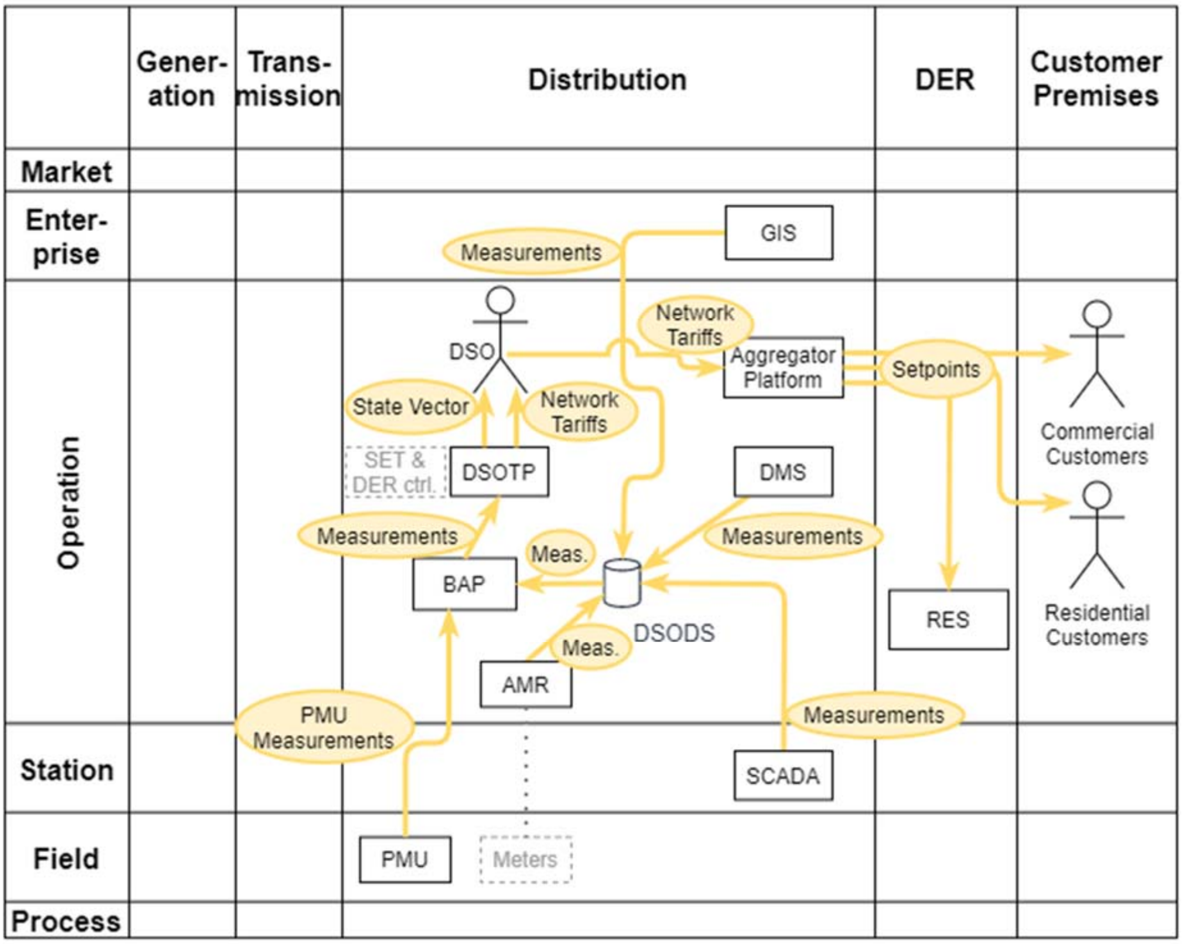



Figure 53: Information Layer for UC-GR-3

### C.1.2.4 UC GR-4: Frequency support by the distribution network

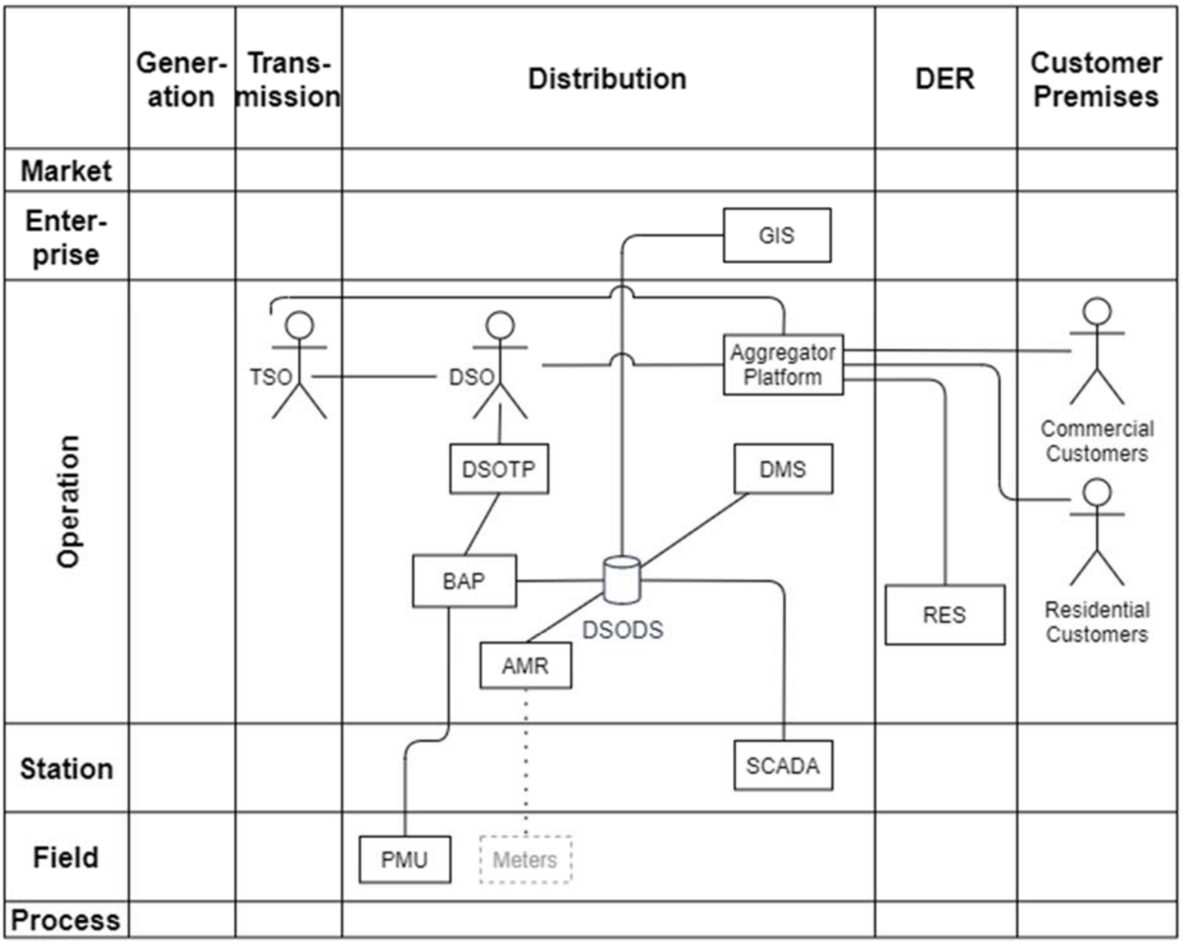



Figure 54: Component Layer for UC-GR-4

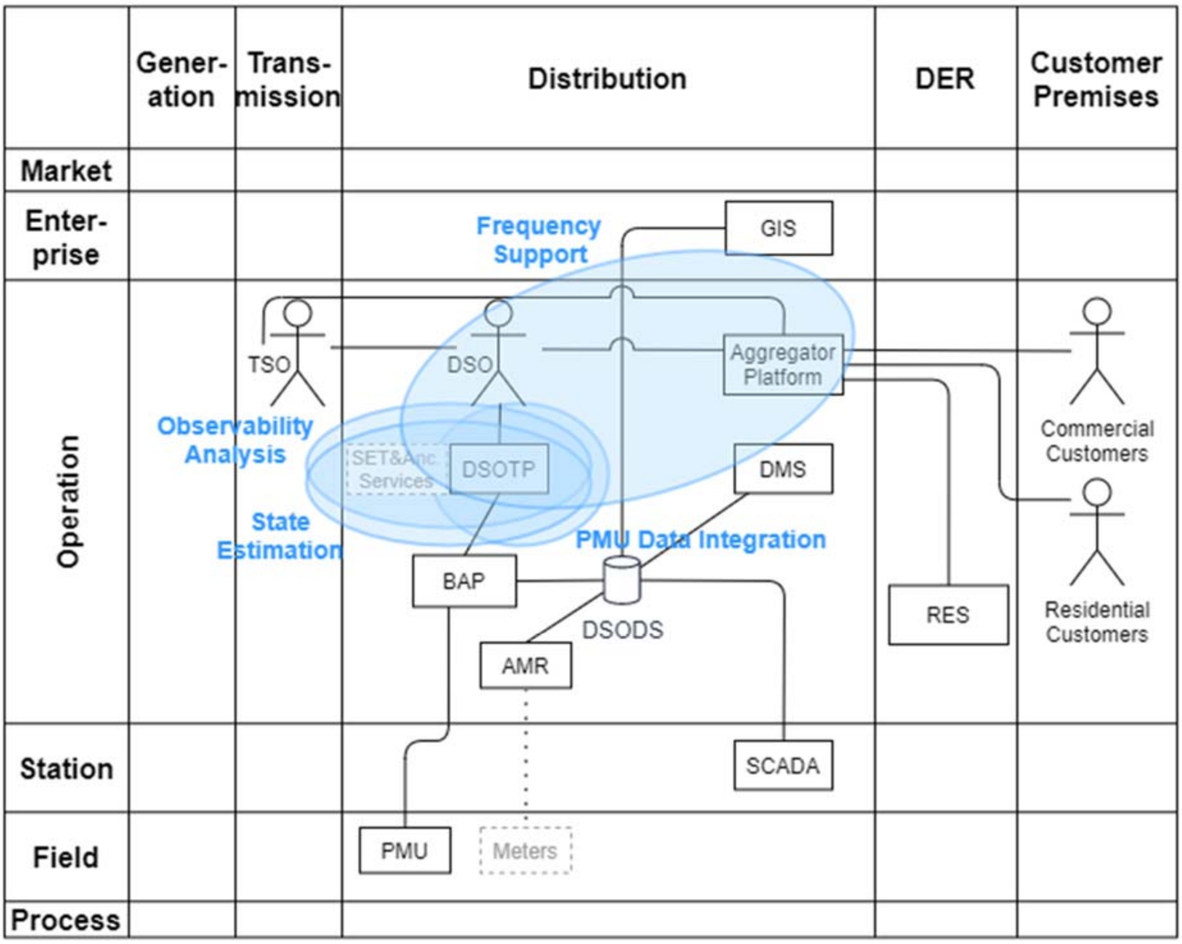



Figure 55: Function Layer for UC-GR-4

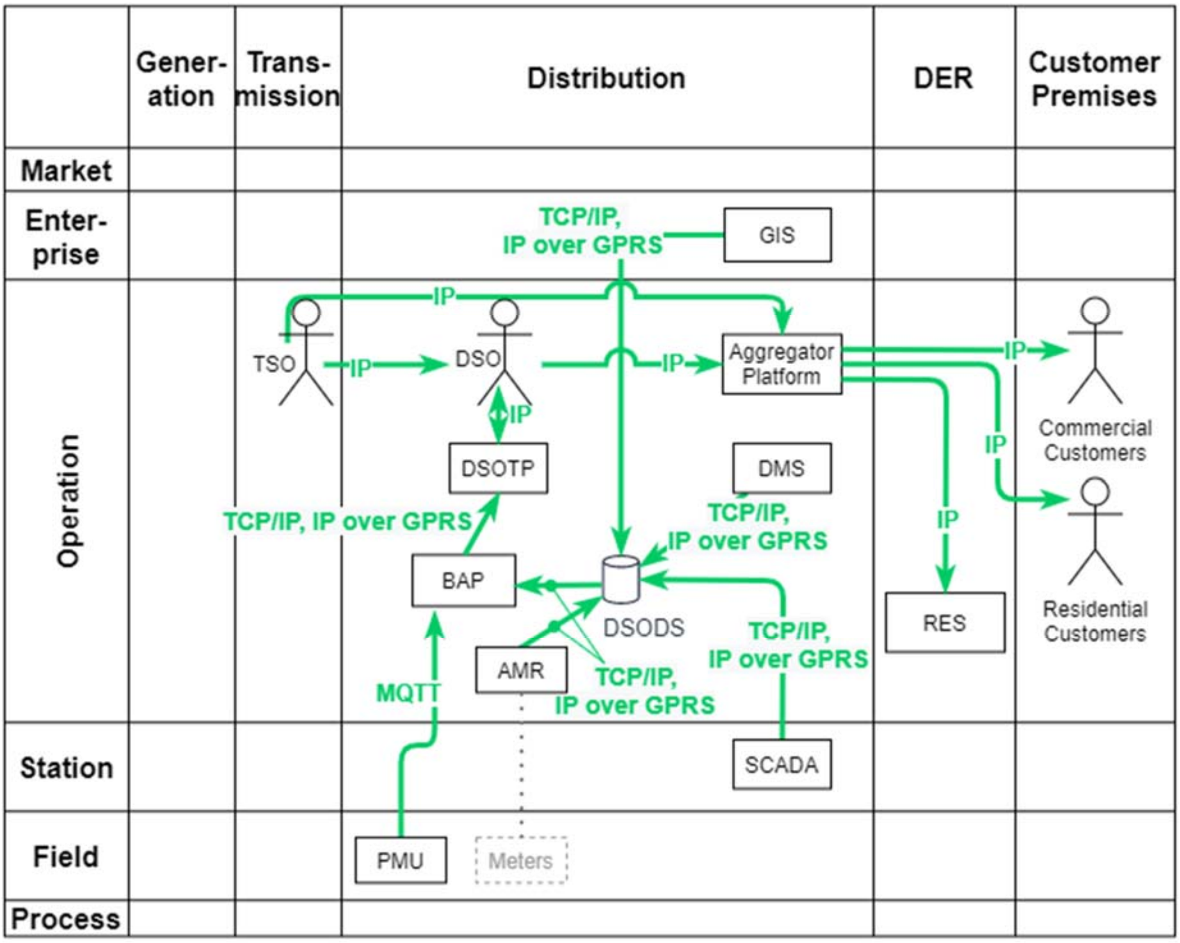



Figure 56: Communication Layer for UC-GR-4

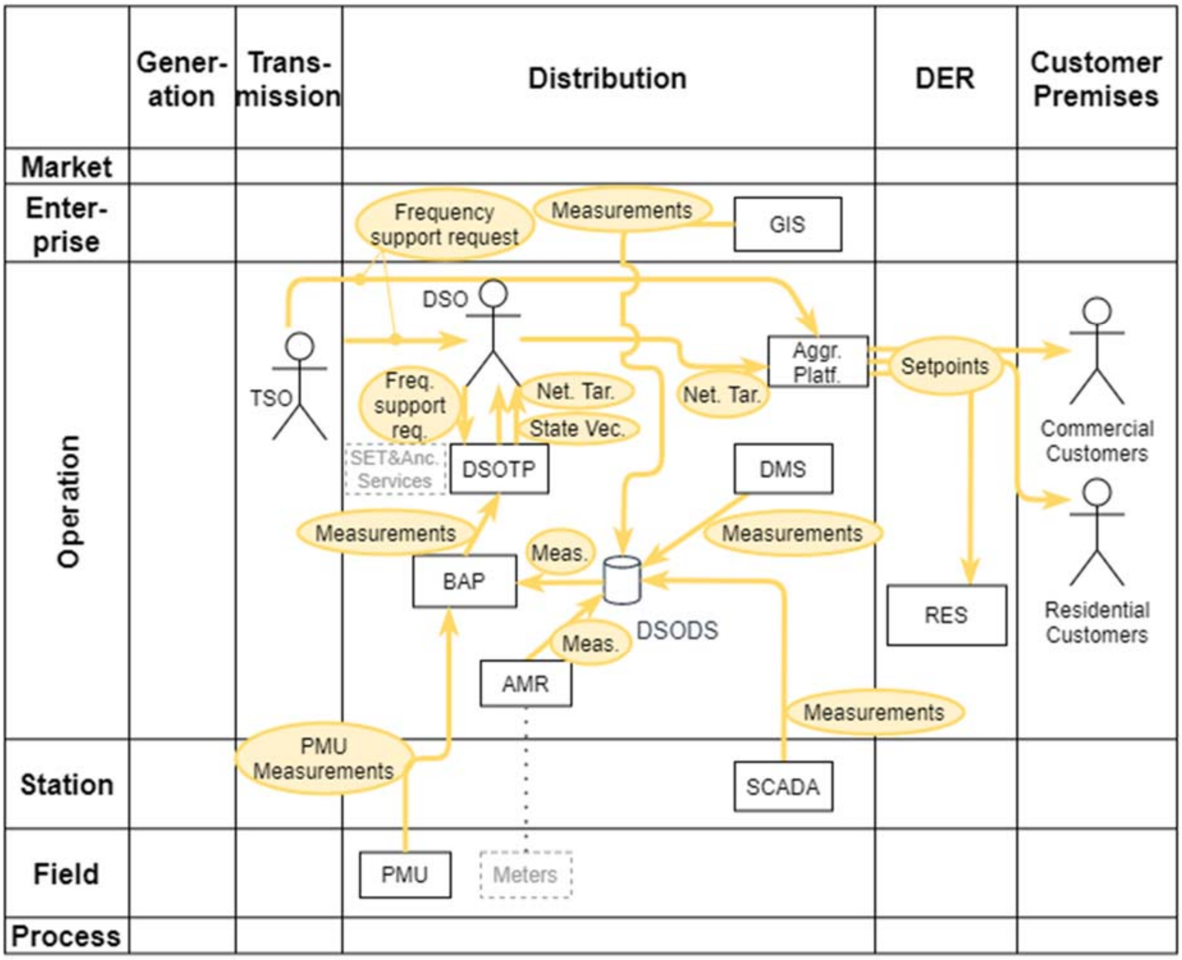



Figure 57: Information Layer for UC-GR-4

### C.1.2.5 UC GR-5: PMU integration and Data Visualization for Flexibility Services

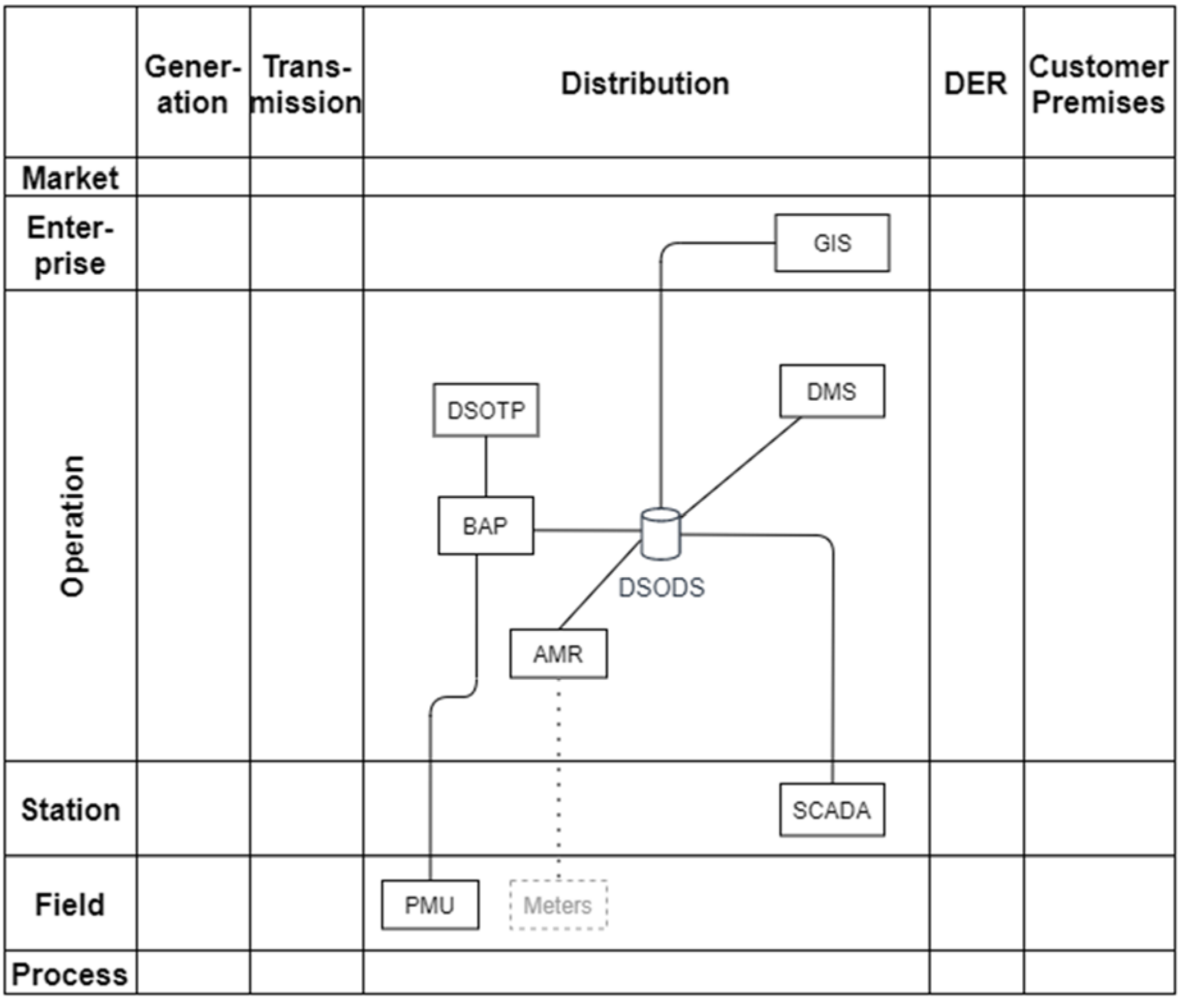



Figure 58: Component Layer for UC-GR-5

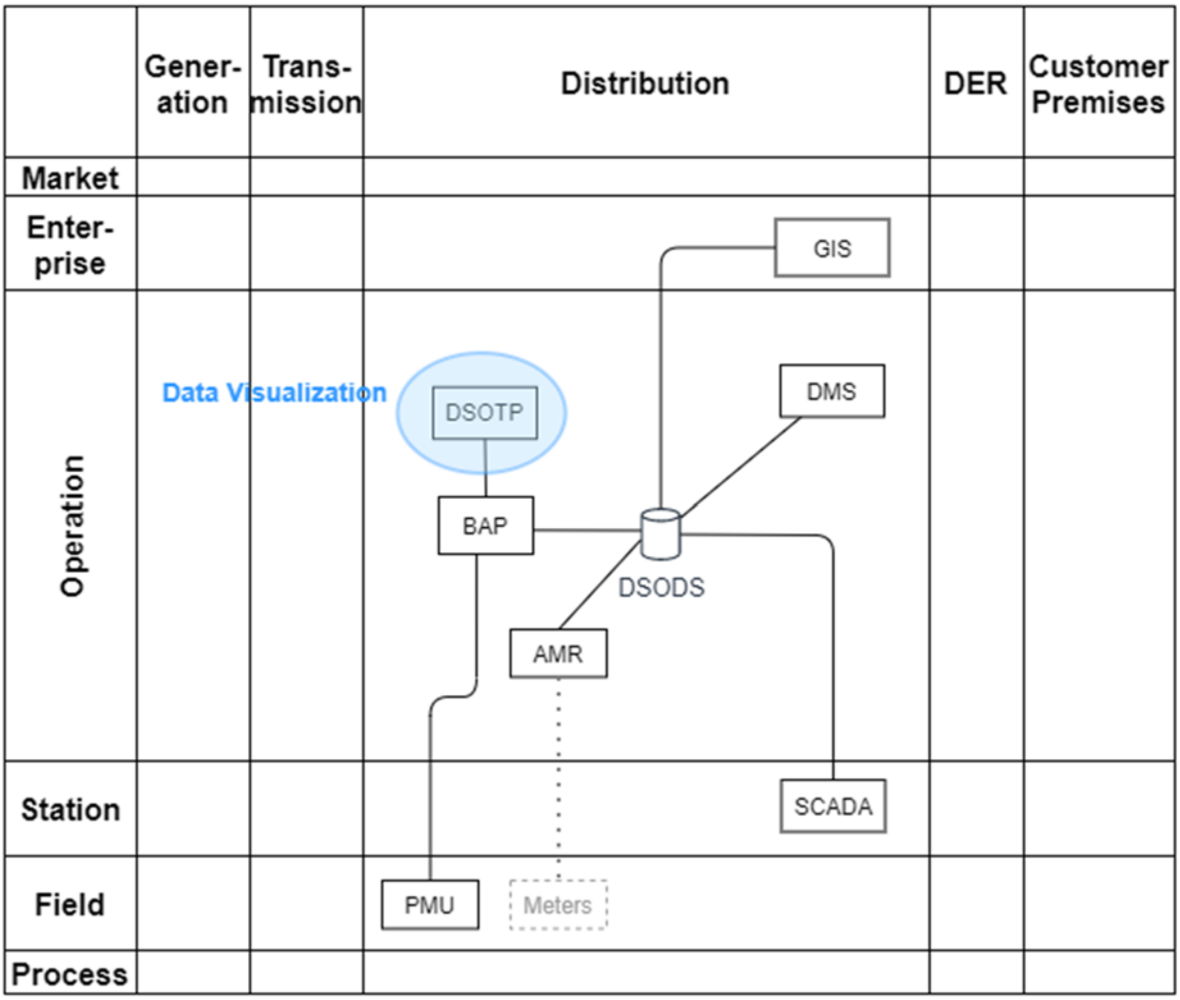



Figure 59: Function Layer for UC-GR-5

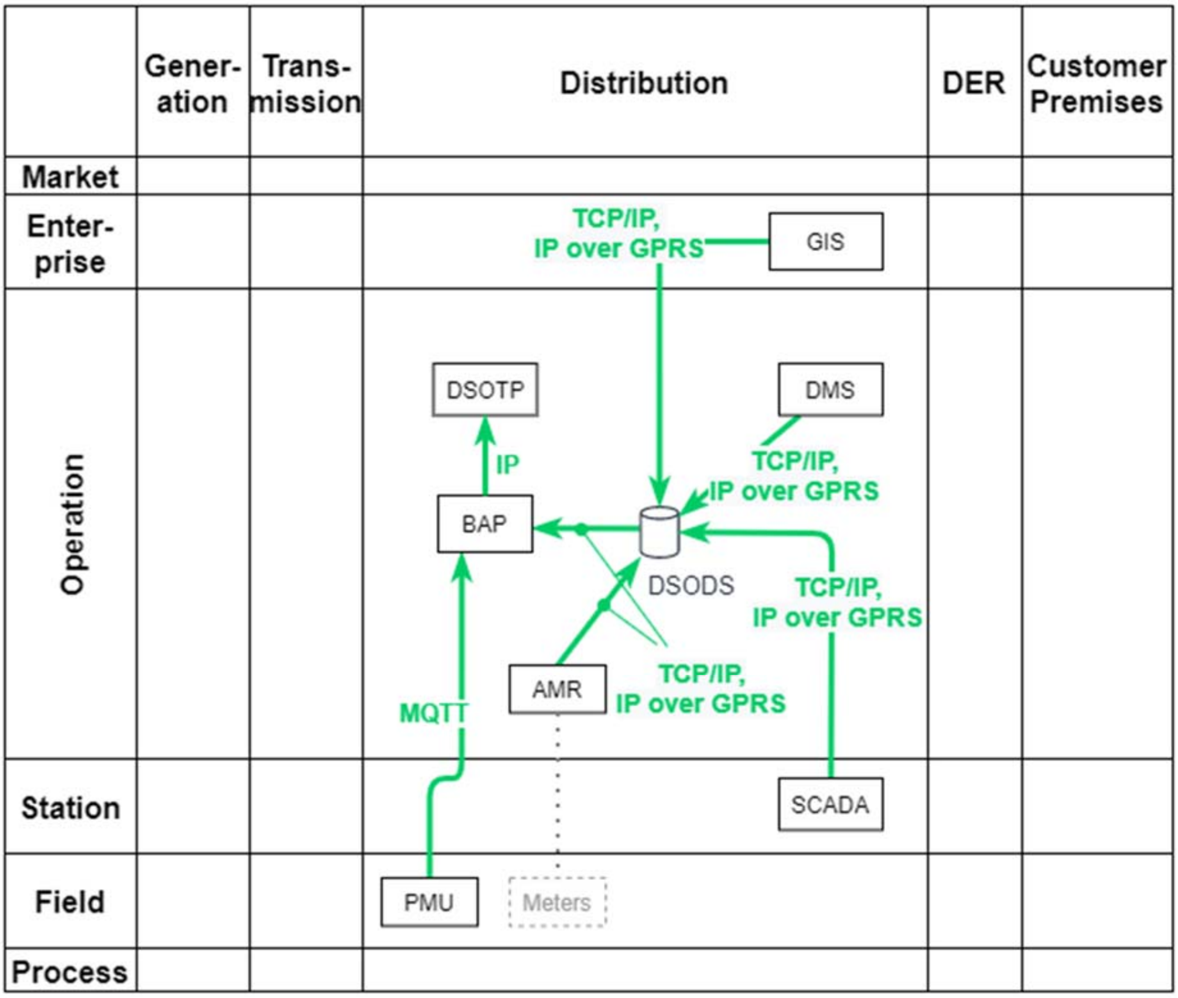



Figure 60: Communication Layer for UC-GR-5

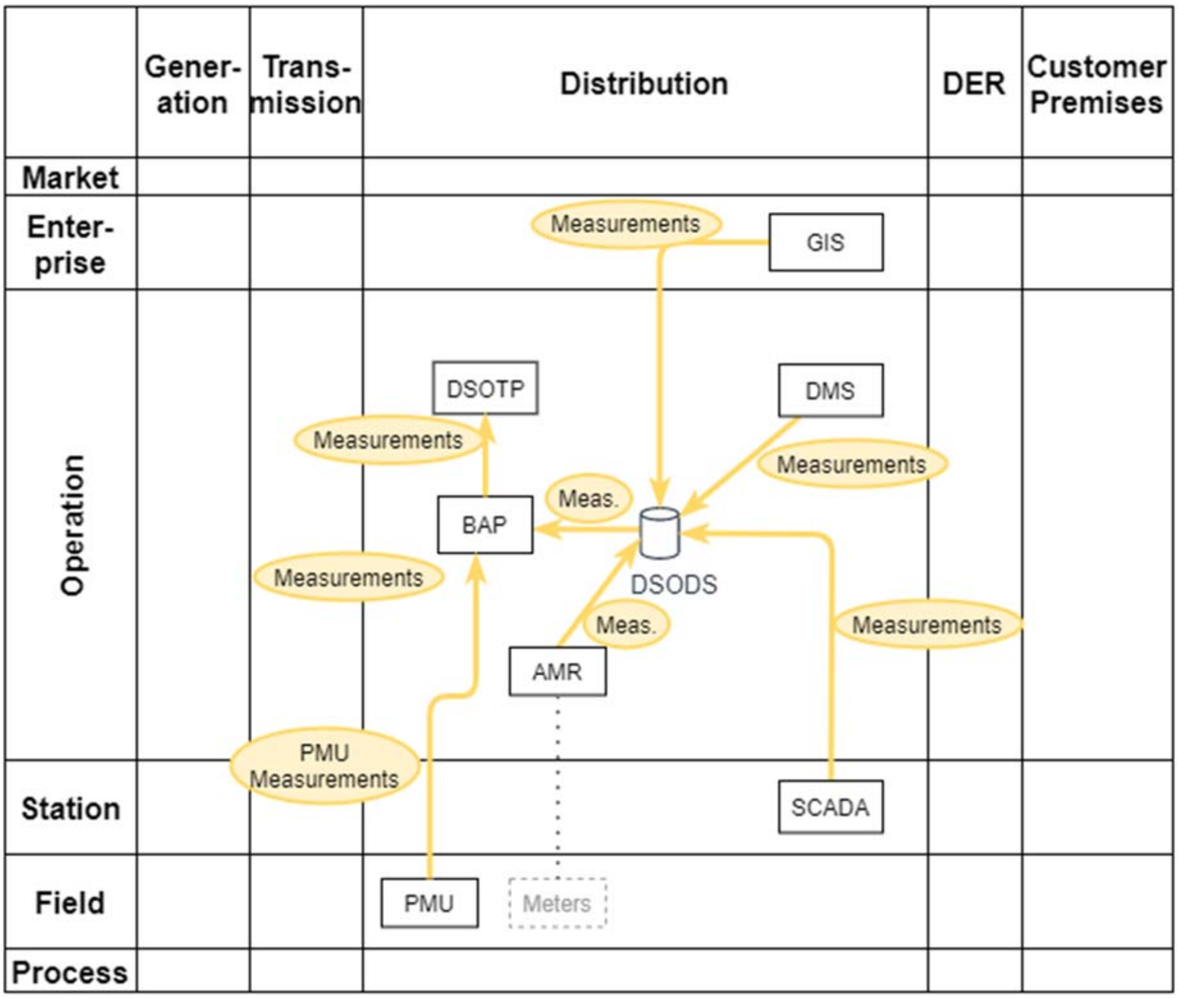



Figure 61: Information Layer for UC-GR-5

### C.1.3 German Demo UC-level SGAM Analysis

The similarity of German UC-1, UC-2, UC-3 and UC-4 means that a single diagram covers these UCs in the Component, Function, Communication and Information Layers.

#### C.1.3.1 Component Layer

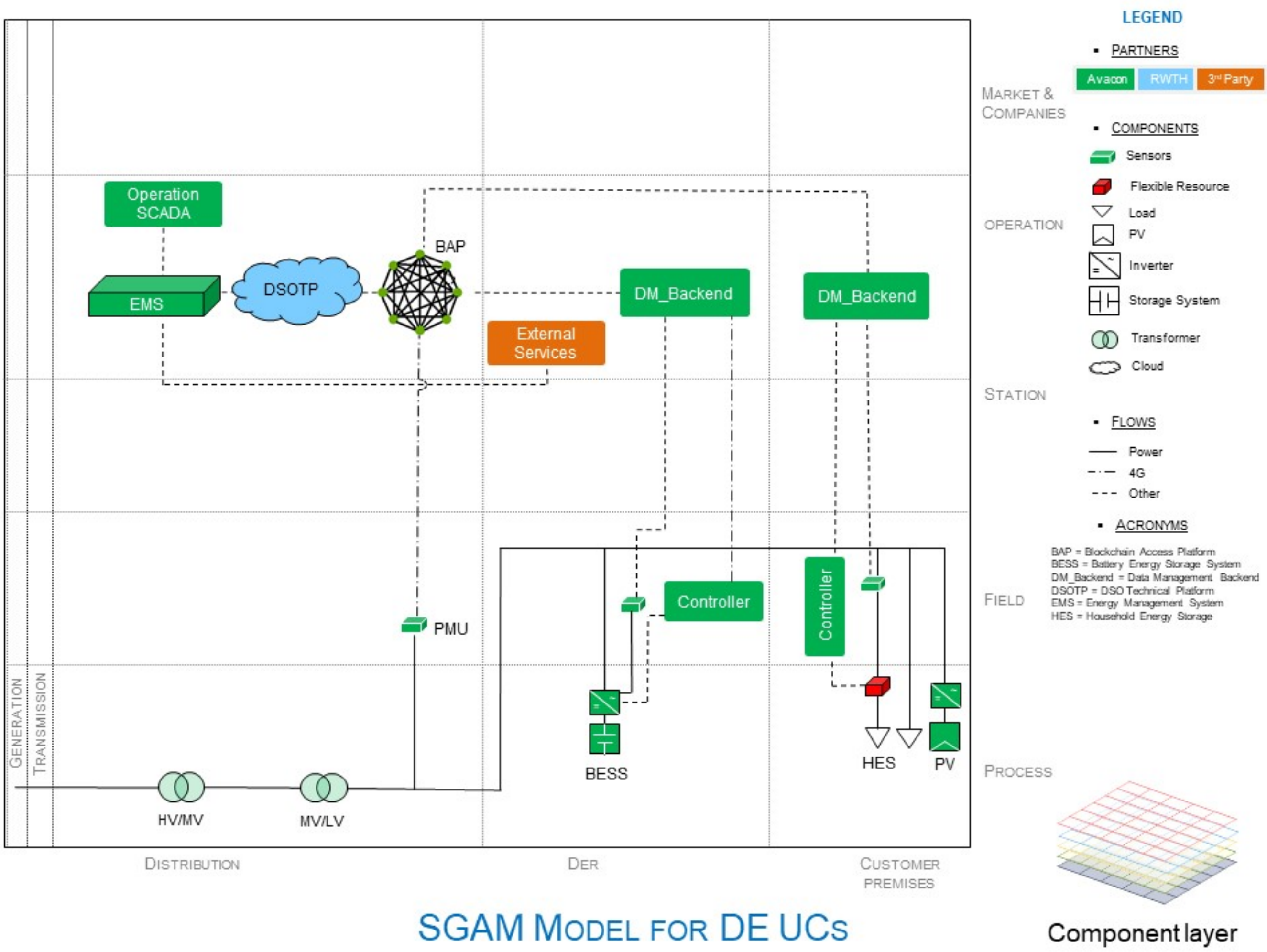



Figure 62: German Demo Component Layer for UC-DE-1-4

### C.1.3.2 Function Layer

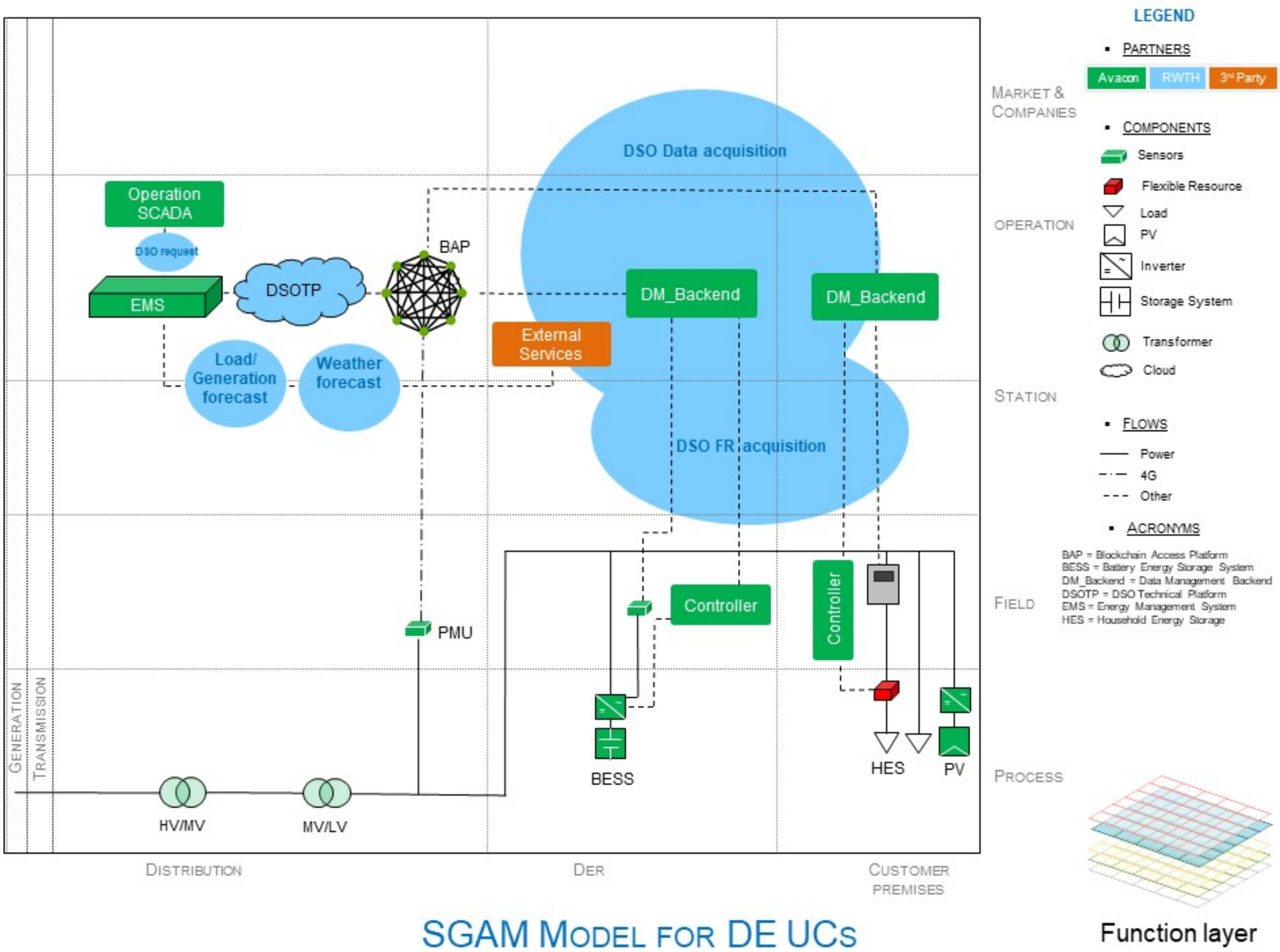



Figure 63: German Demo Function Layer for UC-DE-1-4

### C.1.3.3 Communication Layer

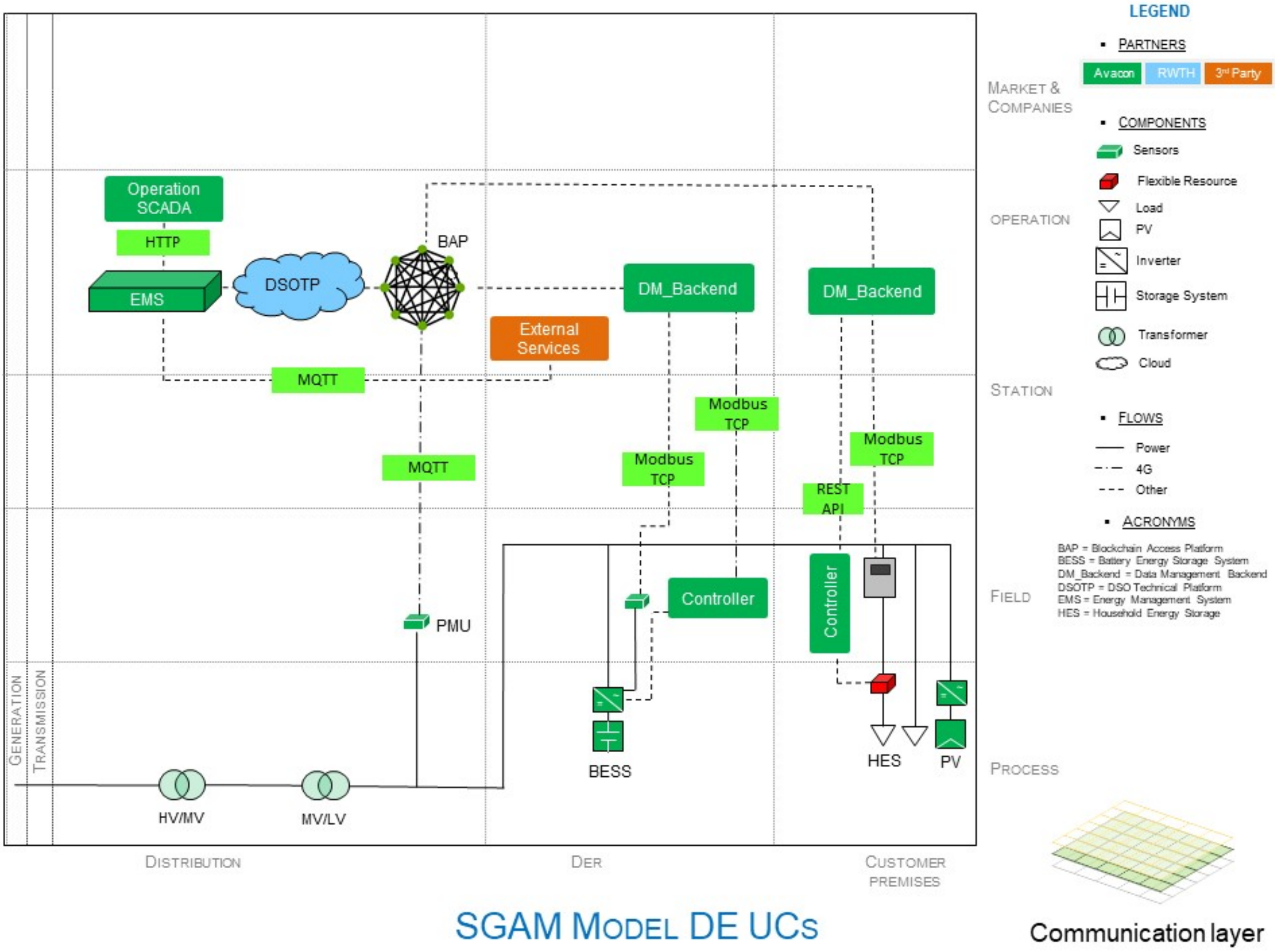



Figure 64: German Demo Communication Layer for UC-DE-1-4

### C.1.3.4 Information Layer

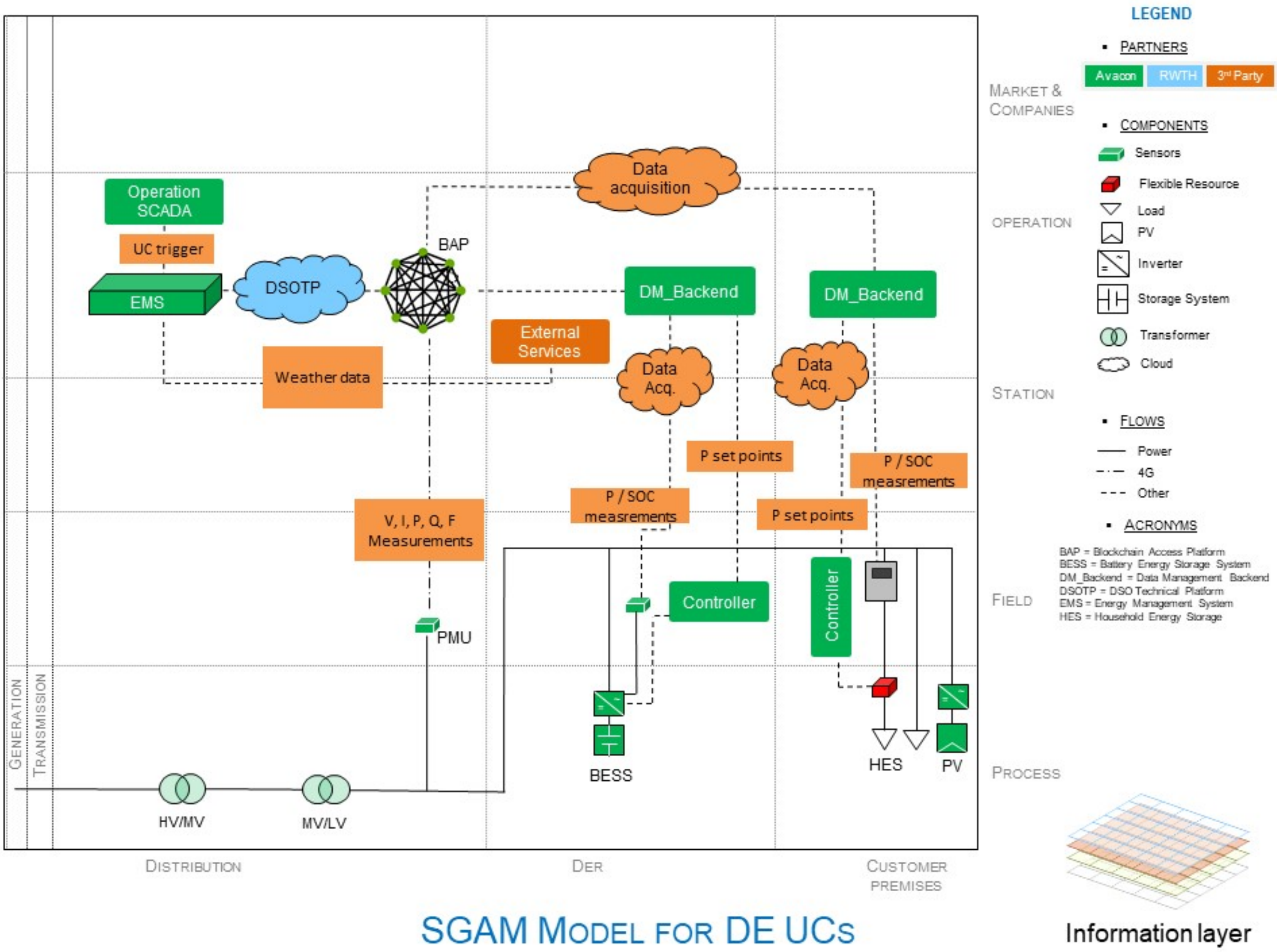



Figure 65: German Demo Information Layer for UC-DE-1-4