System architecture definition

Deliverable D1.2

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Deliverable D1.2
System architecture definition

Organisation: Trialog

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WORK PACKAGE N° 1

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R	Document, report (excluding the periodic and final reports)	X
DEC	Demonstrator, pilot, prototype, plan designs	
DEM	Websites, patents filing, press & media actions, videos, etc.	
O	Software, technical diagram, etc.	

Dissemination level		
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CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

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More information on the project can be found at https://www.maesha.eu

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EXECUTIVE SUMMARY

The goal of this document is to present the system architecture of the MAESHA solution. A generic architecture of the solution as well as specific architectures for each use case are described, using the Smart Grid Architecture Model defined by CEN, CENELEC and ETSI. The document also presents the methodology used to design those architectures.

The document is thus organized in two main sections:

- A presentation of the Smart Grid Architecture Model as well as the methodology followed in MAESHA
- The description of the generic and specific architecture of the MAESHA solution

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NOTATIONS, ABBREVIATIONS AND ACRONYMS

Table 1: Acronyms

Acronyms	
AGC	Automatic Gain Control
BESS	Battery Energy Storage System
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
DER	Distributed Energy Resource
DMS	Distribution Management System
DSO	Distribution System Operator
EDM	Electricité De Mayotte
EMS	Energy Management System
ETSI	European Telecommunications Standards Institute
EU	European Union
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCR	Frequency Containment Reserve
FMTP	Flexibility Management and Trading Platform
FRR	Frequency Restoration Reserve
IEC	International Electrotechnical Commission
LEC	Local Energy Community
KPI	Key Performance Indicator
LEC	Local Energy Community

LV	Low Voltage
MV	Medium Voltage
P2H	Power to Hydrogen
P2H2P	Power to Hydrogen to Power
PV	Photovoltaic
RE	Renewable Energy
RES	Renewable Energy Source
SCADA	Supervisory Control and Data Acquisition
SGAM	Smart Grid Architecture Model
SO	System Operator
TSO	Transmission System Operator
UC	Use Case
V2G	Vehicle-to-Grid
VPP	Virtual Power Plant

1. Introduction

1.1. Scope of the document

The goal of this document is to present the system architecture of the MAESHA solution: a generic architecture of the solution, as well as specific architecture for each of the five selected use cases to demonstrate in MAESHA (see Deliverable 1.1 to be submitted in October 2021).

To describe the system architecture of the MAESHA solution, we rely on the Smart Grid Architecture Model defined by the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI), a Reference Architecture further described in the document.

1.2. About MAESHA

There are more than 2 200 inhabited islands in the European Union, many of which depend on expensive fossil fuel imports for their energy supply. The large-scale deployment of local renewable energy sources and storage systems would contribute to decarbonizing the energy system. However, this endeavor requires flexible solutions, new tools and efficient frameworks that can be adapted to local needs. The EU-funded MAESHA project will develop smart and flexible methods of storage and energy management as well as modelling tools and technical systems with the aim of promoting the transition towards sustainable energy. Designed with respect to the interests of the local communities, adapted to the market and ready to be disseminated, the new approaches will serve as a demonstration for the future decarbonization of Mayotte and other European islands.

2. System architecture definition methodology

To define the system architecture of MAESHA, we decided to rely on Reference Architectures. The primary purpose of a reference architecture is indeed to guide and constrain the instantiation of solution architectures. It also provides a common vocabulary for various stakeholders, reusable designs and best practices that are used as a constraint for more concrete architectures. And it encourages adherence to common standards, specifications and patterns to push interoperability, which is a primary requirement in MAESHA, as it will experiment a wide range of flexibility and energy management solutions.

In the Smart Energy domain, the most used Reference Architecture is the Smart Grid Architecture Model, defined by CEN, CENELEC and ESTI and further described below. It has been selected for the MAESHA project as it provides a complete view gathering different viewpoints:

- The Conceptual architecture: a high-level presentation of the major stakeholders or the major (business) domains in the system and their interactions
- The Functional architecture: an arrangement of functions and interfaces (internal and external) that defines the execution sequencing, the conditions for control or data flow
- The Communication architecture: a specialization of the functional architecture, focusing on the connectivity between interfaces
- The Information architecture: an abstract but formal representation of entities including their properties, relationships and the operations that can be performed on them.

2.1. Smart Grid Architecture Model (SGAM)

The SGAM (Smart Grid Architecture Model) is a unified standard for smart grid use-case and architecture design. It aims to give a global view of a Smart Grid system by mapping its different actors and devices on a *Smart Grid Plane* subdivided in *Domains* and *Zones*. An actor's *Domain* specifies its place in the electric energy conversion chain, whereas its *Zone* provides information on its place in the hierarchy of power system management.

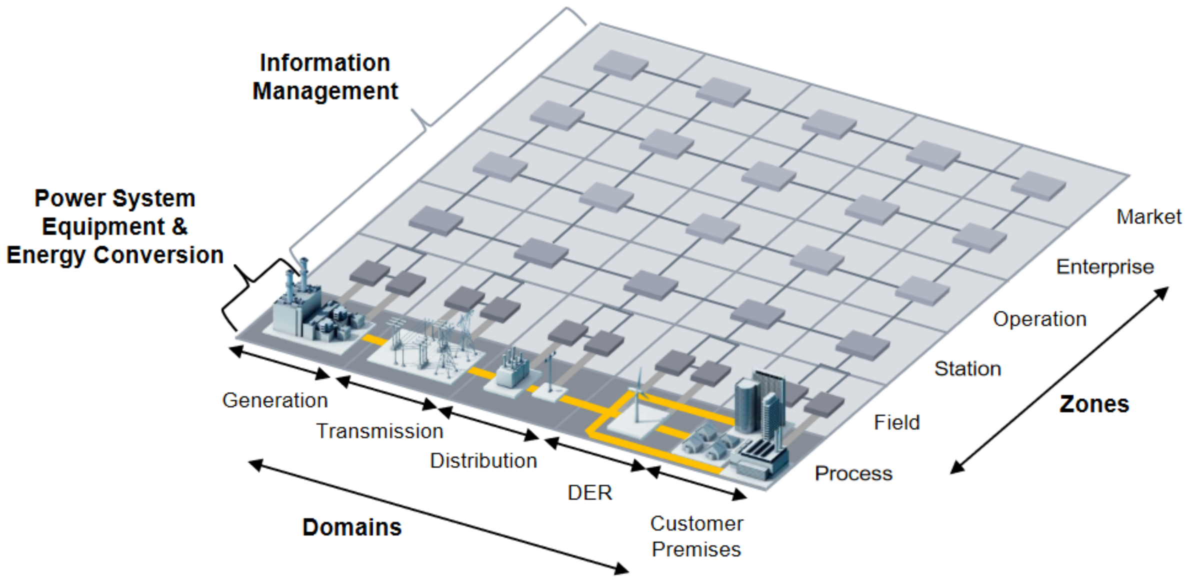

Figure 1: Smart Grid plane – domains and hierarchical zones

The *Domains* are described as follow:

- Bulk Generation: Representing generation of electrical energy in bulk quantities, such as by fossil, nuclear and hydro power plants, off-shore wind farms, large scale solar power plant (i.e., PV)– typically connected to the transmission system.
- Transmission: Representing the infrastructure and organization which transports electricity over long distances.
- Distribution: Representing the infrastructure and organization which distributes electricity to customers.
- DER (Distributed Energy Resource): Representing distributed electrical resources directly connected to the public distribution grid, applying small-scale power generation technologies (typically in the range of 3 kW to 10.000 kW). These distributed electrical resources may be directly controlled by DSO (Distribution System Operator).
- Customer Premises: Hosting both - end users of electricity, also producers of electricity. The premises include industrial, commercial and home facilities (e.g., chemical plants, airports, harbours, shopping centres, homes). Also, generation in the form of e.g., photovoltaic generation, electric vehicles storage, batteries, micro turbines... are hosted.

The *Zones* are defined as follow:

- Process: Including the physical, chemical or spatial transformations of energy (electricity, solar, heat, water, wind ...) and the physical equipment directly involved. (e.g., generators, transformers, circuit breakers, overhead lines, cables, electrical loads any kind of sensors and actuators which are part or directly connected to the process...).
- Field: Including equipment to protect, control and monitor the process of the power system, e.g., protection relays, bay controller, any kind of intelligent electronic devices which acquire and use process data from the power system.
- Station: Representing the areal aggregation level for field level, e.g., for data concentration, functional aggregation, substation automation, local SCADA (Supervisory Control and Data Acquisition) systems, plant supervision...
- Operation: Hosting power system control operation in the respective domain, e.g., distribution management systems (DMS), energy management systems (EMS) in generation and transmission systems, microgrid management systems, virtual power plant management systems (aggregating several DER), electric vehicle (EV) fleet charging management systems.
- Enterprise: Includes commercial and organizational processes, services and infrastructures for enterprises (utilities, service providers, energy traders ...), e.g., asset management, logistics, work force management, staff training, customer relation management, billing and procurement...
- Market: Reflecting the market operations possible along the energy conversion chain, e.g., energy trading, mass market, retail market…

In order to cover interoperability issues of a system, the Smart Grid plane is projected on five layers highlighting different interoperability considerations.

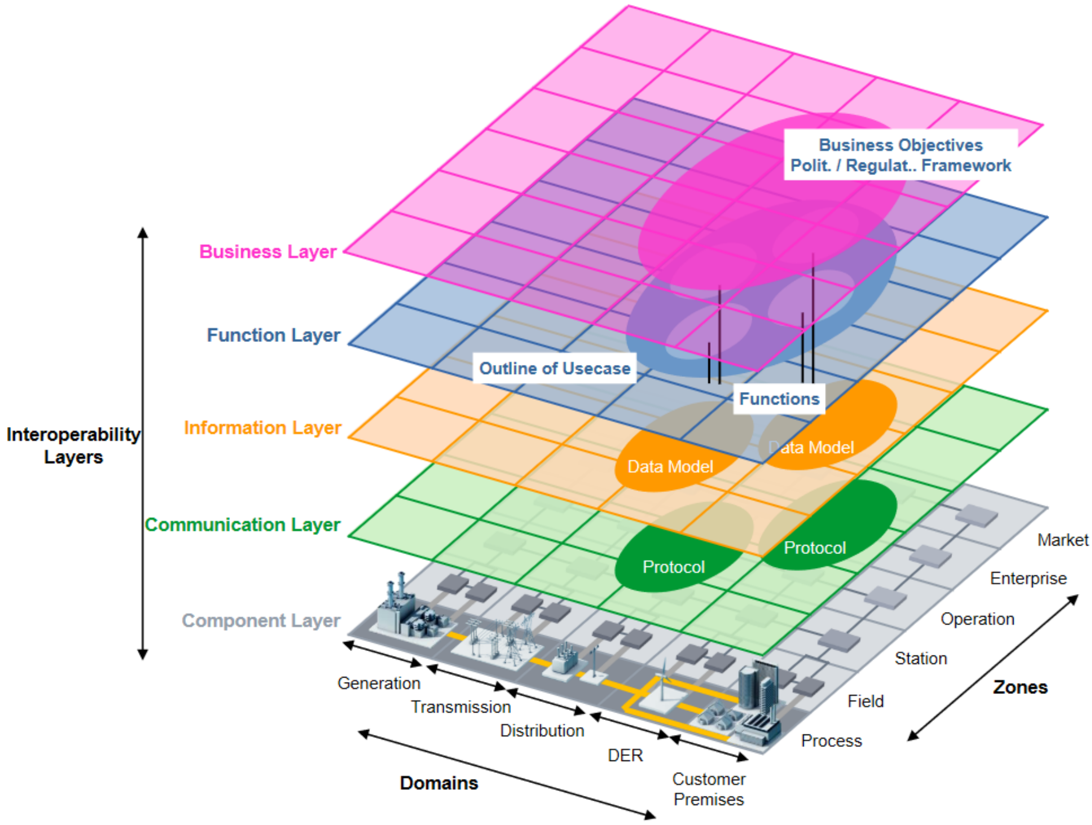

Figure 2: SGAM framework

Each layer can be briefly described as follow:

- Business Layer: The business layer can be used to map regulatory and economic (market) structures and policies, business models, business portfolios (products & services) of market parties involved. Business capabilities and business processes can also be represented in this layer.
- Function Layer: The function layer describes functions and services including their relationships from an architectural viewpoint. The functions are represented independent from actors and physical implementations in applications, systems and components.
- Information Layer: The information layer describes the information that is being used and exchanged between functions, services and components. It contains information objects and the underlying canonical data models.
- Communication Layer: The emphasis of the communication layer is to describe protocols and mechanisms for the interoperable exchange of information between components in the context of the underlying use case, function or service and related information objects or data models.
- Component Layer: The emphasis of the component layer is the physical distribution of all participating components in the smart grid context. This includes system actors, applications, power system equipment (typically located at process and field level), protection and tele-control devices, network infrastructure (wired / wireless communication connections, routers, switches, servers) and any kind of computers.

As such, the SGAM framework allows for the representation of entities and their relationships within a smart grid system while specifying information management hierarchies and with consideration for interoperability aspects.

Within this project, the DISCERN template (see [4]) was used. It provides user-friendly templates and libraries for the conception of SGAMs. The list of objects used in the SGAM component layer is available in ANNEX.

2.2. SGAM METHODOLOGY

In its description of the Smart Grid Reference Architecture (see [1]), CEN, CENELEC and ETSI defined a methodology of the SGAM framework with some principles and guidelines on how to use the SGAM framework. The easiest way to design an architecture is to map the use case to the SGAM framework as depicted in Figure 3 below and as described in this section.

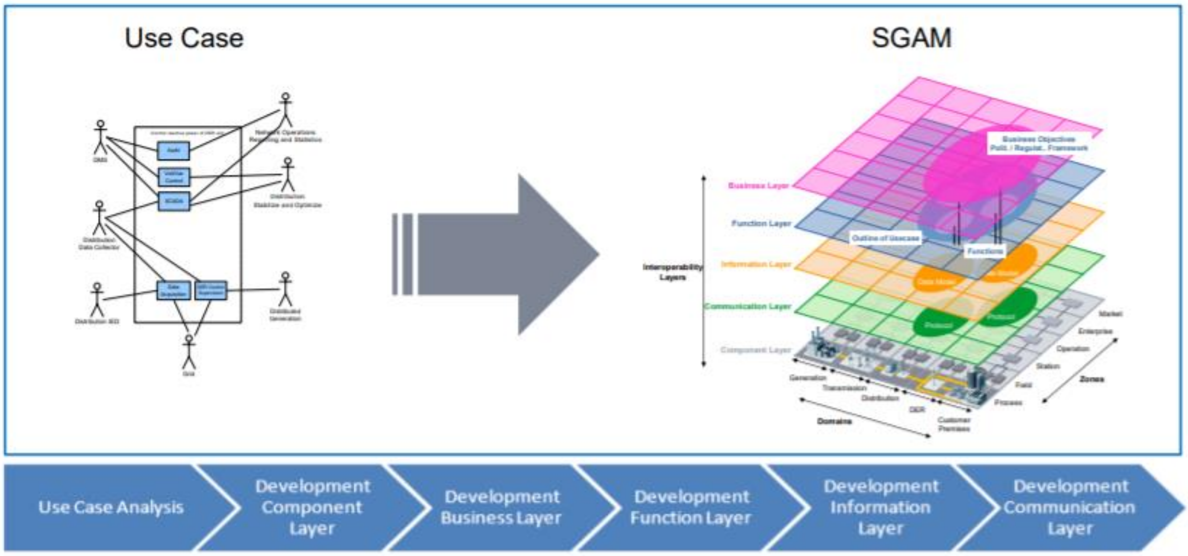

Figure 3: Use case mapping process to SGAM

The starting point is the analysis of the use case to be mapped in order to verify that the use case description provides sufficient information for the mapping. To ensure a complete description, the use of the IEC 62559-2 template is recommended as it provides the required information (see Figure 4 below).

The SGAM Component layer is developed by considering the use case information on actors (section 3.1 of the template). As actors can be of type devices, applications, persons and organizations, these can be associated to the relevant domain and hierarchical zone.

The SGAM Business layer is intended to host the business processes, services and organizations which are linked to the use case. Business objectives, Key Performance Indicators (KPIs), economic and regulatory constraints underlying the use case can also be included in the layer.

The SGAM Function layer is intended to represent functions and their interrelations in respect to domains and zones. Use cases are typically composed of a main scenario, representing a sequence of steps. Those steps are usually **activities/processes** performed by an actor or **interactions** between several actors. The functions to represent in the SGAM Function layer are derived from the first type of steps (activities) when formulating them in an abstract and actor-independent way, whereas the interrelations are derived from the second type of steps (interactions).

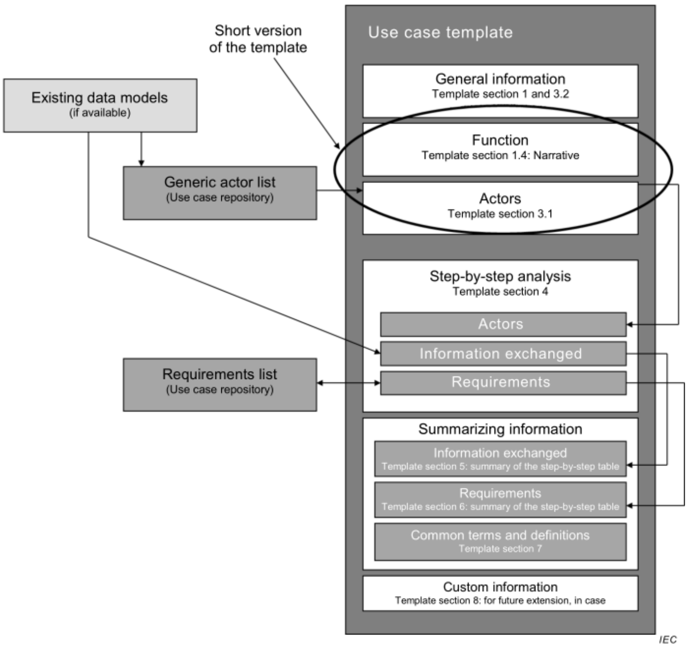

Figure 4: Overview of the IEC 62559-2 template

The SGAM Information layer describes the information that is being used and exchanged between functions, services and components. Latter information is usually found in the step-by-step analysis of the main scenario (section 4 of the template) or in the Information exchanged table, section 5. When information objects are identified, an analysis of available standards is performed to identify the most relevant underlying canonical data models to support the exchange of information objects.

Finally, the emphasis of the SGAM Communication layer is to describe protocols and mechanisms for the interoperable exchange of information between the use case actors. Usually, appropriate protocols are identified on the basis of the canonical data models depicted in the SGAM Information layer.

In MAESHA, five use case-specific architectures were designed – one for each use case described in Deliverable D1.1 (see [3]). Then, an analysis of the commonalities between those five architectures was conducted to define a generic architecture for the MAESHA solution.

3. System Architecture

This section presents the generic architecture of the MAESHA solution as well as the specific architectures for each use case.

3.1 Generic Architecture

The architecture of the MAESHA project aims to integrate several digital solutions – virtual power plant, community self-consumption, industrial energy management, residential energy and flexibility services, smart charging/V2G (Vehicle-to-Grid), hybridization of PV production and EV charging, technologies to provide virtual inertia, battery storage and power to hydrogen - in a way that is technically efficient and takes into account the context of the project. The generic architecture of the solution, described using SGAM, is shown below. Please note that only the Business, Function and Component layers of the generic architecture are described, as the information exchanged between components vary from one use case to another.

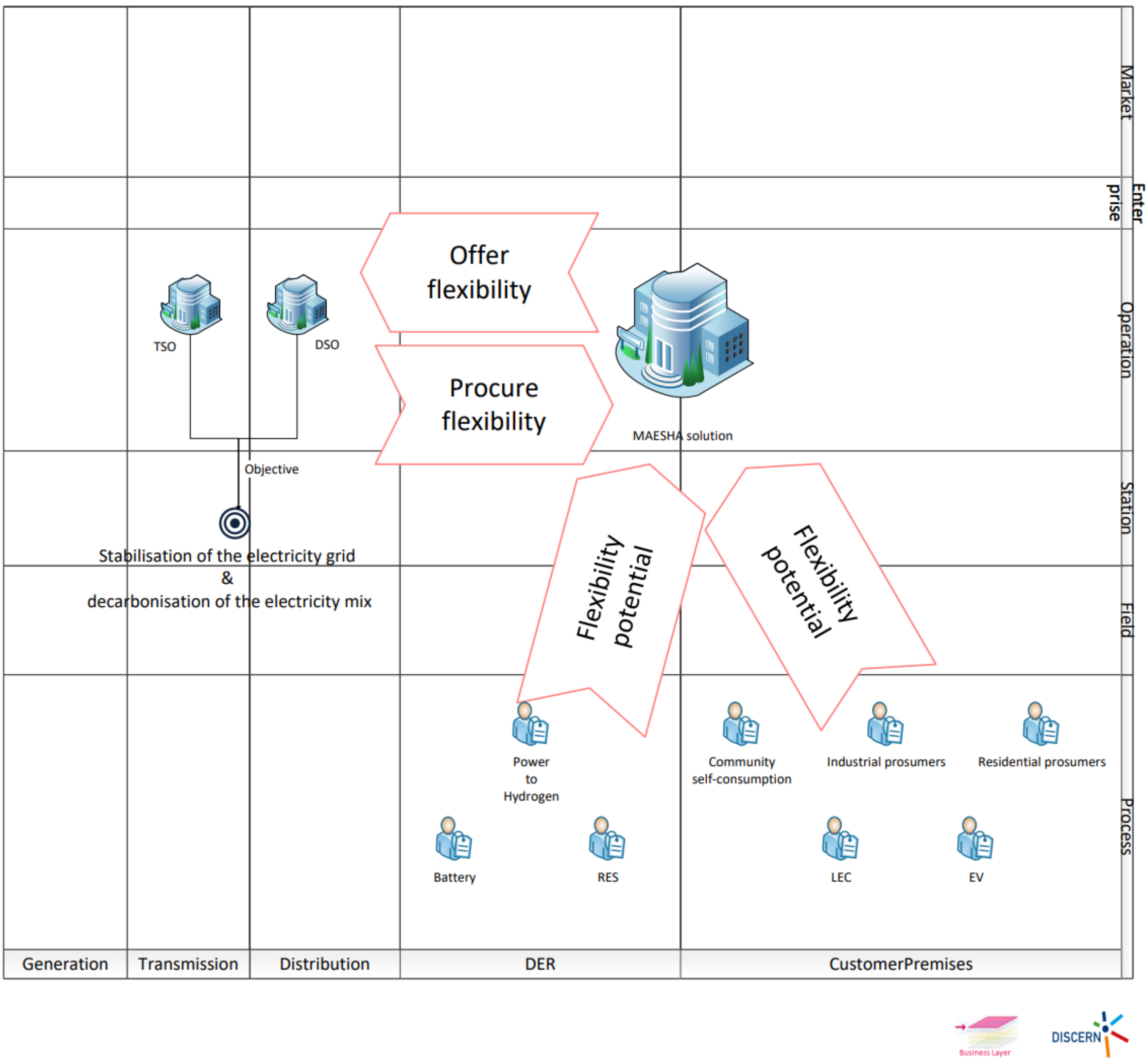

Figure 5: SGAM business layer of the generic architecture

This layer (Figure 5) presents the business actors and organizations involved in the use case, their objectives as well as the business processes that exist to support the use case.

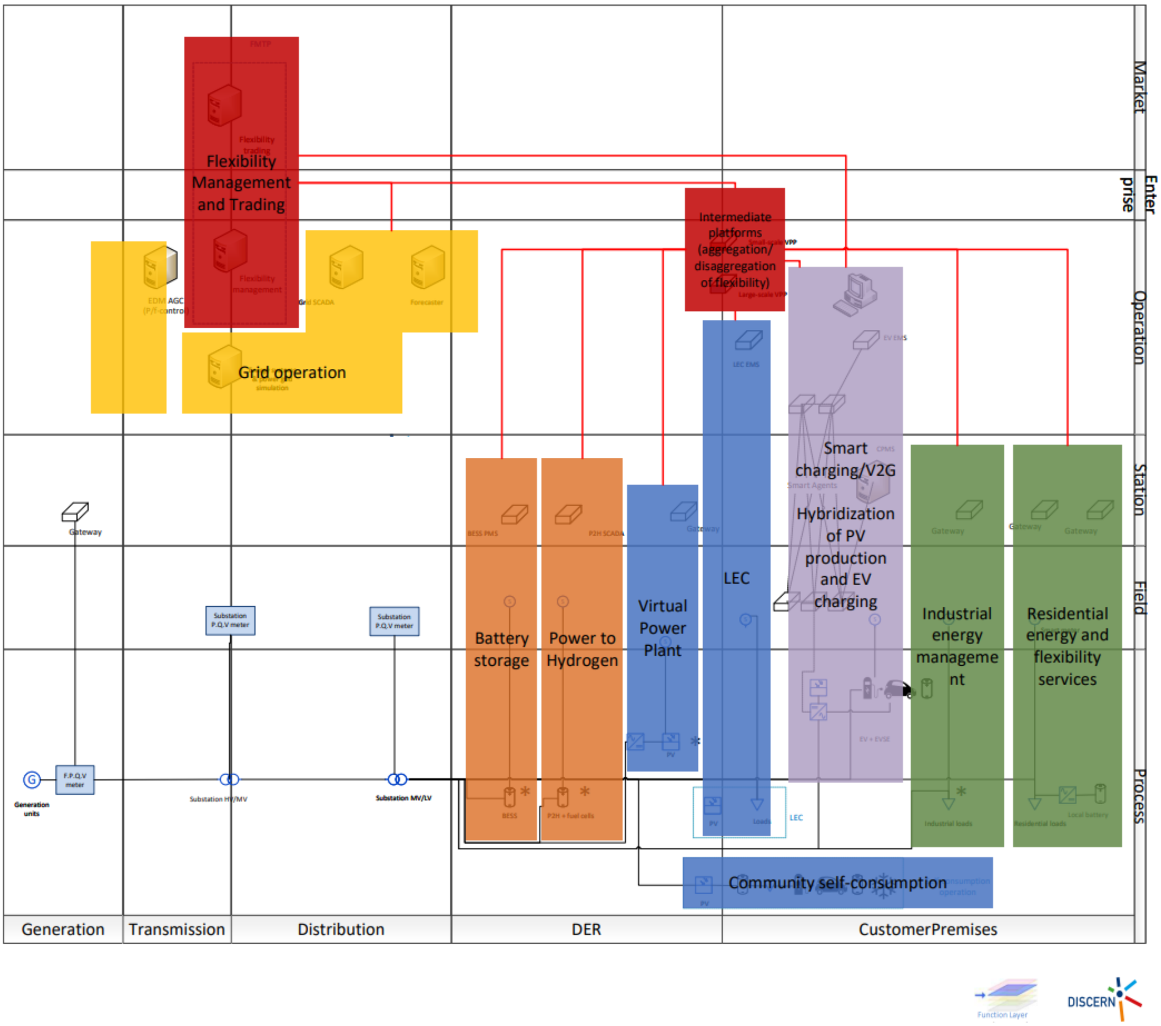

Figure 6: SGAM function layer of the generic architecture

This layer (Figure 6) shows the functions of the different groups of components, as well as their interactions. For this illustration, we used the same colour code as the one that can be found in the illustration of MAESHA overall concept in the Grant Agreement (Figure 4 of the GA, see [2]).

A digital Flexibility Management and Trading Platform will be developed to aggregate flexibility assets and energy management solutions that will be disseminated all over the territory – virtual power plant, community self-consumption, industrial energy management, residential energy and flexibility services, smart charging/V2G, hybridization of PV production and EV charging, battery storage and power to hydrogen. This will ensure the concerted operation and control of mechanisms that will extract all the reachable flexibility from an island. For an exhaustive description of all solutions, please refer to Deliverable D1.1 “Use cases, requirements and KPIs definition”.

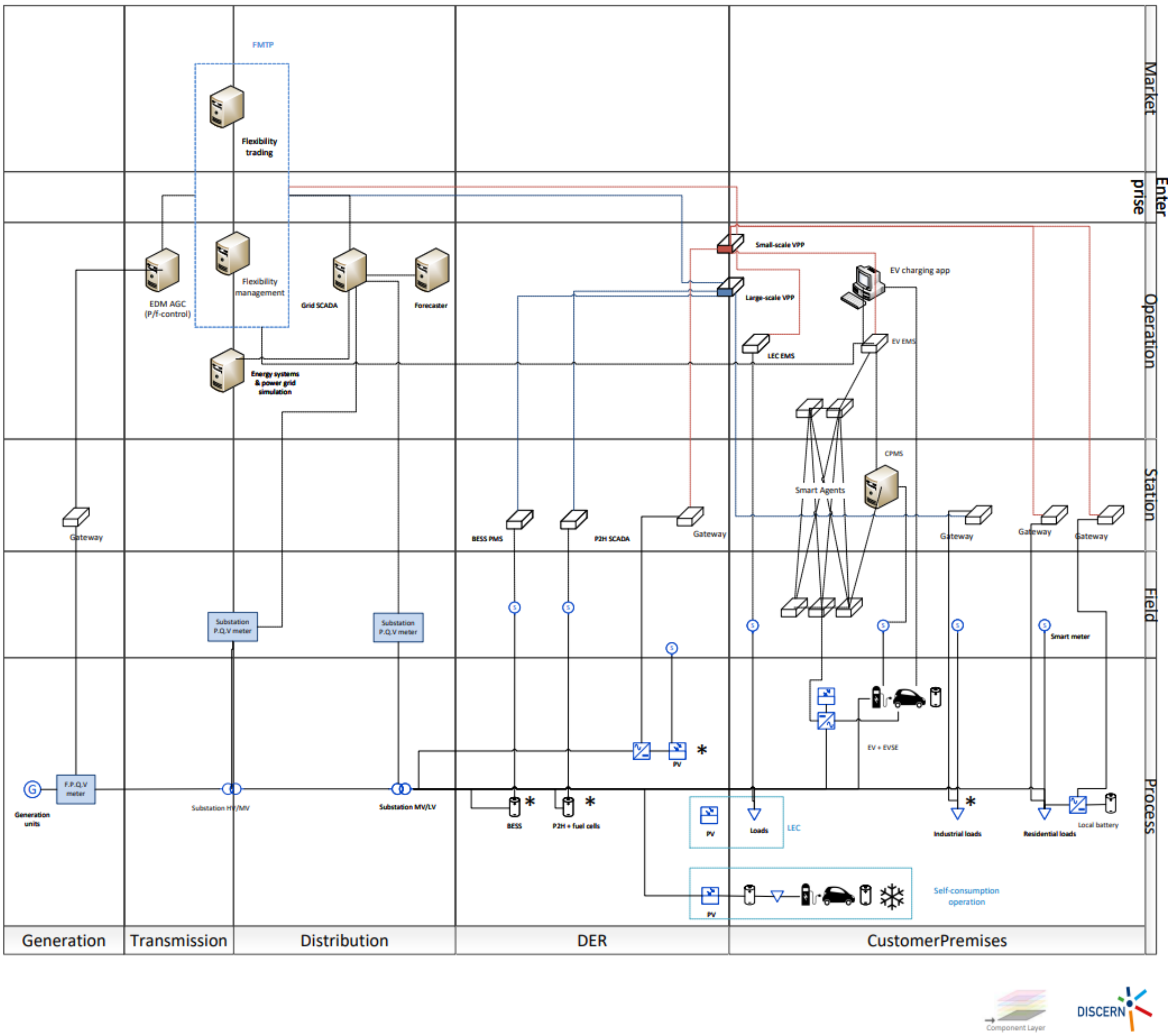

Figure 7: SGAM component layer of the generic architecture

This layer (Figure 7) details the different components of the system according to their relevant domain and hierarchical business zone and their physical interconnections. Please note that Battery Energy Storage System (BESS), Power-to-Hydrogen system, fuel cells, PV power plants and industrial loads can also be connected to the Medium Voltage grid. To ease the reading, only the assets connected to the Low Voltage grid are represented.

3.2 SPECIFIC ARCHITECTURE PER USE CASE

Each use case described in Deliverable D1.1 "Use cases, requirements and KPIs definition" ([2]) implements an instance of the generic MAESHA architecture, integrating it in a context and a business model. This section presents the specific architecture for each of the use cases, using a SGAM model.

Please note that the canonical data models to exchange information between components will be further discussed in task 1.4 "Interoperability and standardization of the technologies" to select the most relevant ones for MAESHA. The communication standards to use in the project will be detailed in D1.4 "Interoperability-by-design framework".

Finally, the specific system architectures described in this section pave the way for the task 7.3 "Data protection and cybersecurity". Its purpose is to define and apply a security and privacy practice, based on relevant reference architectures, ISO standards (such as 27xxx series), NIST guidelines for smart grid cybersecurity (NISTIR 7628) and EC recommendations on cybersecurity in the energy sector. Specific architectures indeed clearly define the stakeholders involved in the use case (in the SGAM Business layers) as well as the information exchanges needed to support it (in the SGAM Information layers).

Cybersecurity in energy sector projects is essential, as cyberattack on the communication medium of a device could lead to an outage, and possibly cascading effects. In particular, this sector has some specificities to take into account when designing the communication devices and security protocols. According to the Commission Recommendations on cybersecurity in the energy sector published by the European Commission in April 2019 (see [5]), three main specificities should be considered:

- *Cascading effects:* in energy networks, a fault at one device can impact the overall network;
- *Legacy technology:* legacy devices with a lifetime of 30-60 years, have to interact with the most recent technologies;
- *Real-time requirements:* many devices in the energy sector must respond in real-time, which puts a very high constraint on the overall system.

Depending on the context, additional specificities should be considered, such as availability: energy systems communication networks need to stay available and operable, even when external communication networks are down.

In addition to cybersecurity, also data privacy and data protection should be considered at an early stage, as the data that will be used in the project needs to be handled with precautions in order to respect the privacy of the users (incl. compliance to GDPR) and the confidentiality of business-related data. Those aspects will be further studied in Task 7.3 "Data protection and cybersecurity".

3.2.1 Frequency control

This use case describes how the MAESHA solution will stabilize the electricity grid of the island by proposing balancing services: Frequency Containment Reserve (FCR) and Frequency Restoration Reserve (FRR). Balancing services will help the Transmission System Operator (TSO) in ensuring the equilibrium between consumption and generation while minimizing frequency deviations from nominal values. It relies on the following scenarios:

- Definition of the frequency reserve requirements
- Frequency Containment Reserve (FCR): detection of the frequency issues
- Frequency Restoration Reserve (FRR): Detection of the frequency issues
- Contracting balancing service products
- FCR: Flexibility activation through local controller

- FRR: Flexibility activation through the Flexibility Management and Trading Platform
- Settlement process to remunerate flexibility activation
- Frequency control by flexibility provider

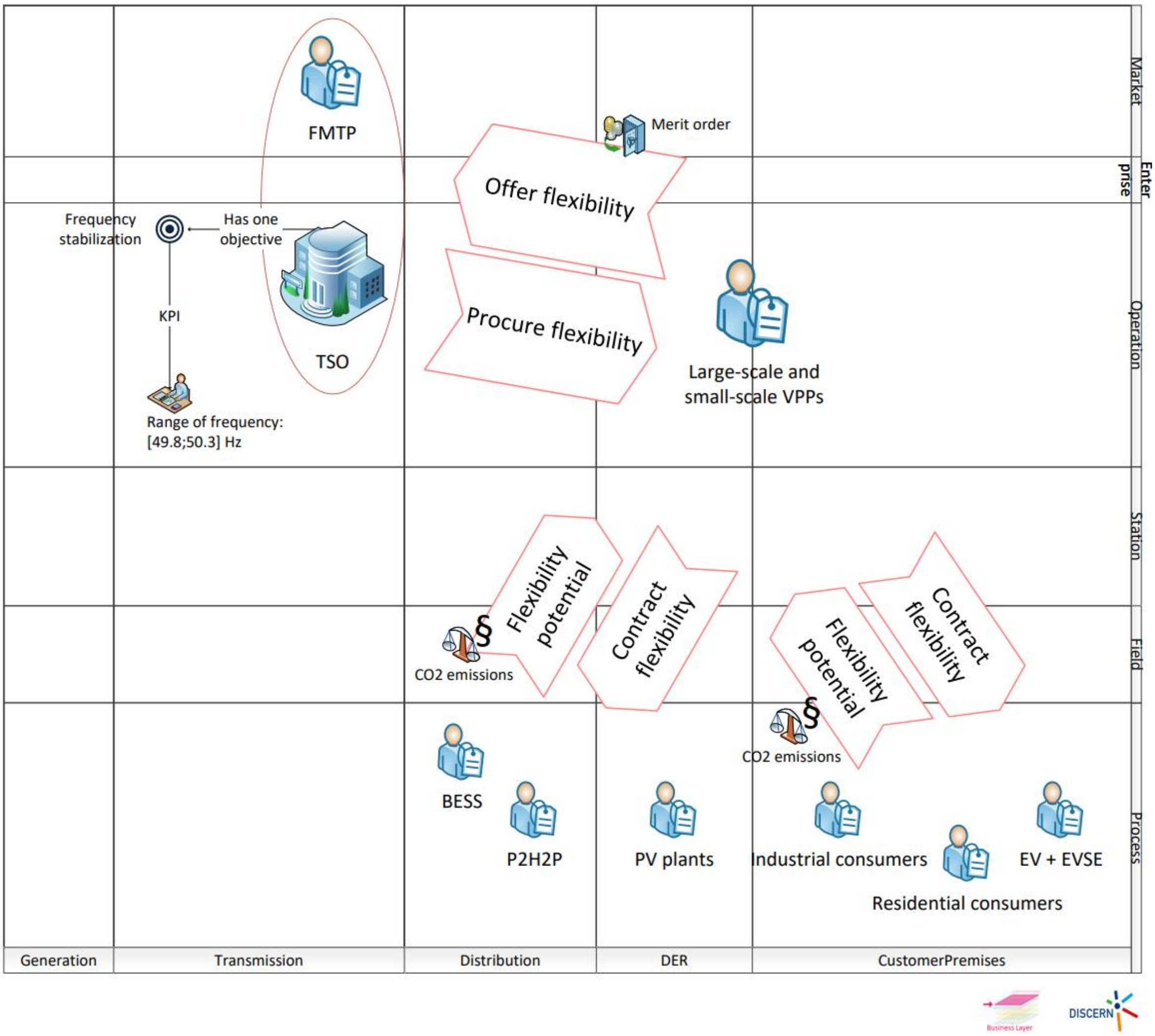

Figure 8: SGAM business layer of the frequency control use case-specific architecture

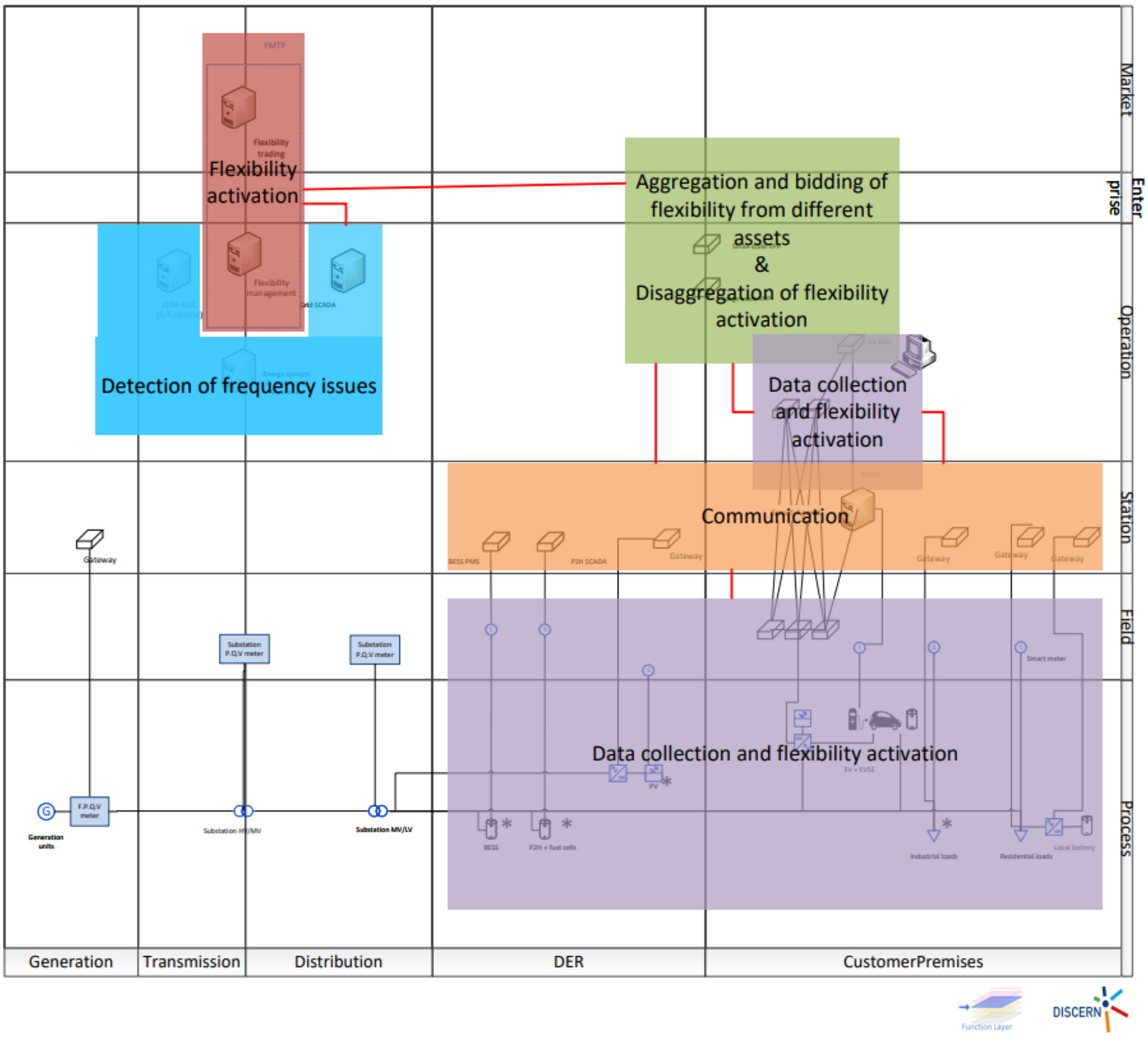

Figure 9: SGAM function layer of the frequency control use case-specific architecture

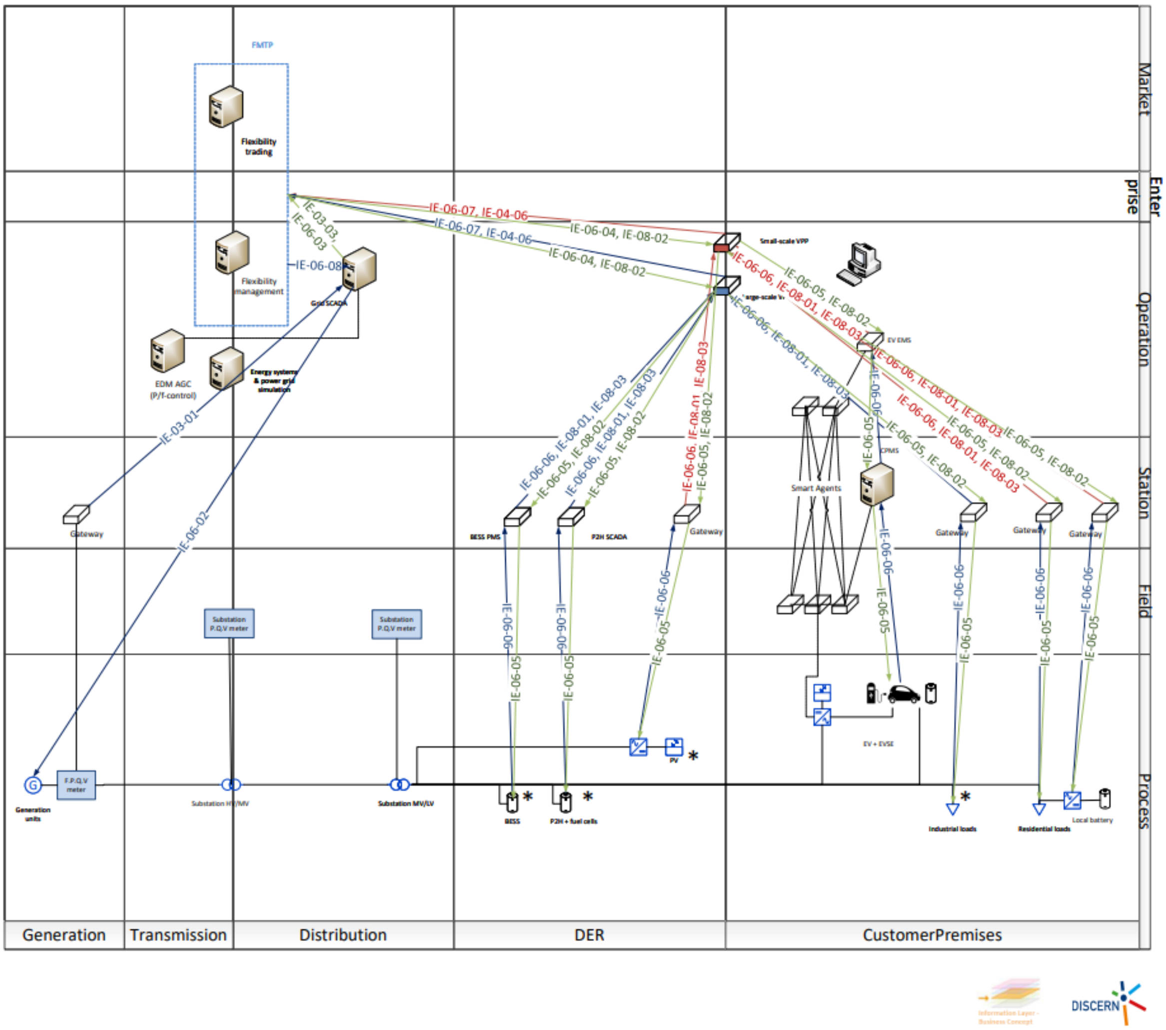

Figure 10: SGAM information layer of the frequency control use case-specific architecture

The information exchanged are described in Table 2 below.

Table 2: Information exchanged in the frequency control use case

ID	Name of information	Description of information exchanged
IE-03-01	Grid Frequency	Actual measurements of grid frequency centrally acquired by SO
IE-03-03	Updated FRR setpoint	Actual FRR setpoint calculated by AGC, sum of all assets participating in FRR service provision
IE-04-06	Balancing service bid document	The aggregator or flexibility provider participates in the tender for balancing services by submitting one or multiple binding bids. Bids contains ID of bidder, date, timespan, product ID, power, capacity price, energy price.
IE-06-02	FRR setpoints for central balancing assets	FRR setpoints for central balancing assets (controlled by the SO)
IE-06-03	FRR setpoint for DER	FRR setpoints for DER (controlled by 3rd party flexibility providers)
IE-06-04	FRR Activation requests	FRR activation requests for DER (controlled by 3rd party flexibility providers)

IE-06-05	Individual FRR setpoints	Individual FRR setpoints for DER controlled via an intermediate platform
IE-06-06	Individual FRR monitoring data	Monitoring data of individual DER, which is sent to an intermediate platform Datapoints: active power, baseline, setpoint, FRR activation, control bandwidth
IE-06-07	Aggregated FRR monitoring data	Aggregated monitoring data of a pool of DER (managed by an intermediary platform), which is sent to the FMTP. Datapoints: active power, baseline, setpoint, FRR activation, control bandwidth
IE-06-08	FRR validation report	The FRR validation report summarizes the quality of FRR service provision of a flexibility provider.
IE-08-01	Forecast of flexible capacity and costs	The forecast of flexible capacity and costs of a DER is generated for the entire upcoming product duration, that is tendered.
IE-08-02	Flexibility merit order	The flexibility merit order sorts the DER's flexibility forecasts according to their costs (from cheapest to most expensive).
IE-08-03	Actual flexibility of DER	The actual flexibility bandwidth of a DER

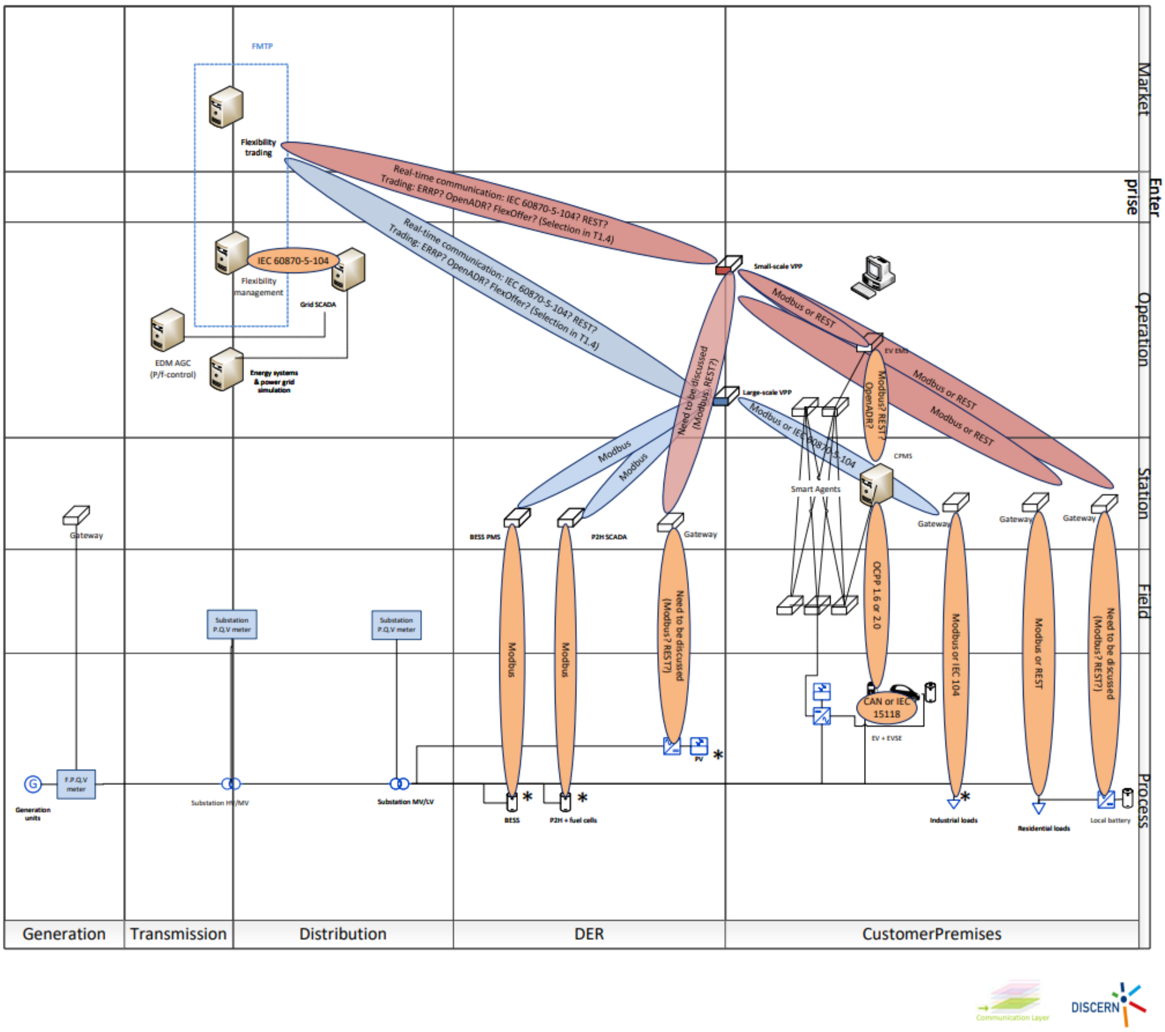

Figure 11: SGAM communication layer of the frequency control use case-specific architecture

The canonical data models listed in this illustration are not final and will be further discussed in task 1.4 “Interoperability and standardization of the technologies”. Please refer to deliverable D1.4 “Interoperability-by-design framework” for further details on the communication standards to use in MAESHA.

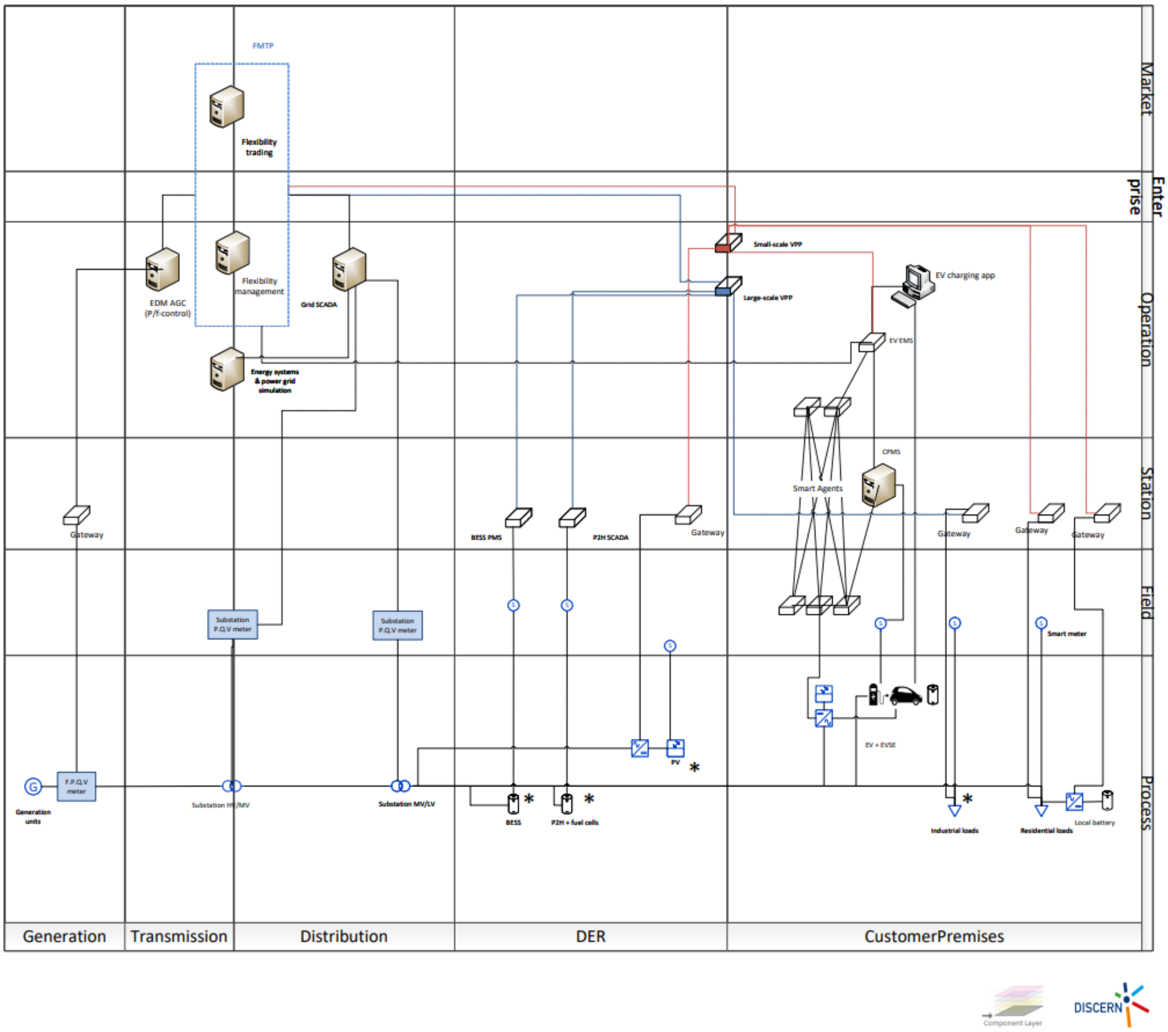

Figure 12: SGAM component layer of the frequency control use case-specific architecture

3.2.2 Voltage control

This use case describes how the MAESHA solution will help to stabilize the electricity grid of the island by proposing voltage control services. Those services aim at keeping voltages within specific safety bands and restore their values to the normal range after grid disturbances occur, to minimize reactive power flows, investments and technical losses. This use case will focus on voltage control through reactive power control using static voltage droop curves of flexibility assets, such as Battery Energy Storage System (BESS), renewable energy Virtual Power Plants (VPPs), Power-to-Hydrogen (P2H) or Demand Response (DR). It relies on the following functions:

- Communication of the capabilities curves of the assets involved in the use case to the DSO
- Calculation of static voltage droop curves for each asset
- Real-time calculation of reactive power setpoints by the local controllers based on the static voltage droop curve of the asset

- Sending of setpoints to individual assets
- Modification of the reactive power output
- Voltage and power measurement and communication for validation process

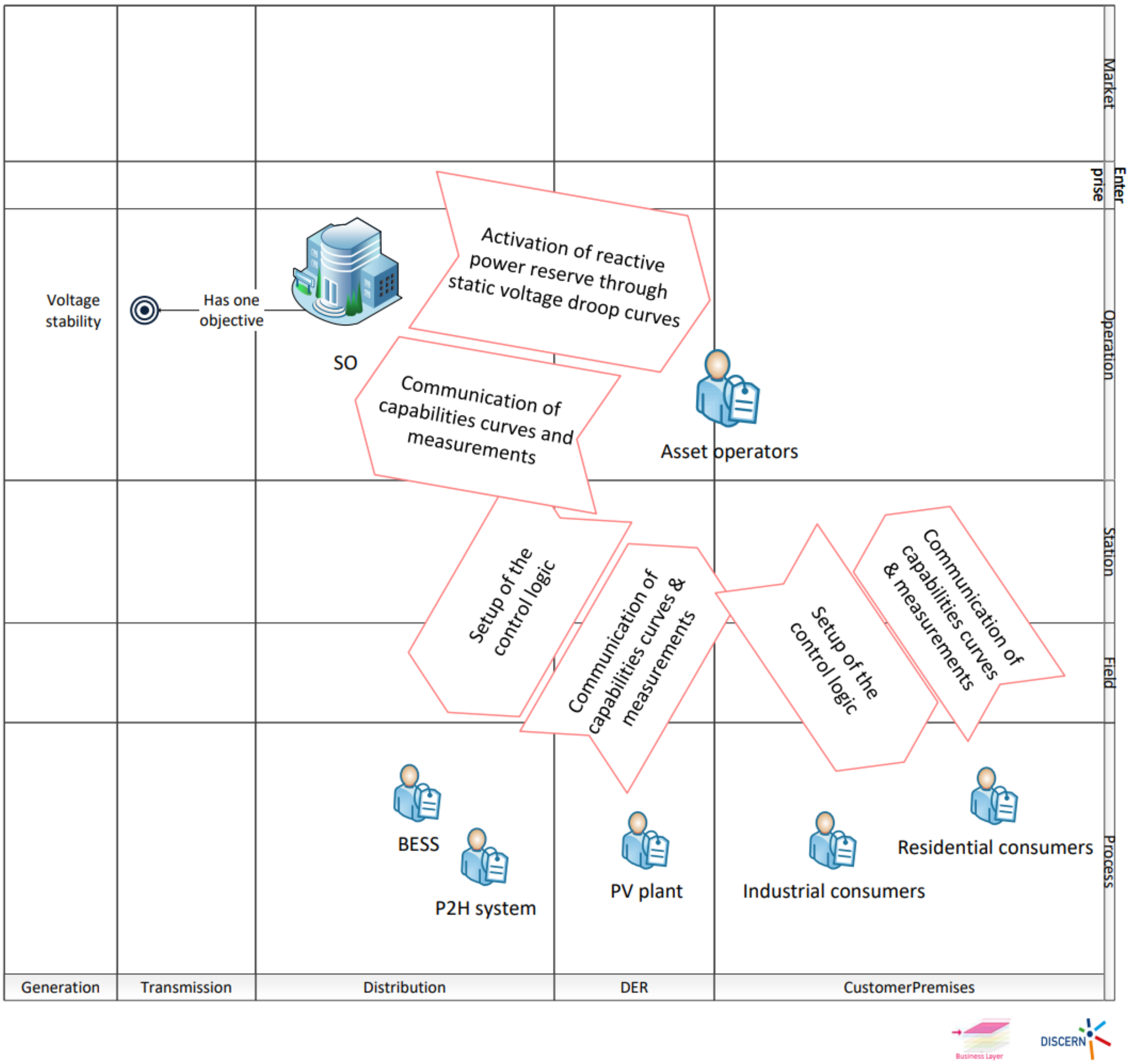

Figure 13: SGAM business layer of the voltage control use case-specific architecture

Please note that industrial and residential consumers equipped with invertor-interfaced demand or generation assets can theoretically propose voltage control services. However, the service is quite specific – the control of the invertor will be further detailed in task 5.2 “Technologies to increase grid inertia and improve power quality” - and the ability to demonstrate it in MAESHA still needs to be evaluated.

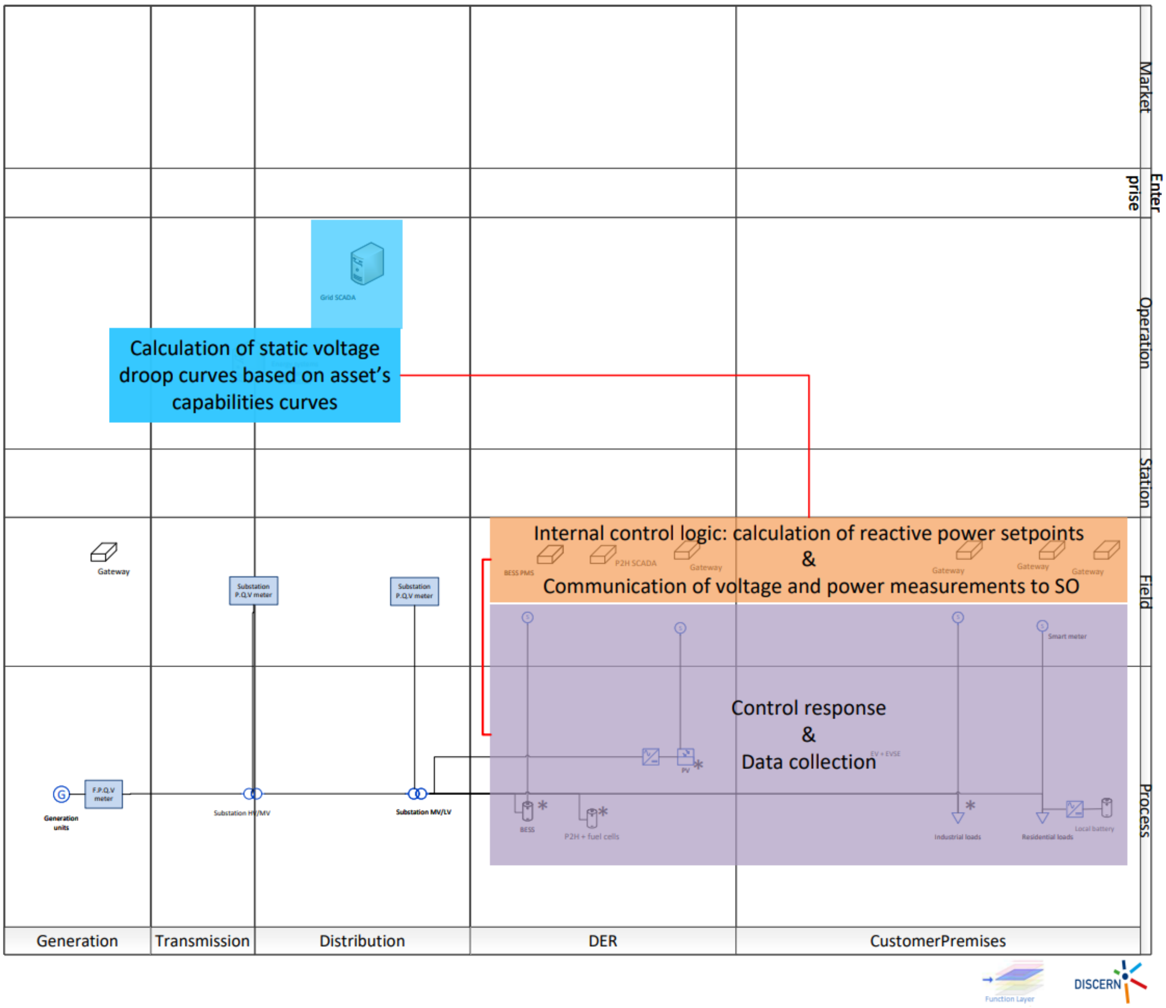

Figure 14: SGAM function layer of the voltage control use case-specific architecture

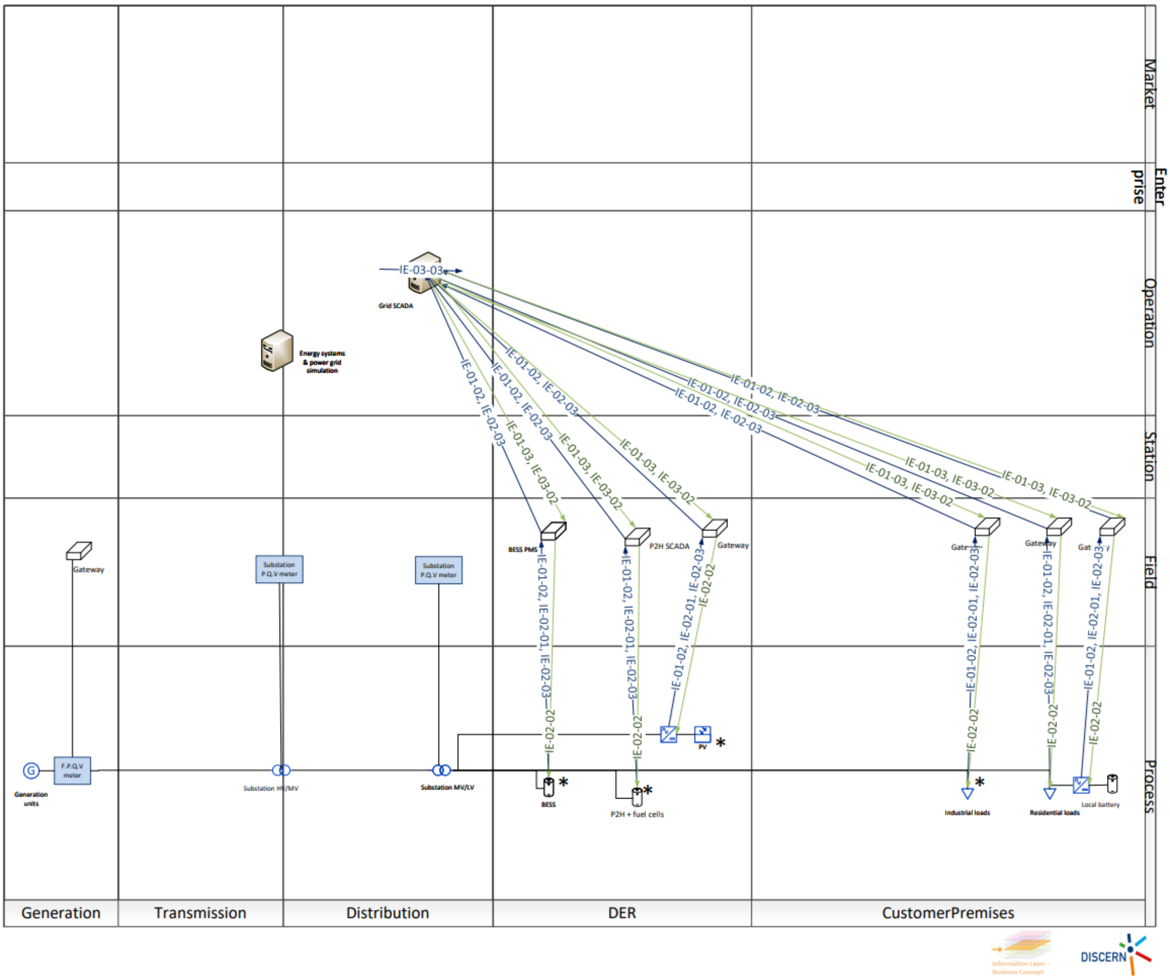

Figure 15: SGAM information layer of the voltage control use case-specific architecture

The information exchanged are described in Table 3 below.

Table 3: Information exchanged in the voltage control use case

ID	Name of information	Description of information exchanged
IE-01-02	Capabilities curves	This curve represents the capabilities of individual assets as represented in Q-U-ranges.
IE-01-03	Static voltage droop curve	This curve is a voltage-to-power response curve that translates local voltage measurements to active and reactive power response. This curve is specific to an individual asset.
IE-02-01	Voltage data	Local voltage level measured at the asset level
IE-02-02	Reactive power setpoint	This setpoint is the reactive power response calculated by the gateway in charge of the control logic based on the static voltage droop curve of the asset.
IE-02-03	Validation data	Those data is needed for the validation process. It includes the baseline, power and voltage measurements and is submitted in a format predefined by the (D)SO.
IE-03-02	Request for validation data	A formal request of the (D) SO to submit the validation data
IE-03-03	Validation report	A document issued by the (D)SO reporting the result of the validation process

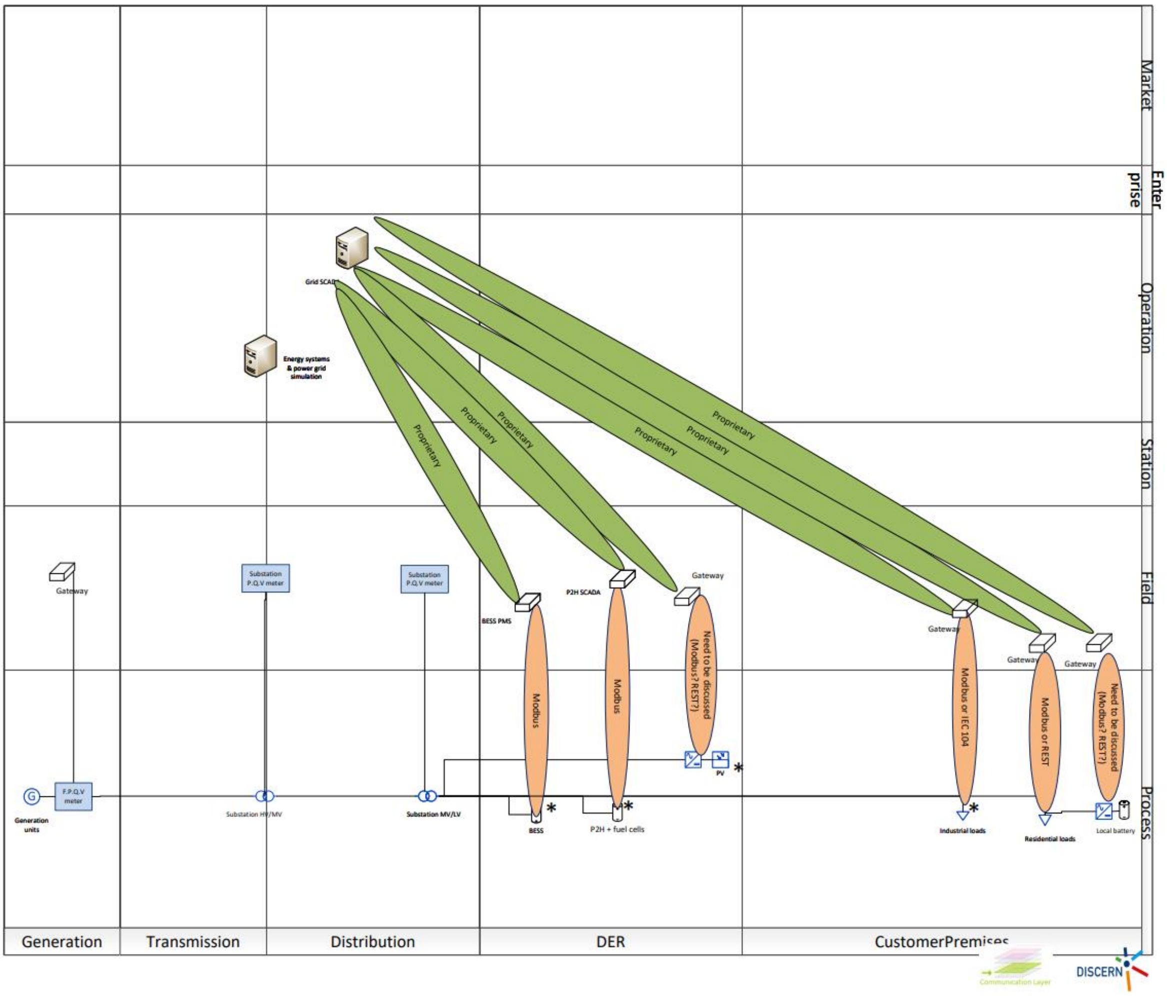

Figure 16: SGAM communication layer of the voltage control use case-specific architecture

The canonical data models listed in this illustration are not final and will be further discussed in task 1.4 “Interoperability and standardization of the technologies”. Please refer to deliverable D1.4 “Interoperability-by-design framework” for further details on the communication standards to use in MAESHA.

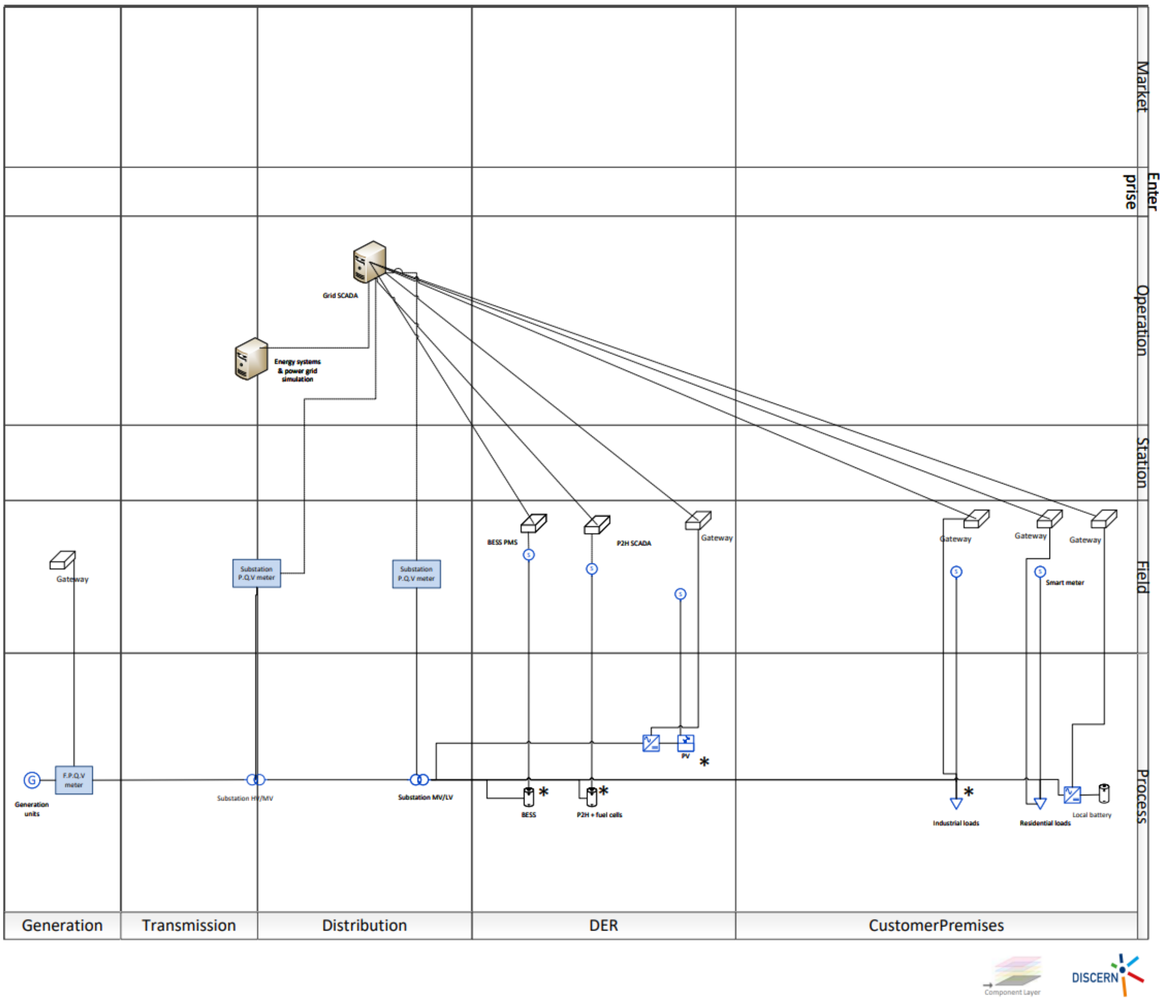

Figure 17: SGAM component layer of the voltage control use case-specific architecture

3.2.3 Minimization of the consumption peak

This use case describes how the MAESHA solution will minimize the consumption peak to avoid potential congestion that may occur in the electricity system of the island. The main objectives are to minimize the consumption peak by proposing load shifting and/or load shedding to the DSO through a flexibility market and, on a regular basis, e.g., by following the EV signal set by Electricité de Mayotte (EDM) on its Open Data to advertise favourable periods of consumption.

The two mechanisms are quite independent from each other. That's why we built two different specific architectures for this use case.

3.2.3.1 Flexibility market

The flexibility market supporting this use case relies on the following functions:

- Contracting flexibility products
- Forecast and operational planning
- Aggregation and bidding of flexibility from different assets
- Flexibility activation
- Disaggregation of flexibility activation
- Consumption/Generation profile changes

- Settlement/Validation process

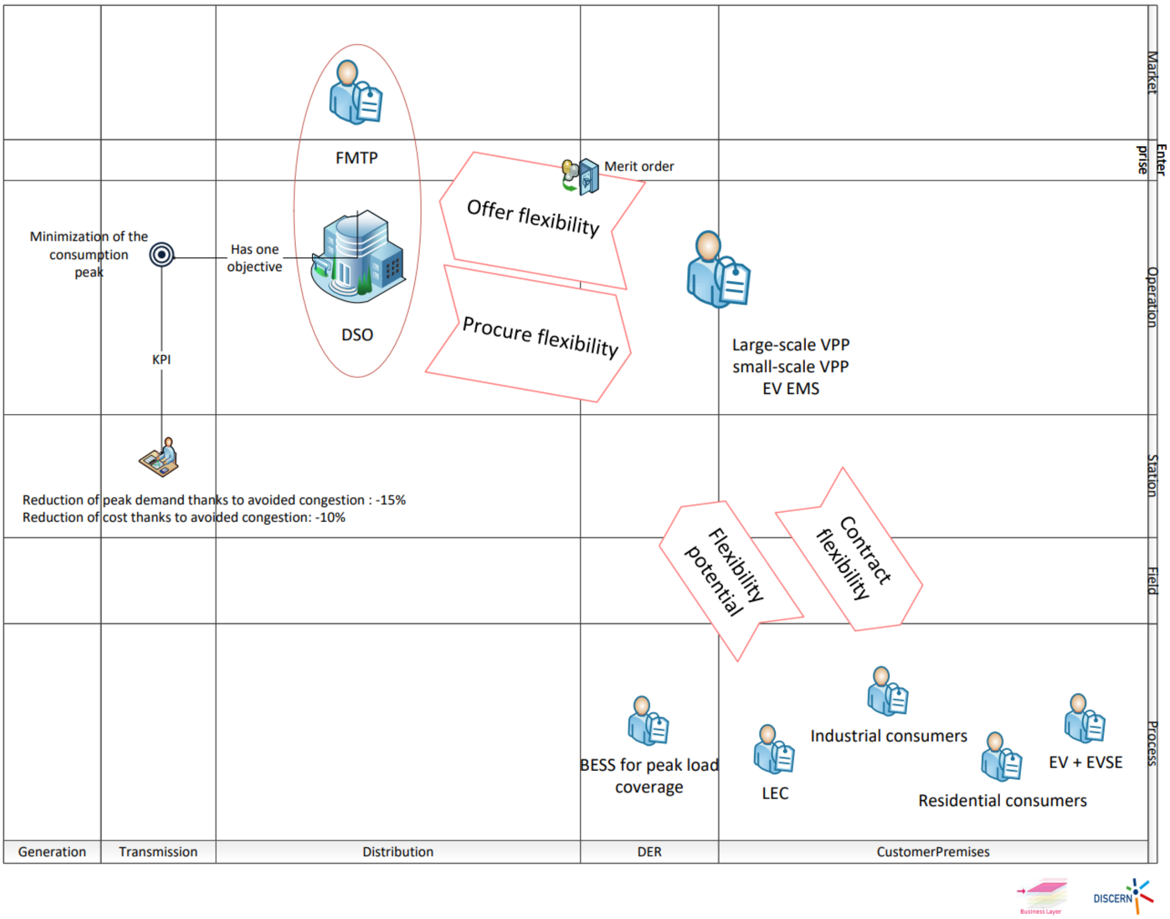

Figure 18: SGAM business layer of the minimization of the consumption peak use case-specific architecture (flexibility market)

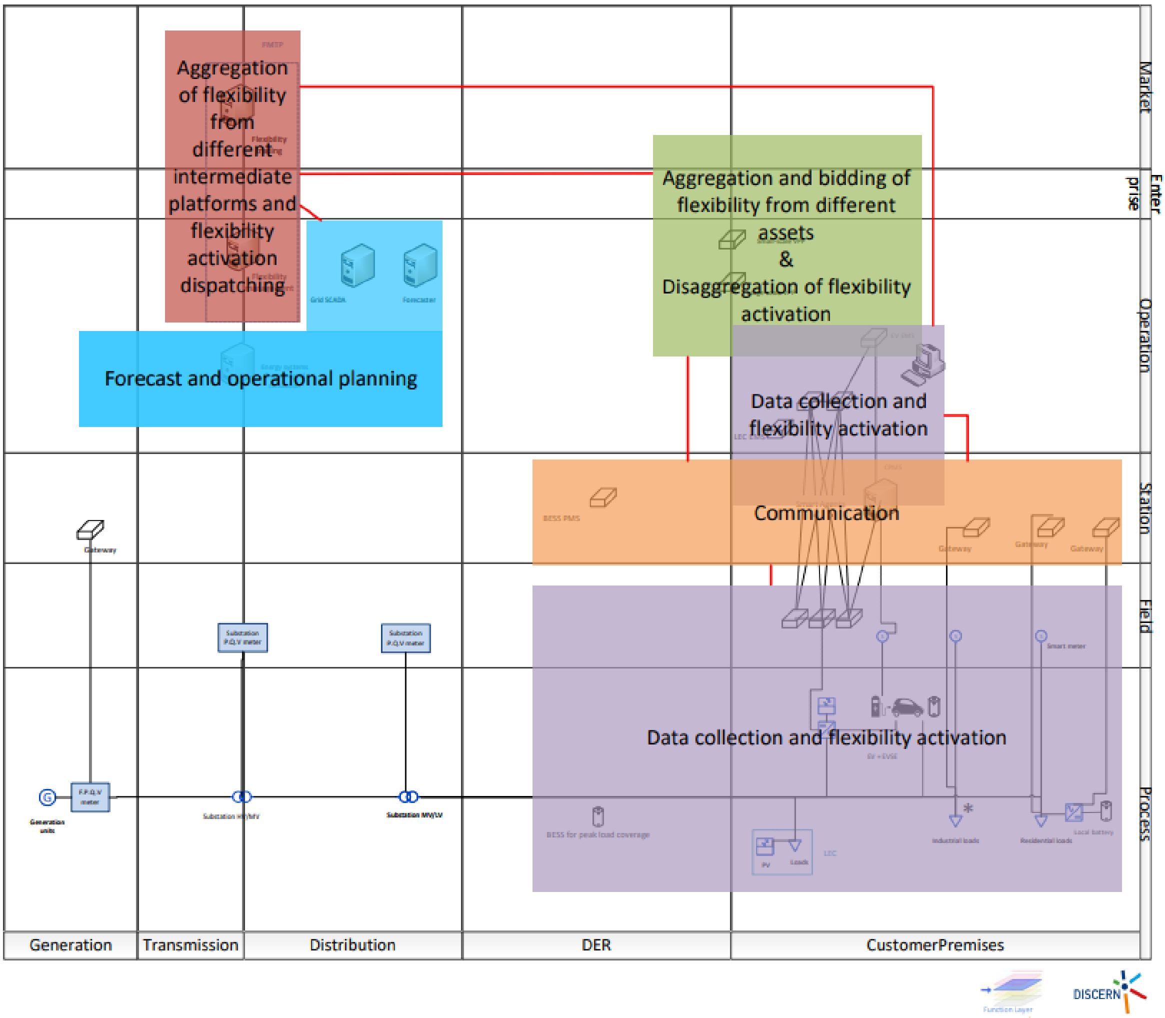

Figure 19: SGAM function layer of the minimization of the consumption peak use case-specific architecture (flexibility market)

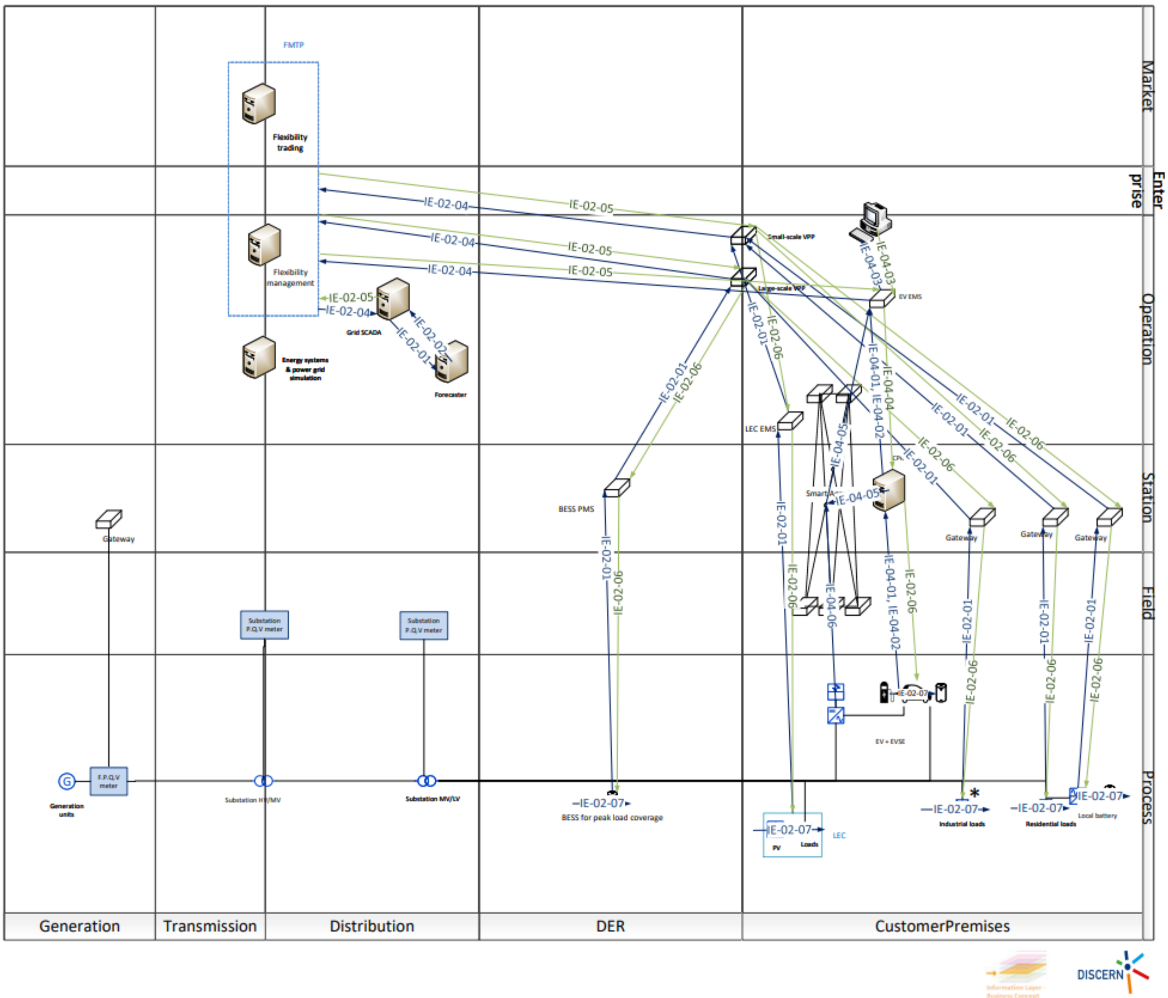

Figure 20: SGAM information layer of the minimization of the consumption peak use case-specific architecture (flexibility market)

The information exchanged are described in Table 4 below.

Table 4: Information exchanged in the minimization of the consumption peak use case (flexibility market)

ID	Name of information	Description of information exchanged
IE-02-01	Consumption data	Various consumption data collected from the assets involved in the flexibility market for minimizing the consumption peak. At least one utility meter should be installed in each of the facility involved in the flexibility market and should communicate consumption/generation data at the facility level. At least, data should present a 30-minute granularity and be pushed to the SO once per day.
IE-02-02	Baseline forecast	Estimate of the future demand that is based on the historical demand
IE-02-03	Flexibility potential forecast	Estimate of the flexibility potential of the asset (by load shedding or load shifting)
IE-02-04	Flexibility bid	A flexibility bid consists of the aggregation of the flexibility potentials of the different assets connected to an intermediate platform. They

		usually come with a pricing.
IE-02-05	Flexibility activation request	A flexibility activation is a request from the SO to modify the load profile at a specific location by reducing the consumption.
IE-02-06	Disaggregated flexibility activation	Flexibility activation request is disaggregated for control dispatching of the different assets connected to the intermediate platforms.
IE-02-07	Consumption profile	Consumption profile of the assets involved in the flexibility market. Ideally, if a flexibility activation has been requested by the SO, it should be different from the baseline forecast (IE-02-02) as the assets has performed load shifting/shedding to minimize the consumption peak.
IE-04-01	ID Tag	Authentication of EV using RFID/NFC tag
IE-04-02	New EV connection signal	The Charging Point Management System (CPMS) communicates with EV EMS information about connected charger and EV driver data.
IE-04-03	EV driver's preferences	Through the mobile app, the EV driver indicates his/her preferences for the EV parking status, such as desired state of charge, departure time, etc. and whether he or she wants to engage in smart charging.
IE-04-04	Smart charging profile	Charging/discharging profile to be performed by an individual EV connected to the EVSE (and related to a specific ID Tag), based upon various parameters such as EV driver's preferences, renewable energy generation forecast, energy prices and potential grid constraints
IE-04-05	energy consumption – kWh	Charge point meter readings are received from the CPMS and communicated to the EV EMS, tracking each kWh of energy charged and discharged in the smart charge points.

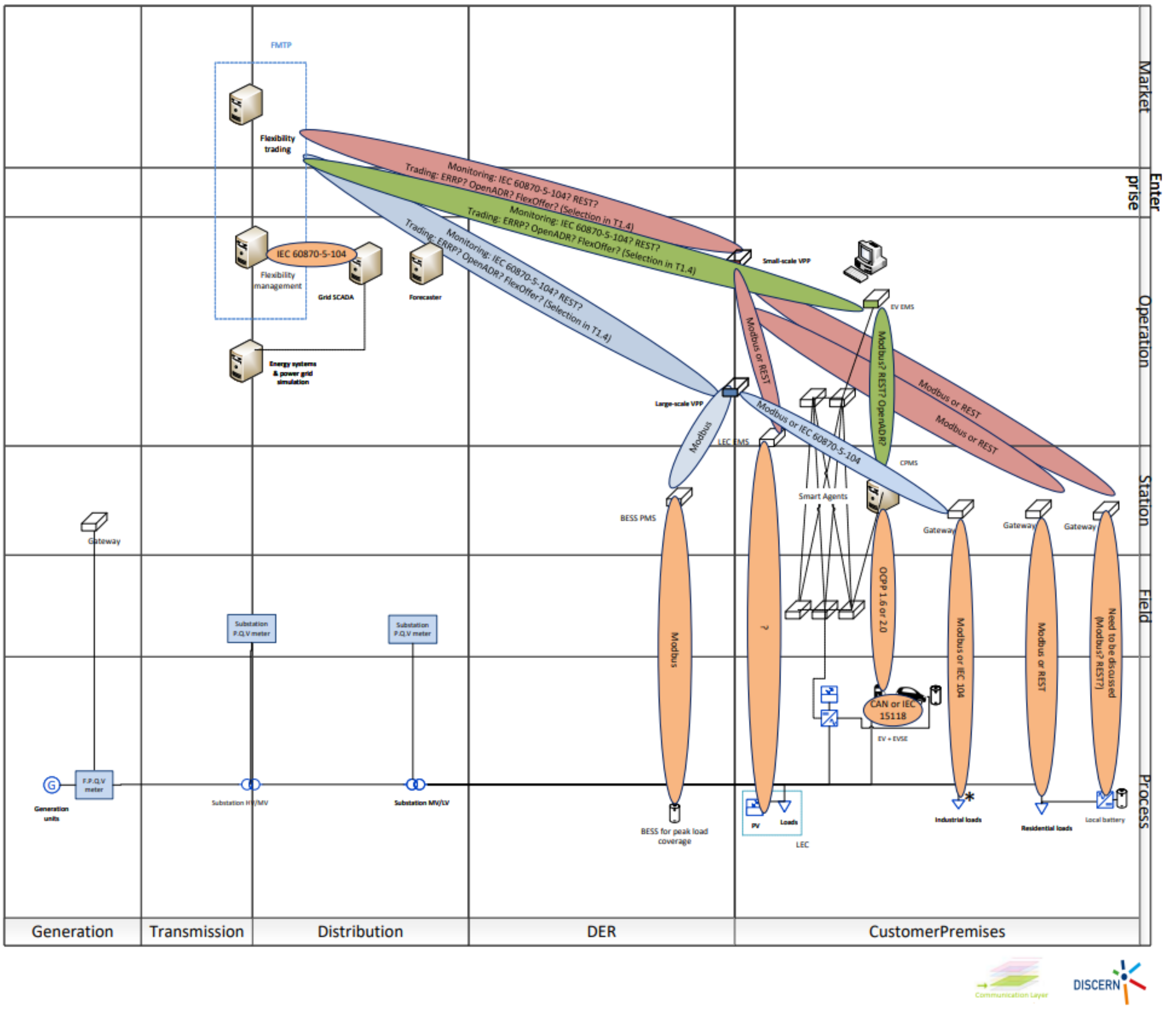

Figure 21: SGAM communication layer of the minimization of the consumption peak use case-specific architecture (flexibility market)

Please note that the communication protocols to use to communicate with the LEC depends on the assets considered (e.g., residential load, batteries, EV charging stations etc.). Also, the canonical data models listed in this illustration are not final and will be further discussed in task 1.4 “Interoperability and standardization of the technologies”. Please refer to deliverable D1.4 “Interoperability-by-design framework” for further details on the communication standards to use in MAESHA.

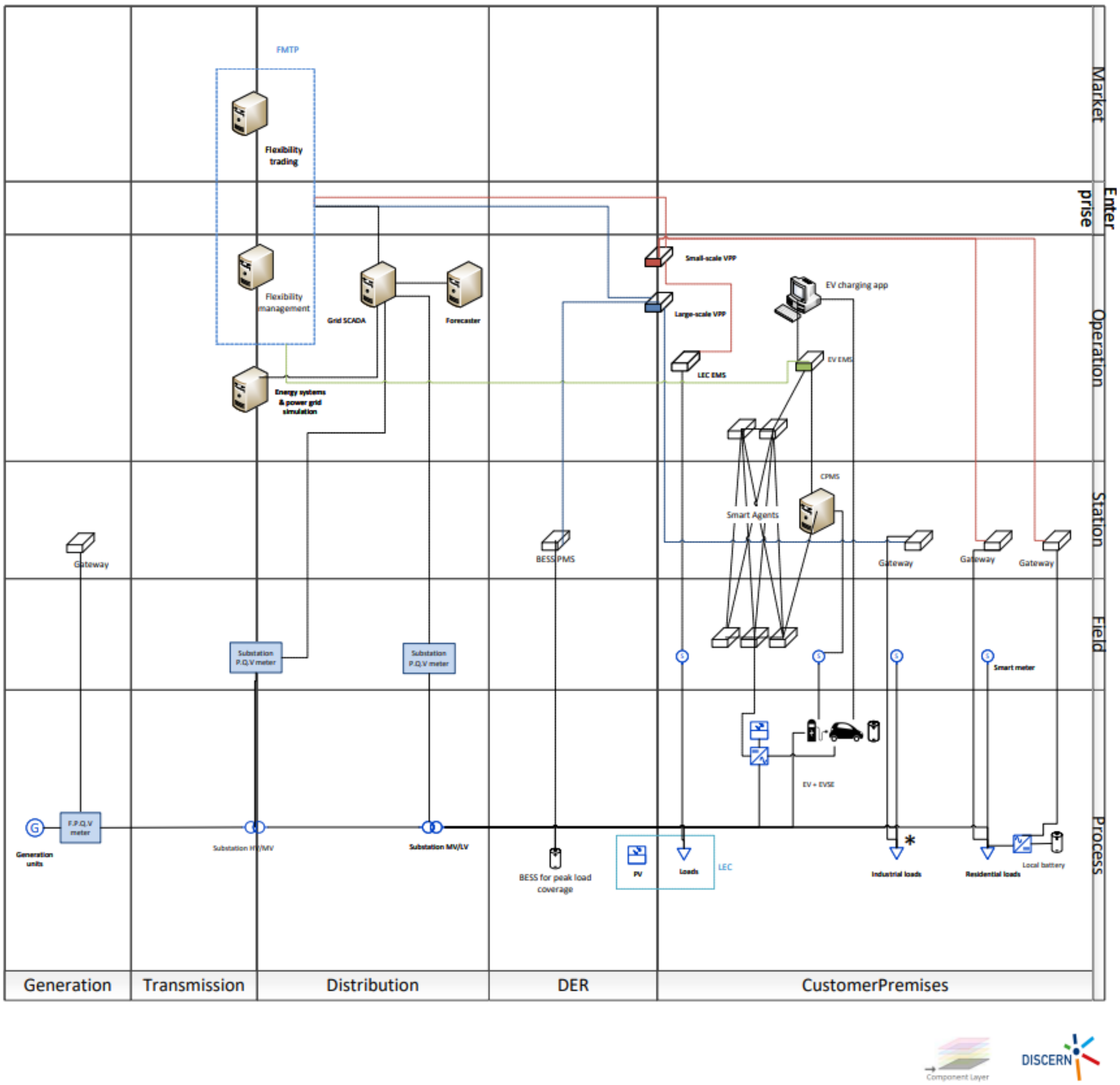

Figure 22: SGAM component layer of the minimization of the consumption peak use case-specific architecture (flexibility market)

3.2.3.2 EV signal

The optimization done by following the EV signal relies on the following functions:

- Forecast and EV signal implementation
- EV signal reading and operational scheduling
- Signal response

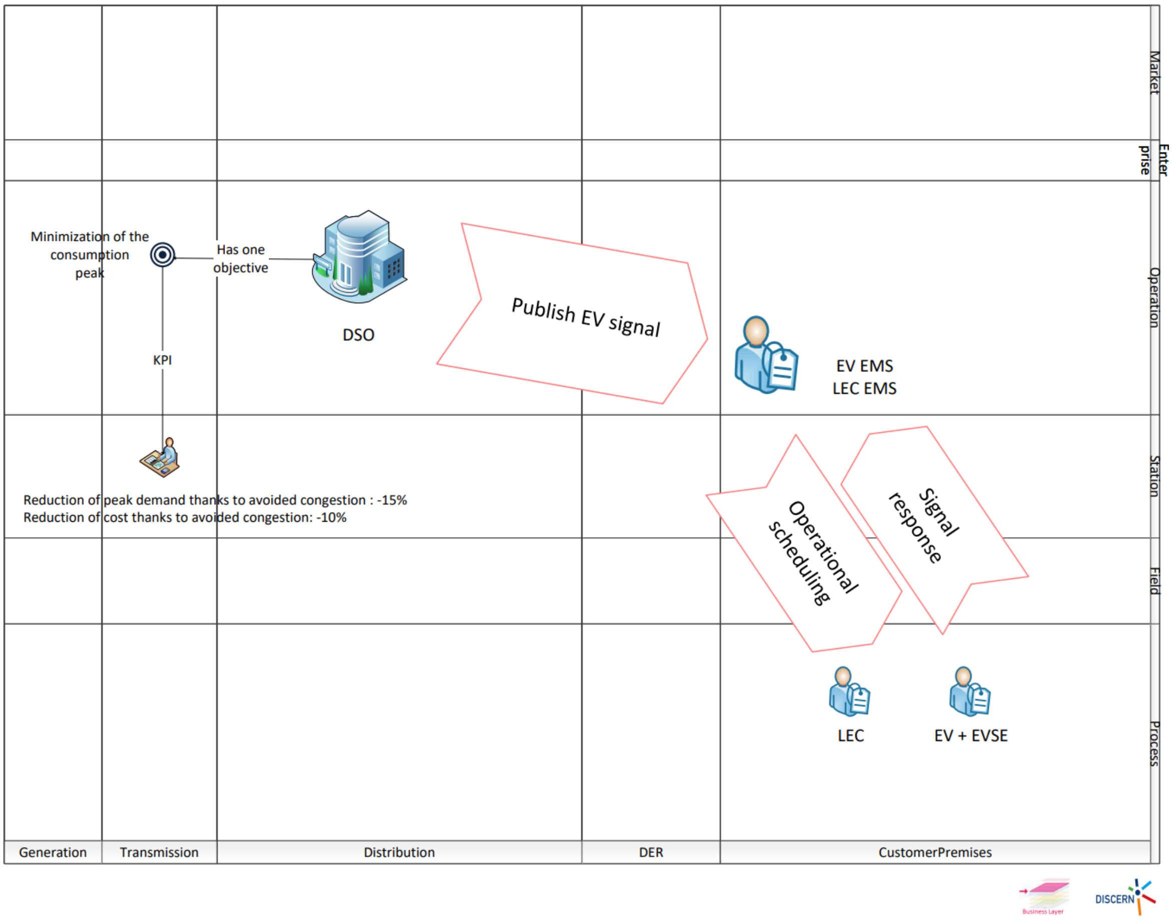

Figure 23: SGAM business layer of the minimization of the consumption peak use case-specific architecture (EV signal)

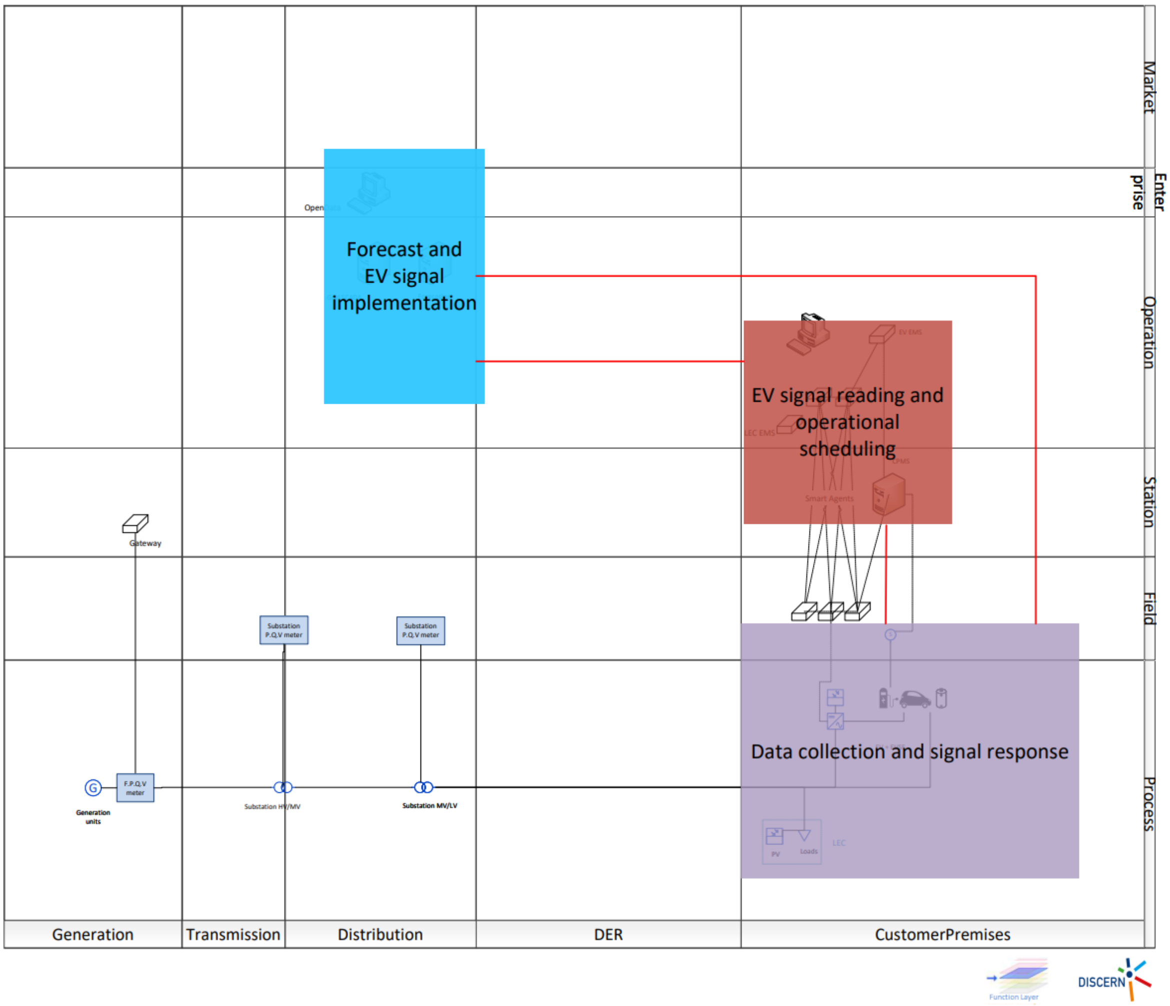

Figure 24: SGAM function layer of the minimization of the consumption peak use case-specific architecture (EV signal)

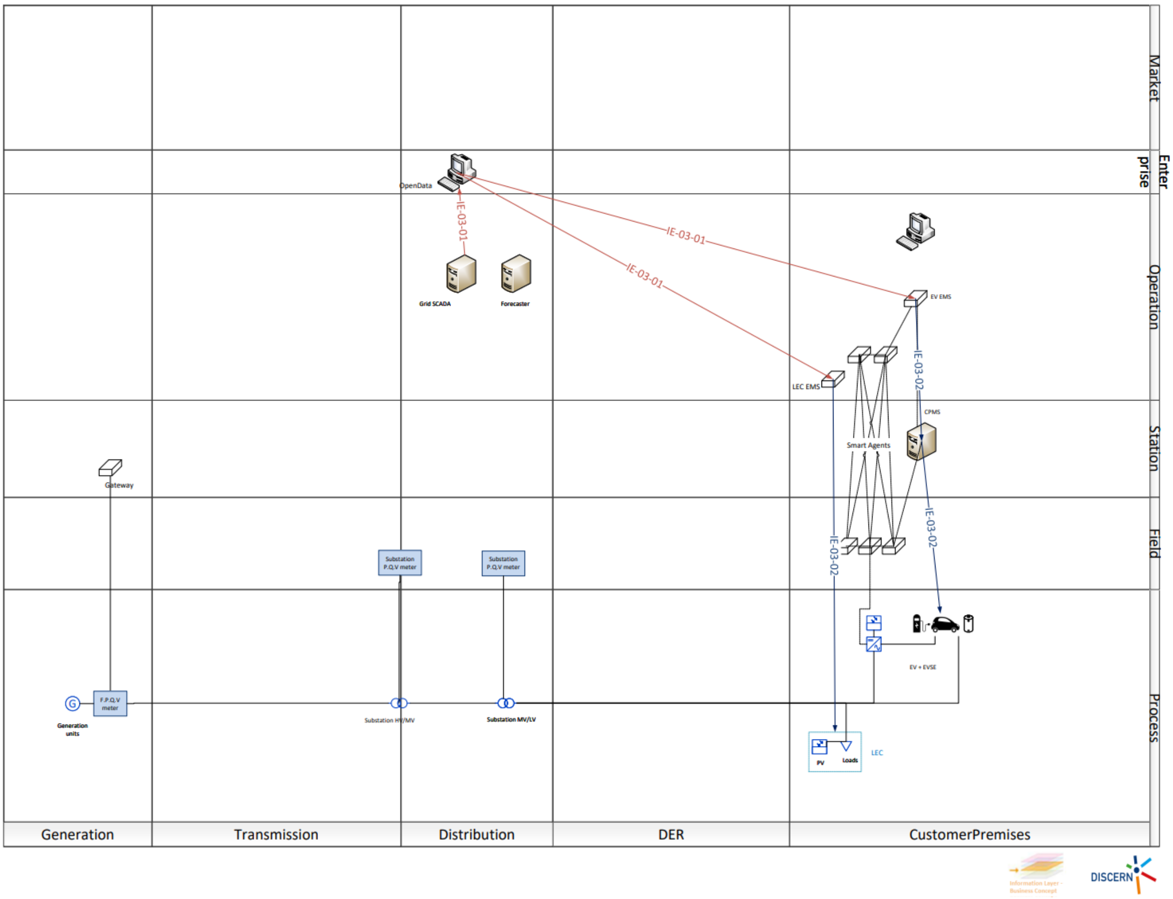

Figure 25: SGAM information layer of the minimization of the consumption peak use case-specific architecture (EV signal)

The information exchanges are described in Table 5 below.

Table 5: Information exchanged in the minimization of the consumption peak use case (EV signal)

ID	Name of information	Description of information exchanged
IE-03-01	EV signal	EV signal, available on EDM Open Data to advertise favourable periods of Electric Vehicles charging – to promote Smart Charging and to not add any burden to the electricity grid of the island. This signal is binary: • 1 means that the period is favourable and that EV charging is recommended at 7.4kW. • 0 means that the period is not favourable and that the charging is to avoid or to limit at 3.7kW.
IE-03-02	Control dispatching	Control dispatching proposed after analysis of the EV signal. It has the form of a charging/discharging schedule in the case of EV.

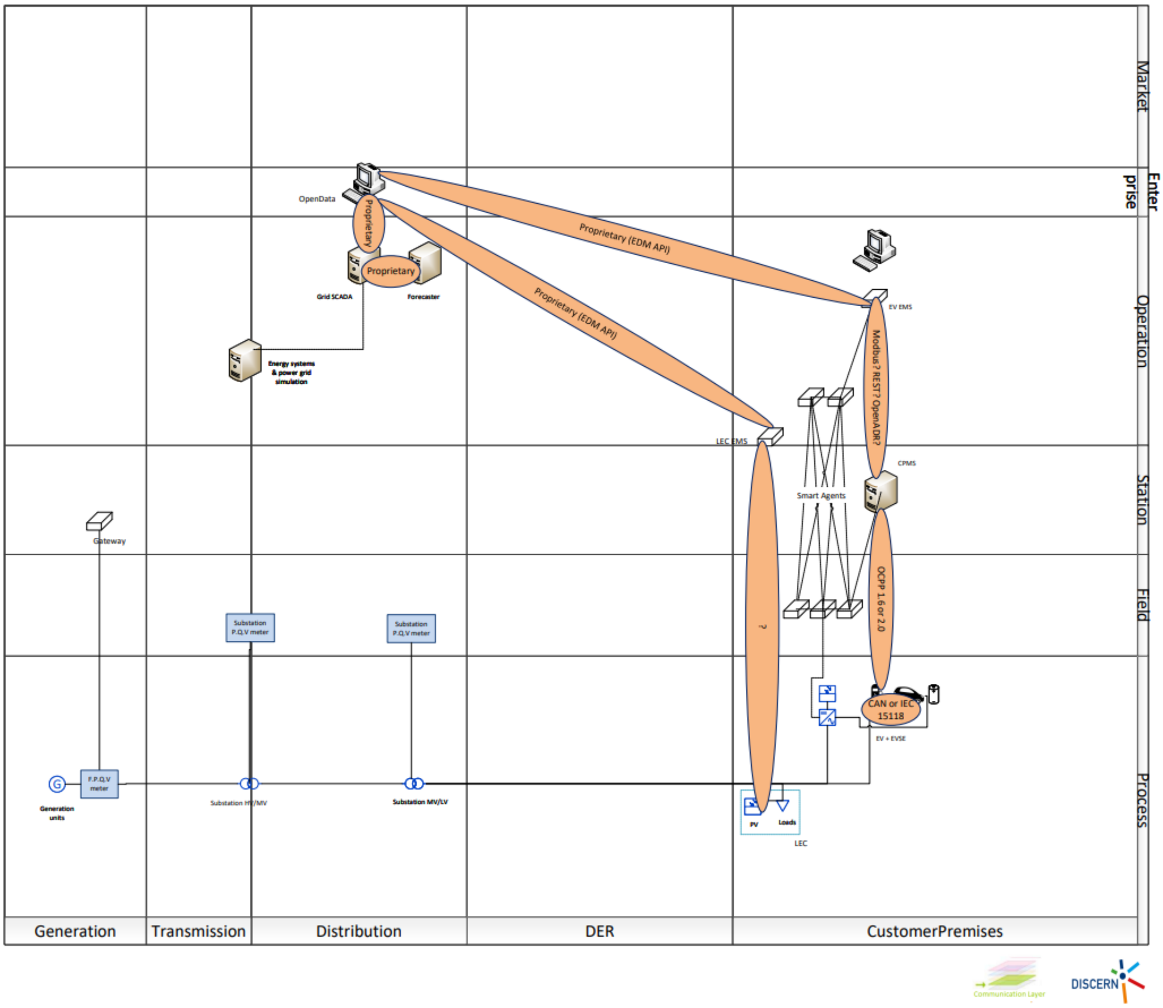

Figure 26: SGAM communication Layer of the minimization of the consumption peak use case-specific architecture (EV signal)

Please note that the communication protocols to use to communicate with the LEC depends on the assets considered (e.g., residential load, batteries, EV charging stations etc.). Also, the canonical data models listed in this illustration are not final and will be further discussed in task 1.4 “Interoperability and standardization of the technologies”. Please refer to deliverable D1.4 “Interoperability-by-design framework” for further details on the communication standards to use in MAESHA.

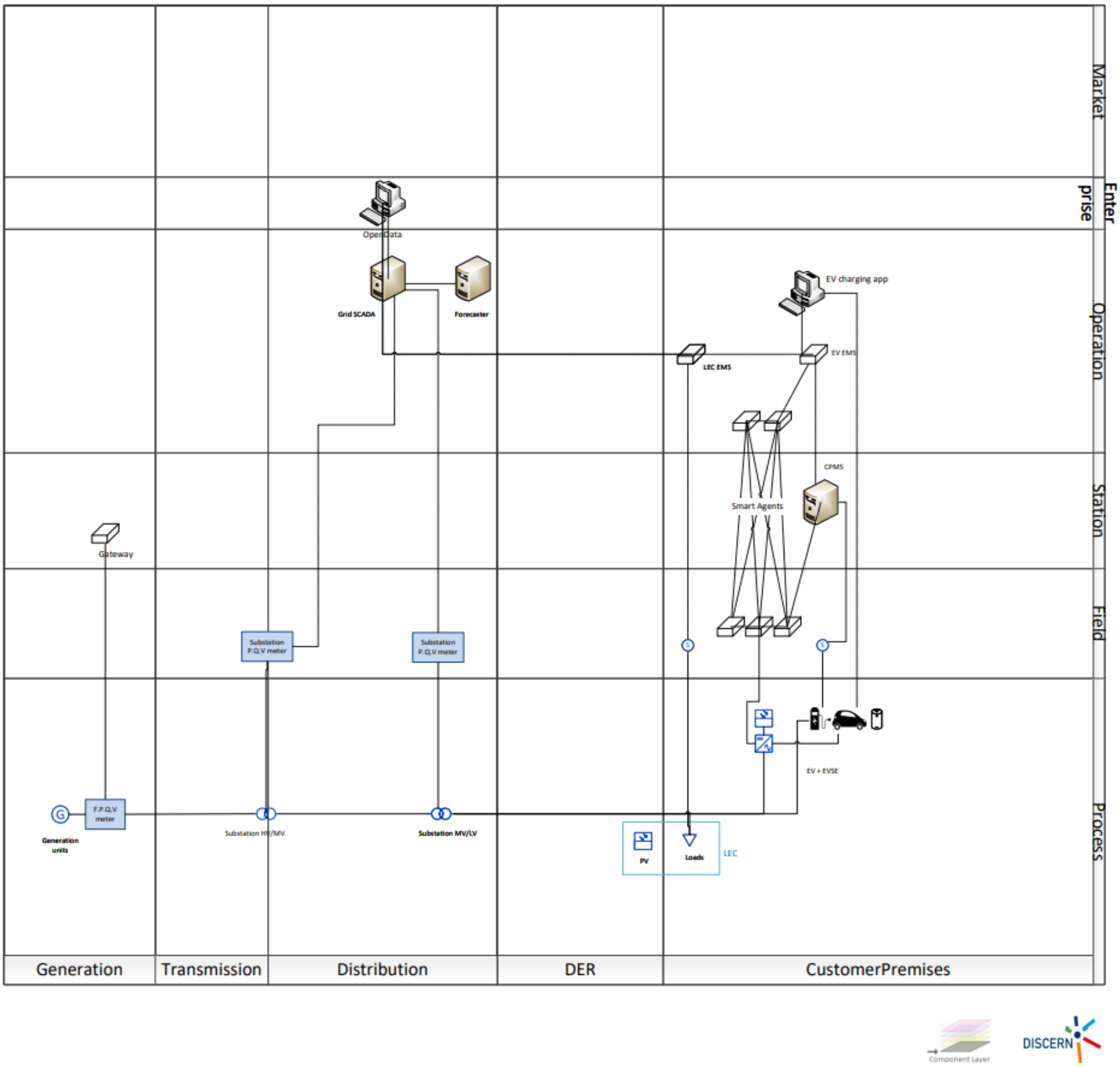

Figure 27: SGAM component layer of the minimization of the consumption peak use case-specific architecture (EV signal)

3.2.4 Maximization of self-consumption and hybridization

This use case describes how the MAESHA solution will maximize the use of renewable energy sources in the daily life through collective self-consumption operations, local energy communities and hybridization of assets (air-conditioning units and Electric Vehicle charging stations). It relies on the following functions:

- Forecast of the supply (diesel and PV)
- Self-consumption optimization
- Metering
- Certification of the electricity origin

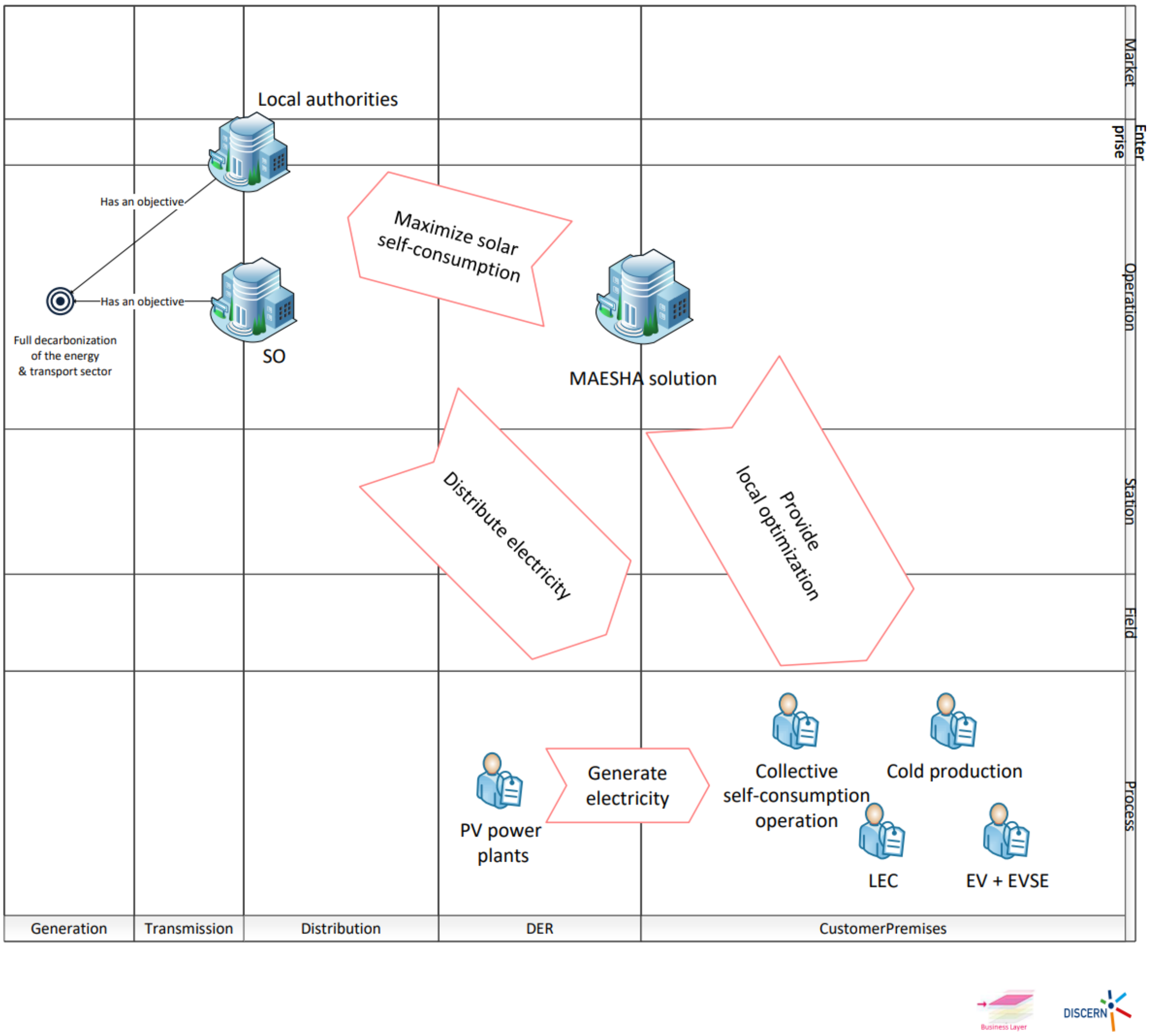

Figure 28: SGAM business layer of the maximization of self-consumption and hybridization use case-specific architecture

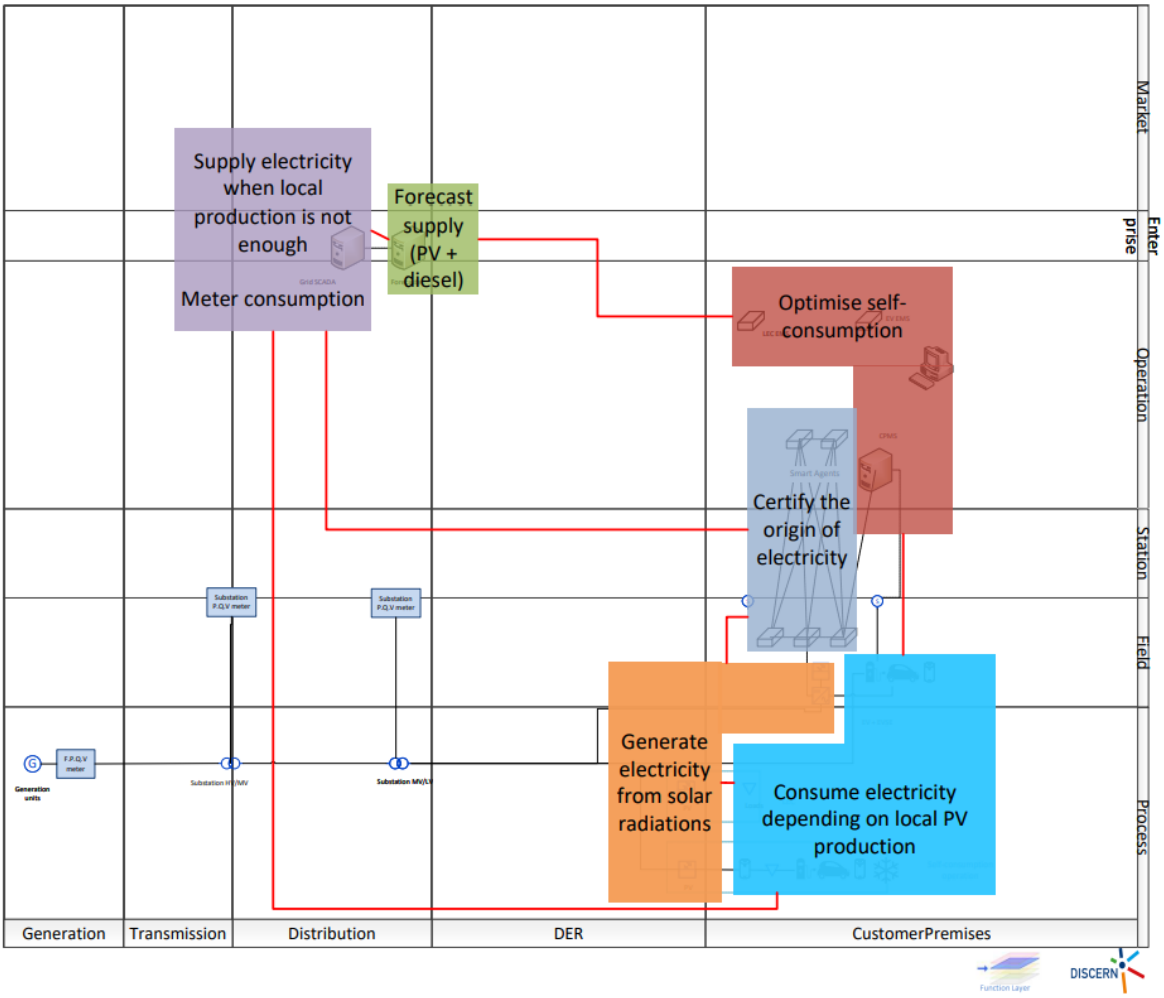

Figure 29: SGAM function layer of the maximization of self-consumption and hybridization use case-specific architecture

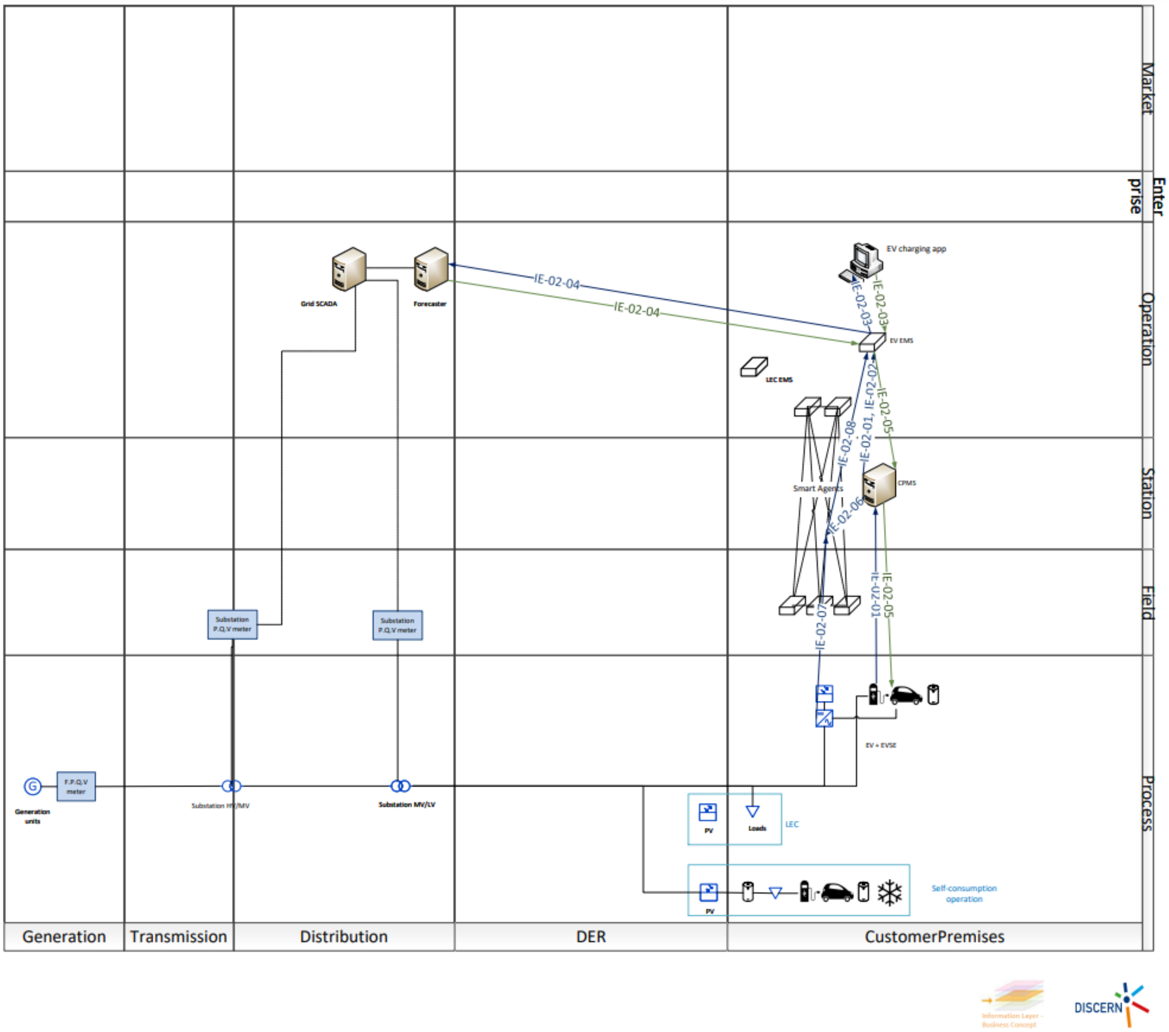

Figure 30: SGAM information layer of the maximization of self-consumption and hybridization use case-specific architecture

The information exchanges are described in Table 6 above.

Table 6: Information exchanged in the minimization of the consumption peak use case (EV signal)

ID	Name of information	Description of information exchanged
IE-02-01	ID Tag	Authentication of EV using RFID/NFC tag
IE-02-02	New EV connection signal	The Charging Point Management System (CPMS) communicates with EV EMS information about connected charger and EV driver data.
IE-02-03	EV driver's preferences	Through the mobile app, the EV driver indicates his/her preferences for the EV parking status, such as desired state of charge, departure time, etc.
IE-02-04	Renewable energy generation forecast	Local renewable energy generation forecast, calculated by the Forecaster
IE-02-05	Smart charging	Charging/discharging profile to be performed by an individual EV connected to the EVSE (and related to a specific ID Tag), based upon

	profile	various parameters such as EV driver's preferences, renewable energy generation forecast, energy prices and potential grid constraints.
IE-02-06	Energy consumption – kWh	Charge point meter readings are received from the CPMS and communicated to the EV EMS, tracking each kWh of energy charged and discharged in the smart charge points.
IE-02-07	Renewable energy generation - kWh	Meter readings of the renewable energy generation (kWh) are performed, auditing its source of origin and sharing information to prevent double spending.

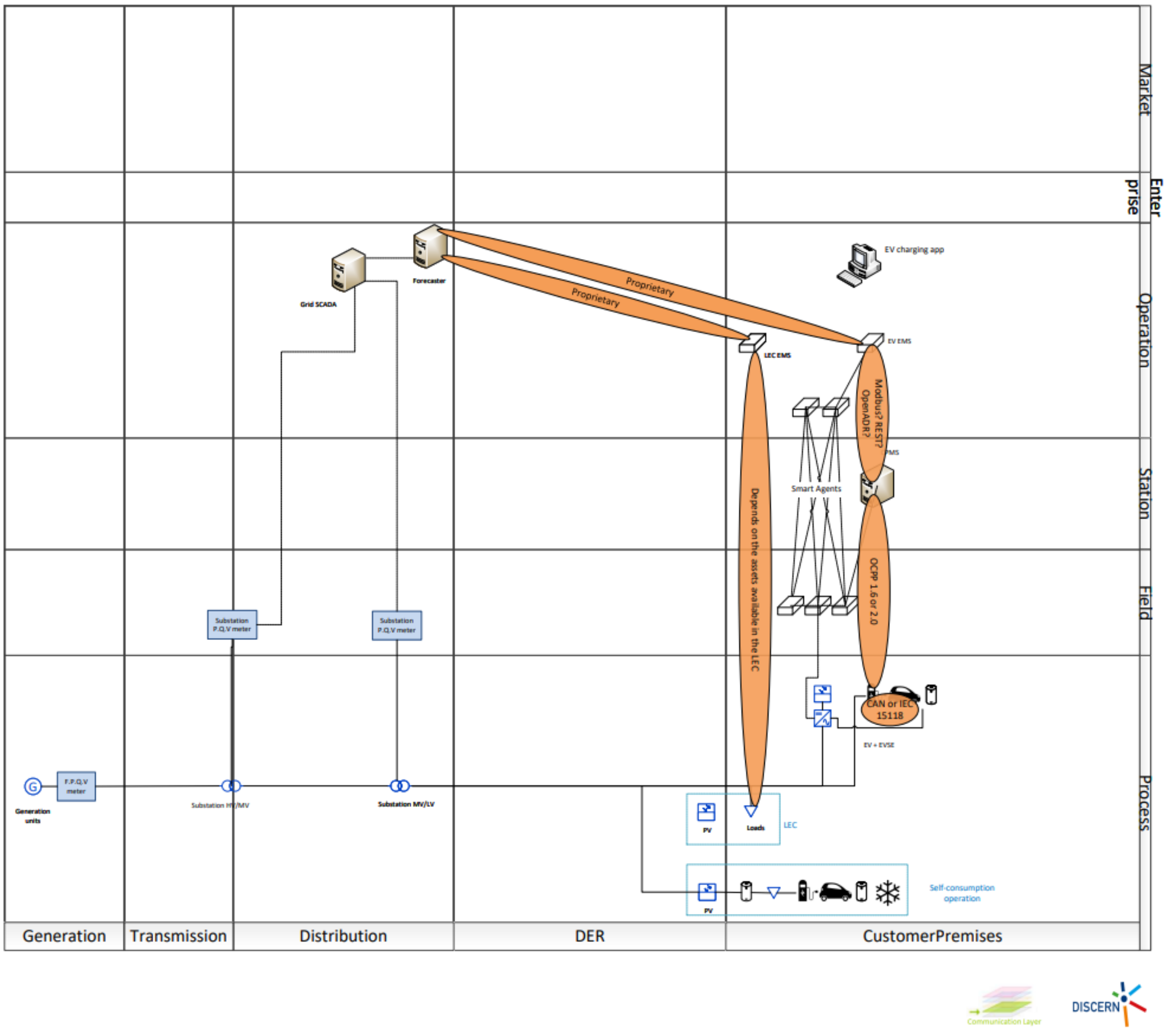

Figure 31: SGAM communication layer of the maximization of self-consumption and hybridization use case-specific architecture

The canonical data models listed in this illustration are not final and will be further discussed in task 1.4 "Interoperability and standardization of the technologies". Please refer to deliverable D1.4 "Interoperability-by-design framework" for further details on the communication standards to use in MAESHA.

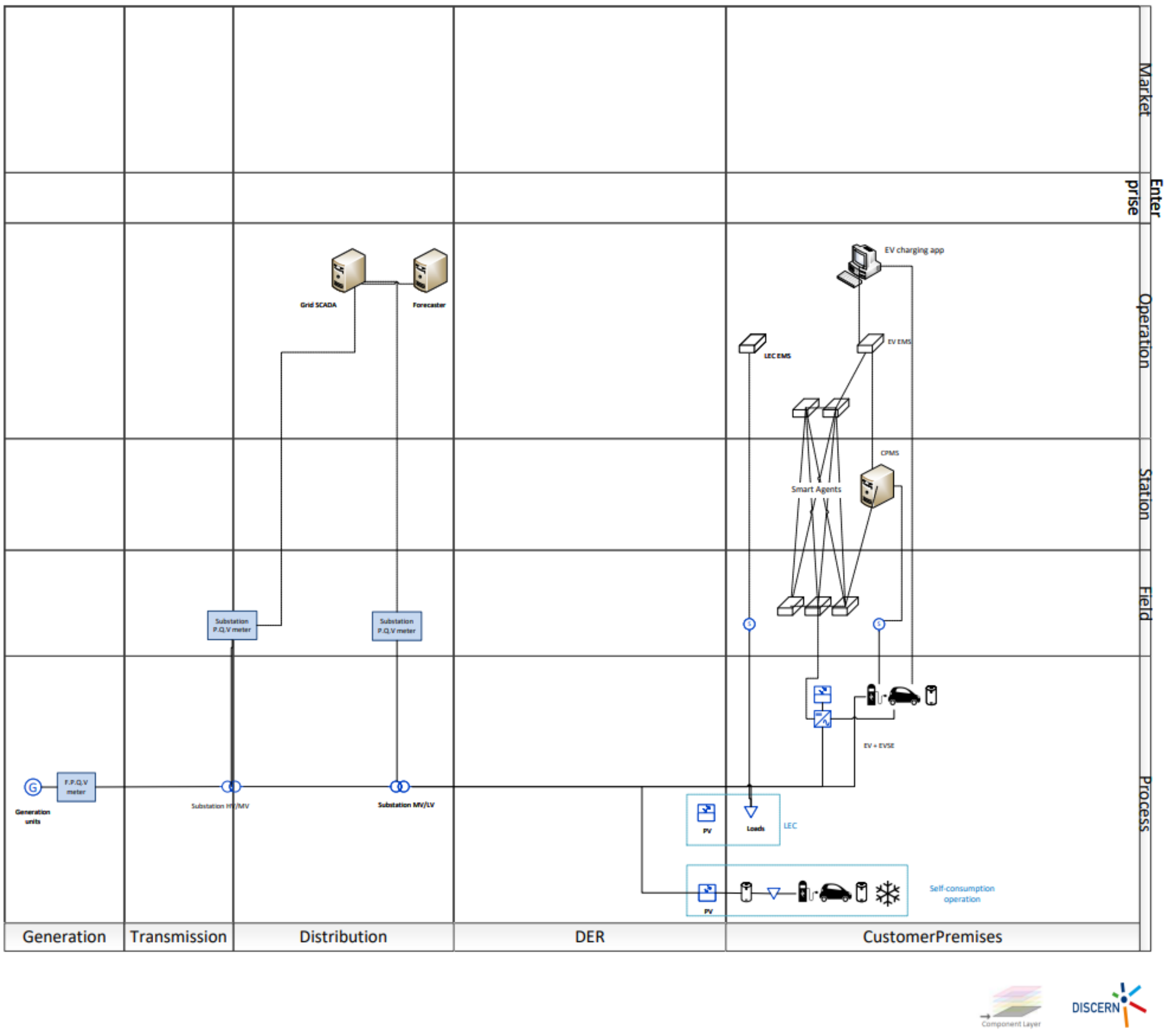

Figure 32: SGAM component layer of the maximization of self-consumption and hybridization use case-specific architecture

3.2.5 Energy access

The objective of this use case is to respond to the lack of reliable access to electricity in Mayotte through community solar self-consumption and Power-to-Hydrogen system, thus fostering higher community involvement and support for renewable energy technology. To empower those marginalized communities and enable citizens to become an active part of the energy system, this use case will also examine how they can offer services to the grid such as demand side mechanisms or frequency control. Please note that only the Business, Function and Component layers of this specific architecture are described, as this use case does not really imply information exchanges.

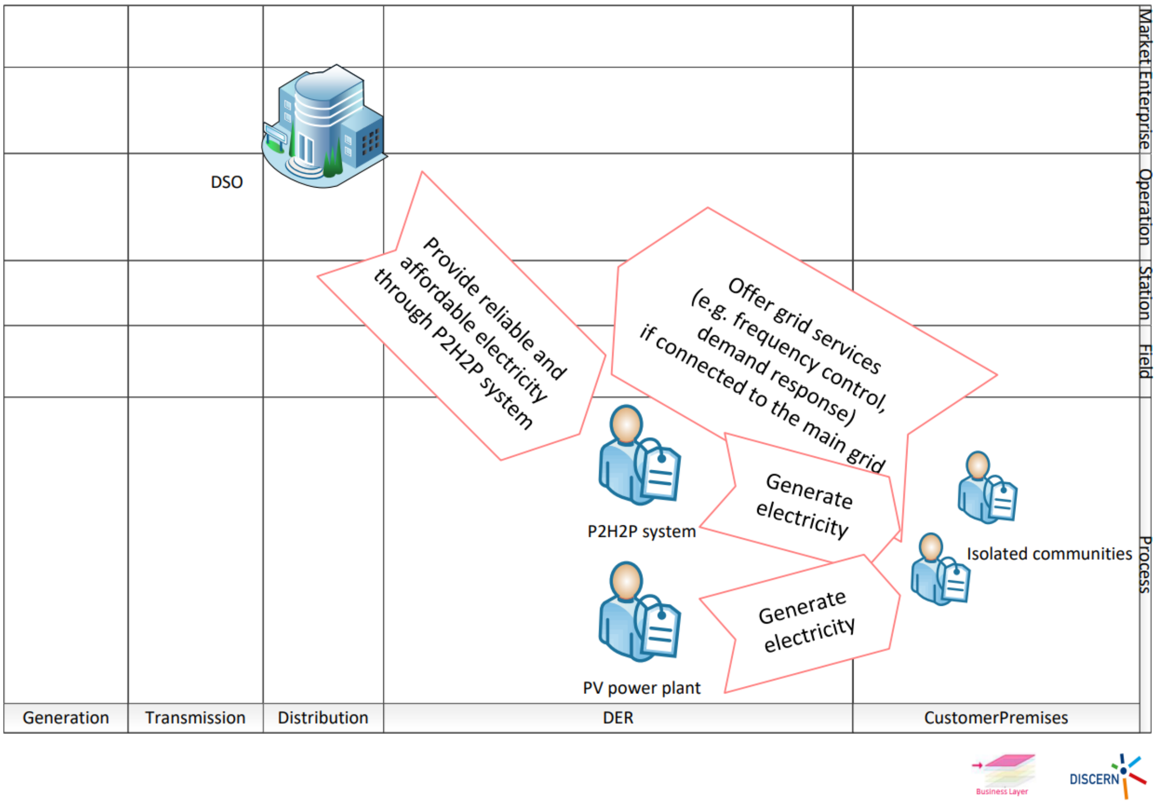

Figure 33: SGAM business layer of the energy access use case-specific architecture

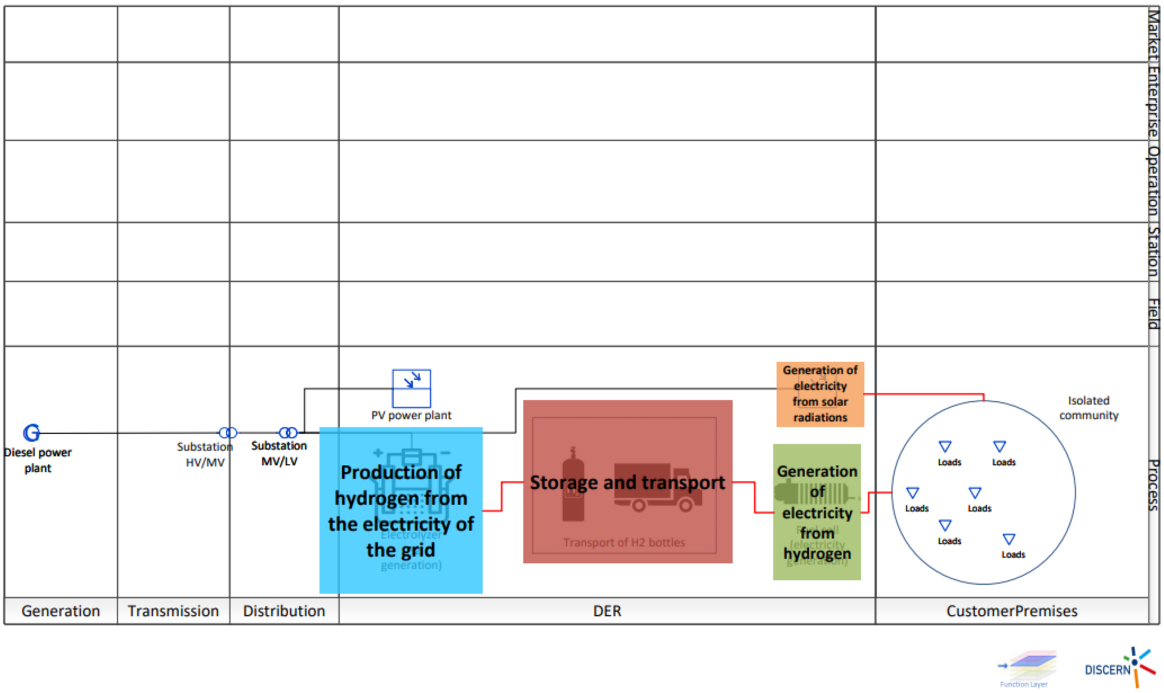

Figure 34: SGAM function layer of the energy access use case-specific architecture

Please note that the responsible entity for the transport of hydrogen needs to be defined. For instance, local people can be trained to transport the hydrogen from the electrolyzer connected to the main grid to the fuel cell connected to the community.

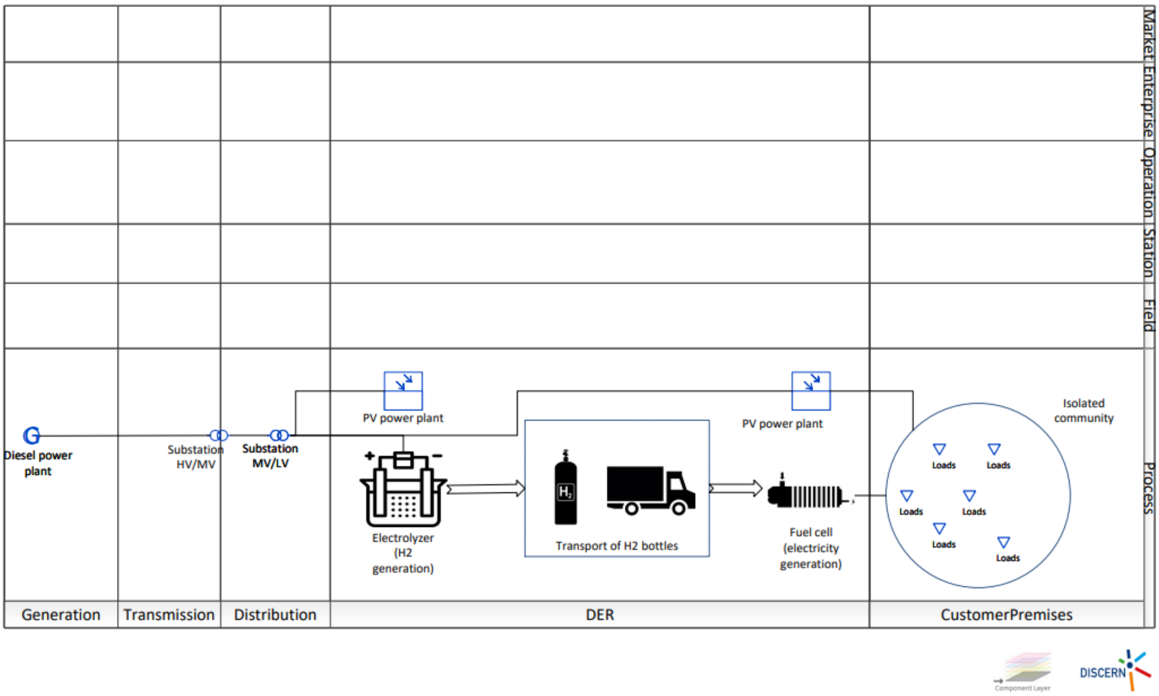

Figure 35: SGAM component layer of the energy access use case-specific architecture

4 CONCLUSIONS AND NEXT STEPS

This document presents the generic system architecture of the MAESHA solution as well as specific architectures for each of the five use cases selected for MAESHA, defined along with the project stakeholders. The next steps are now to select the most relevant communication protocols for information exchanges between components, to define the means to achieve interoperability to ease the integration of all components in the system (task 1.4) and to define and apply a coordinated security and privacy-by-design practice (task 7.3). Individual platforms will be architected in WP5, 6 and 7, whereas flexibility markets will be defined in WP4. Once all components developed, it will be time to do the interoperability and integration testing (WP8) before the demonstration of the MAESHA solution in Mayotte (WP9).

REFERENCES

[1] CEN-CENELEC-ETSI Smart Grid Coordination Group, "Smart Grid Reference Architecture", 2012. Available: xpert_group1_reference_architecture.pdf (europa.eu)

[2] MAESHA European project (Grant Agreement N°957843), 2020

[3] MAESHA, "Deliverable 1.1: Use cases, requirements and KPIs definition", 2021

[4] DISCERN European project (Grant Agreement ID 308913), "Tools", [No more accessible online]

[5] European commission, "Commission recommendation on cybersecurity in the energy sector (C (2019) 2400 final)", April 2019 [Online]. Available: https://ec.europa.eu/energy/sites/default/files/commission_recommendation_on_cybersecurity_in_the_energy_sector_c2019_2400_final.pdf [Accessed October 2021]

ANNEX

SGAM Objects

Here are the objects used to form the SGAM component layer. They have been defined in the DISCERN project (see [4]).

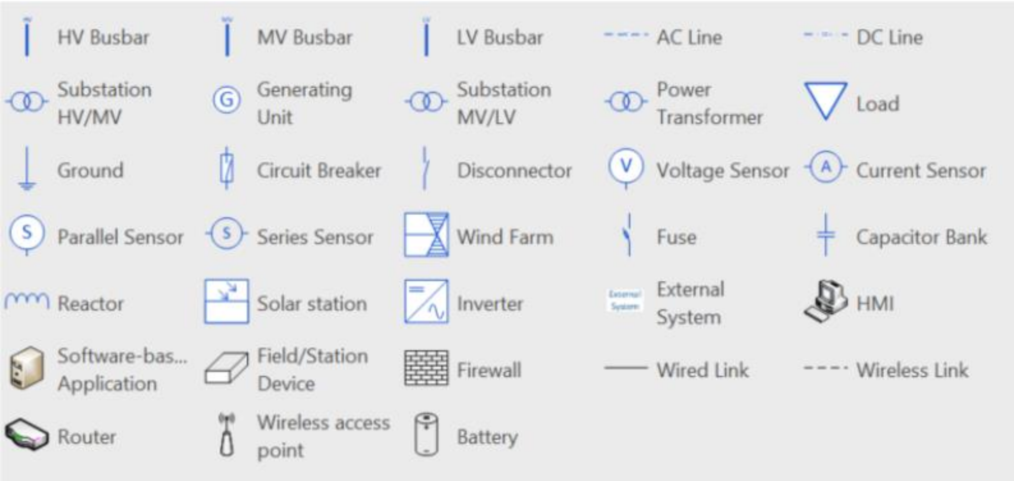

Figure 36: SGAM objects defined in the DISCERN template