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Demo and use case view on required interfaces/functionalities v2.0

Deliverable D3.1

29/08/2019

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EXECUTIVE SUMMARY

The goal of this document is to study and analyse the demonstrators involved in InterFlex project and their use cases, from an interoperability point of view.
A methodology is defined, based on the Smart Grid Architecture Model (SGAM) to compare the demonstrators. In particular, a SGAM clustering approach is set up in order to group devices and actors within common entities. The results of this analysis show that the use-cases and interfaces are comparable between the demos, but the chosen solutions or protocol are specific to each demonstrator. This analysis also highlights that real connections between devices are always orthogonal: domains are crossed in a same zone (horizontal link), and zones are crossed in the same domain (vertical link). As a result, two main alternatives are identified to realize a diagonal link: the "upper-bound" alternative connects the domains at a high level zone (operation, enterprise or market), while the "lower-bound" alternative connects the domains at a low level zone (field, station or process).
As a conclusion, the document selects three interfaces of interest as an input for task 3.1.2 (interoperability and interchangeability laboratory tests):

- two "lower-bound" interfaces:
    - Interface between field gateway and storage
    - Interface between field gateway and smart appliances, and
- one "upper bound" interface:
    - Interface between DSO SCADA and aggregators.

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1. INTRODUCTION

1.1. Scope of the document

The scope of this document is to study and analyse the demonstrators involved in the Inter-Flex project and their use cases, from an interoperability point of view.

For each demonstrator the architecture is studied, the interfaces are listed with solutions and standard used, and then an analysis of interoperability and exchangeability is performed.

1.2. Notations, abbreviations, and acronyms

The table below provides an overview of the notations, abbreviations and acronyms used in the document.

BAT	Battery
BMS	Building Management System
CP	Customer Premises
DER	Distributed Energy Resource
DG	Diesel Generator
DSO	Distribution System Operator
DSR	Demand Side Response
EC	European Commission
EC-GA	European Commission Grant Agreement
EMS	Energy Management System
ESCO	Energy Service Company
EU	European Union
EV	Electric Vehicle
GA	General Assembly
GFU	Grid Forming Unit
GSU	Grid Supporting Unit
GW	Gateway
GWP	General Work Package
HP	Heat Pump
HV	High Voltage
IMP	Intermediate Management Platform
KPI	Key Performance Indicator
LV	Low Voltage
MDM	Meter Data Management
MGC	Microgrid Controller
MV	Medium Voltage
P2H	Power-to-Heat
PC	Project Coordinator
PM	Portfolio Manager
PV	Photo Voltaic
RES	Renewable Energy Source
SC	Steering Committee
SSU	Smart Storage Unit
TC	Technical Committee
TD	Technical Director

WP	Work Package
WPL	Work Package Leader
WT	Wind Turbine

Figure 1. List of acronyms

1.3. EU Expectations from InterFlex

InterFlex is a response to the Horizon 2020 Call for proposals, LCE-02-2016 (“Demonstration of smart grid, storage and system integration technologies with increasing share of renewables: distribution system”).

This Call addresses the challenges of the distribution system operators in modernizing their systems and business models in order to be able to support the integration of distributed renewable energy sources into the energy mix. Within this context, the LCE-02-2016 Call promotes the development of technologies with a high TRL (technology readiness level) into a higher one.

InterFlex explores pathways to adapt and modernize the electric distribution system in line with the objectives of the 2020 and 2030 climate-energy packages of the European Commission. Six demonstration projects are conducted in five EU Member States (Czech Republic, France, Germany, the Netherlands and Sweden) in order to provide deep insights into the market and development potential of the orientations that were given by the call for proposals, i.e., demand-response, smart grid, storage and energy system integration.

With Enedis as the global coordinator and ČEZ Distribuce as the technical director, InterFlex relies on a set of innovative use cases. Six industry-scale demonstrators are set up in the participating European countries:

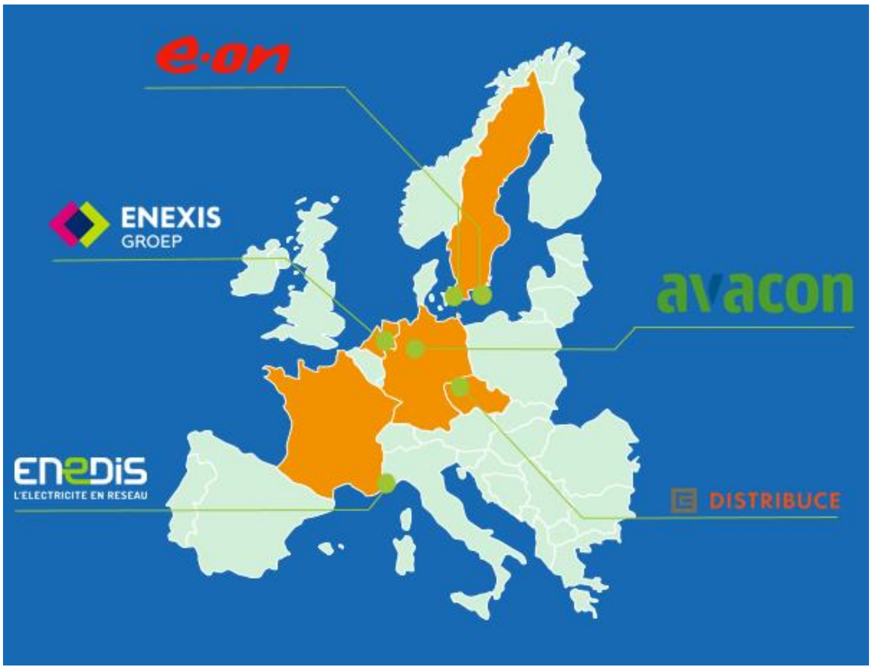


Figure 2. InterFlex Demo Map

Through the different demonstration projects, InterFlex assesses how the integration of the new solutions can lead to a local energy optimisation. Technically speaking, the success of these demonstrations requires that some of the new solutions, which are today at TRLs 5-7, are further developed reaching TRLs 7-9 to be deployed in real-life conditions.

The LCE-02-2016 call, as well as the other smart grid calls from Horizon 2020 program, explicitly required to perform “a detailed analysis of current regulations, standards and interoperability/interfaces issues applying to their case, in particular in connection to ongoing work in the Smart Grid Task Force and its Experts Groups in the field of Standardisation (e.g. CEN-CLC-ETSI M/490)”.
In particular, interoperability and standards are key enablers to allow the replicability of the project results, by ensuring a harmonised solution between EU countries.

The work detailed in this deliverable replies to these expectations by assessing the interoperability of the demonstrated solutions, at several layers, and based on the Smart Grid Architecture Model.

1.4. References

[1] “Smart Grid Reference Architecture”, November 2012, CEN-CENELEC-ETSI, Smart Grid Coordination Group
[2] InterFlex D2.1
[3] InterFlex Grant Agreement
[4] Uses cases and SGAM diagram from WP5-6-7-8-9
[5] https://ses.jrc.ec.europa.eu/

2. Methodology

This chapter describes the methodology used for a SGAM-based comparative study of interoperability challenges in the InterFlex demonstrators.

2.1. Aim of the study

Within the cross-demonstrator work package WP3 in InterFlex, the individual ICT architectures of the five European InterFlex demonstrators in Czech Republic, France, Germany, the Netherlands and Sweden are studied. This allows for a systematic deduction of general and specific interoperability challenges in ICT solutions for flexibility provision, as the scope of the topics under study from different InterFlex demonstrators is substantially wide. The present document outlines the approach that is used in this SGAM-based comparative study of interoperability challenges in European flexibility demonstrators. In this regard, technical and organisational solutions and recommendations are worked out to tackle the existing difficulties.

2.2. Input material

The analysis is based on detailed documentation of use cases and respective ICT architectures developed within the individual demonstrators. In order to identify similar ICT solutions but also similar challenges, as well as to be able to compare different implementations, the input material is harmonised in SGAM notation. For this work, the component, communication and information layers are most relevant, while the function and business layers are only required as a reference to the implemented functionality and use case. Therefore, the available input material for this study can be modelled as a set of graphs (one per use case, see Figure 3) with the nodes representing devices or logical actors and edges representing logical or physical communication relations with associated protocols and data models. In fact, the level of hierarchical clustering of devices, sub-systems and systems differs from demonstrator to demonstrator.

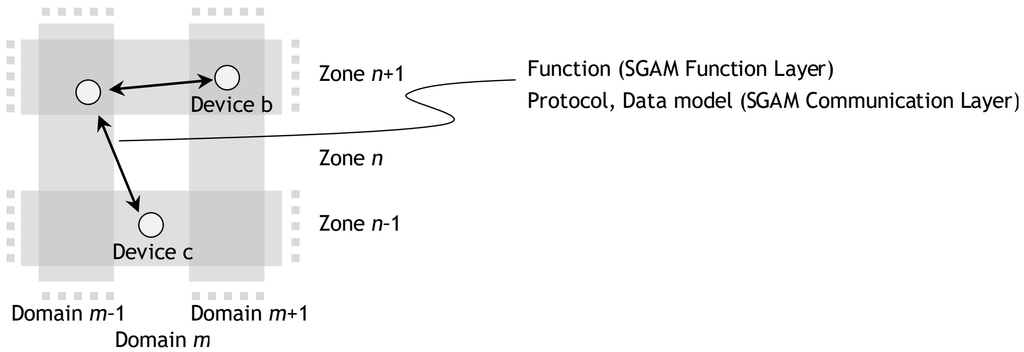


Figure 3. SGAM graph representation of demonstrator ICT architecture available for the study

2.3. Focus

In order to analyse interoperability and exchangeability among the InterFlex demonstrators, it is essential to identify relevant interfaces, preferably implemented in more than one instance. In an initial assessment together with responsible representatives of each InterFlex demonstrator, a number of relevant interoperability issues have already been identified qualitatively (for details see the chapter Interoperability analysis). This activity has shown that inter-domain communication (e.g. from the Distribution domain to the Customer Premises) should be in the main focus, while intra-domain links are mostly based on available solutions or are not subject to interoperability as much as the inter-domain links.

2.4. SGAM clustering

The level of devices, sub-systems and systems shown in the individual architectures differs from demonstrator to demonstrator. It is therefore useful to cluster devices and logical actors across different demonstrators in larger entities in order to achieve coherent sub-system representations. A straight-forward clustering approach is to merge all components that are placed in an SGAM cell (having same domain and zone) to one cluster. For the development of the methodology, this approach proved to be effective. This approach is also supported by the fact that inter-domain links can be regarded as more relevant than intra-domain communications

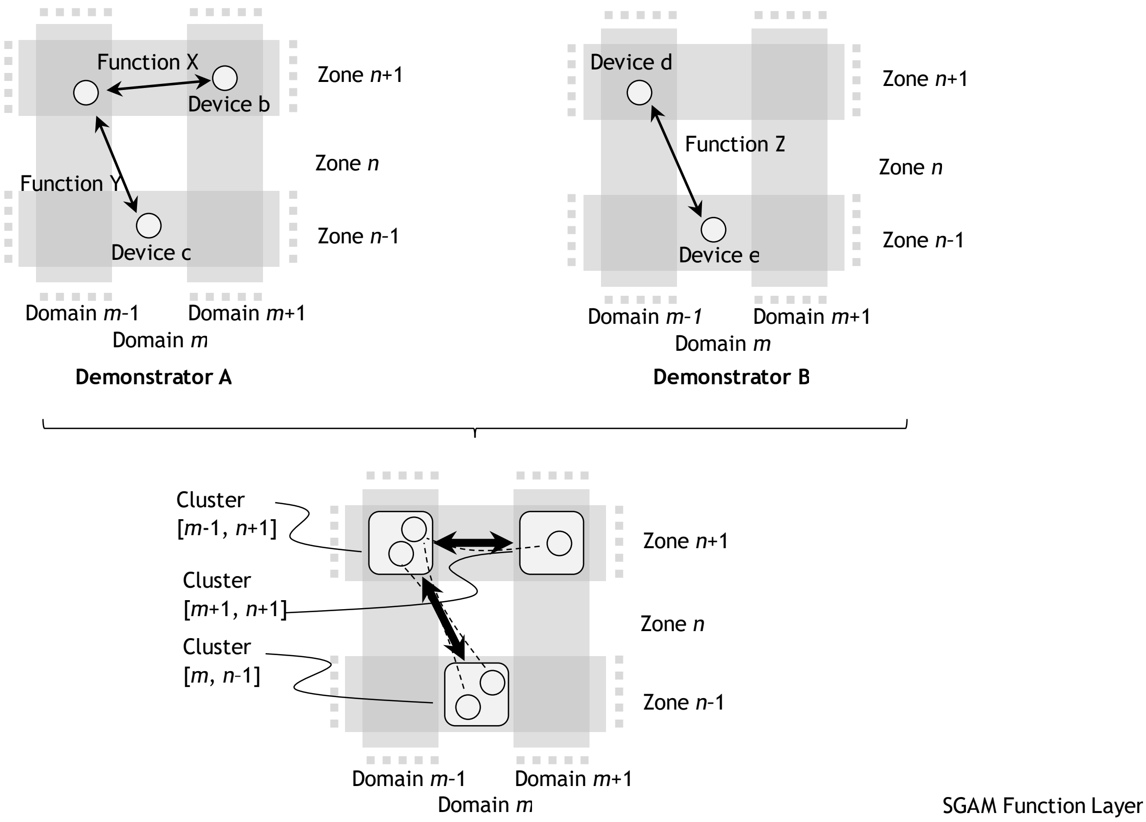


Figure 4. Approach for clustering devices and logical actors from different demonstrators and defining bundled communication links (bold arrows)

As shown in Figure 4, the clustering of logical actors and devices with one SGAM cell forces all individual communication relations between devices in different cells into one single bundled communication interface that supports multiple functions, potentially multiple protocols and data models, and in extreme cases even use different physical links.

2.5. Orthogonality in SGAM communication links

A closer look at the example in Figure 4 reveals that the shown configuration of a diagonal link between two different zones and two different domains is actually an abstraction done on the function layer. On the communication layer, the technical realisation of such a diagonal link is most likely an orthogonal arrangement with an intermediate actor. This can be seen in an example shown in Figure 5. This SGAM diagram illustrates a PV inverter in the DER domain (Field zone) remotely monitored by the Distribution System Operator's (DSO's) SCADA system. In this case, there are two principle methods to communicate between the SCADA and PV inverter.

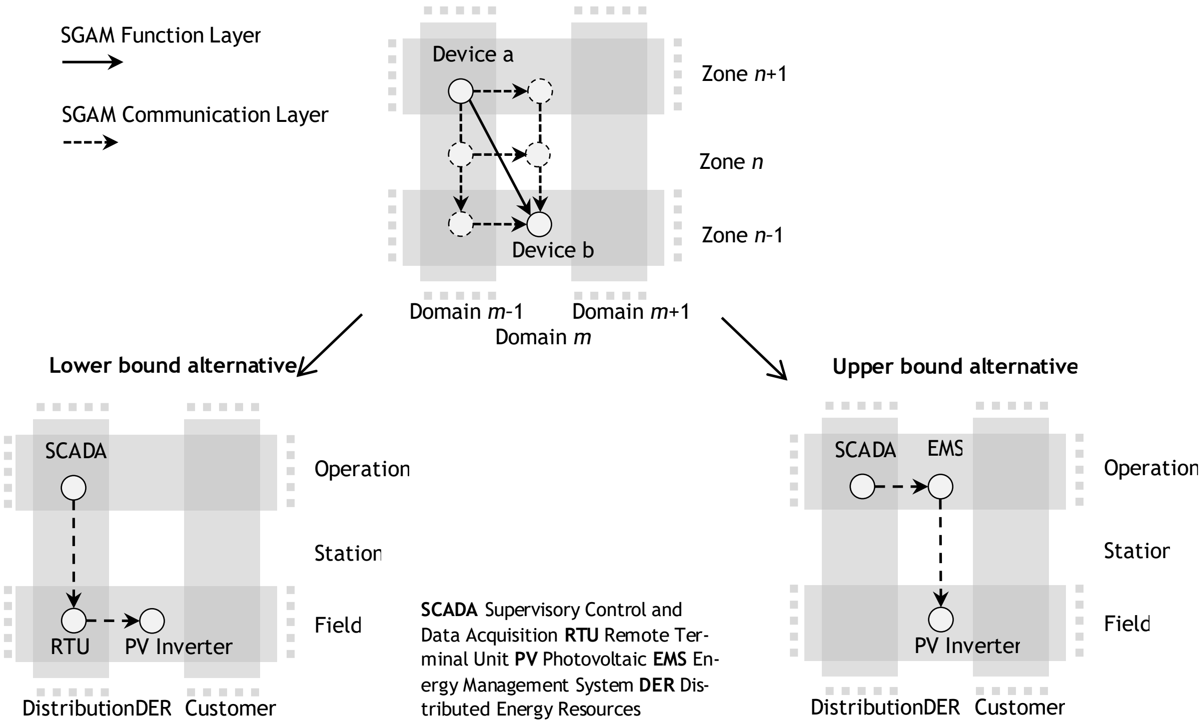


Figure 5. The realisation of a cross-domain and cross-zone communication link splits up into a series of orthogonal links.

The DSO could either employ its own Remote Terminal Unit (RTU) in the Field zone from where a monitoring interface is provided to the PV system (left side of the figure). Alternatively, the DSO's SCADA system can be interfaced with the PV operational system, i.e. Energy Management System (EMS) in the Operation zone and from there the PV operator interfaces the Field device.

Most inter-domain connections start and end in the same SGAM zone. While this is not a strict technical necessity, there are however a number of reasons for this way of implementing cross-domain links.

1. When the system scales (e.g. DSO requires to contract more individual flexibilities), the associated engineering effort and scaling costs should be handled by the domain where the scaling occurs (in the example: customer domain). In a diagonal link scenario, handling scalability is pushed to the domain that has no direct influence on the number of devices in the scaling domain (in the example: Distribution Domain).

2. A cross-domain link has cyber-security implications as it is a potentially more prominent target for cyber attacks. Definition of security measures should be based on an agreement among both domains (e.g. Distribution and Customer Premises). Connecting not only two domains but also different zones with such a link would result in a situation where one domain (e.g. Distribution) has to deal with security issues of a lower zone in another domain (e.g. customer domain field equipment), which is often undesired.

Theoretically, the horizontal link can also be made on an intermediate zone. However, this implies that not only a single but even two intermediate devices are required (or have to be upgraded) to facilitate the link. Consequently, this solution is typically not chosen for cost implications.

2.6. Localisation-based versus ownership-based placement

The above described orthogonality can only be observed when the respective SGAM model employs a strict ownership-based domain placement. This is different to a localisation-based placement, where devices are shown in the respective domain in which they physically can be found. Location information is sometimes of more use for a device operator than the ownership information. However, for the present study, all underlying SGAM documentation requires to be ownership-based. For this reason, some of the SGAM models provided by the InterFlex demonstrators were slightly changed, to reflect ownership-based placement.

2.7. Consequences for the clustering approach

The considerations of the previous section result in the finding that primarily two solutions exist for each cross-zone and cross-domain information exchange. Field zone devices are typically involved in such cases in practice. Access to such field zone devices, therefore, is either possible via a dedicated field zone counterpart in the neighbouring domain (lower bound connection), or via a higher level counterpart to and from there down to the device (upper bound connection). This is also shown in Figure 5. Within the InterFlex demonstrators, there are examples for both solutions. They can be assessed as belonging to the same class of clustered interface (see Figure 2), but individual interoperability analysis has to be done for both solutions separately, since data models, protocols and physical channels differ significantly.

2.8. Expected outcome

The clustering analysis of ICT architectures from InterFlex demonstrators will result in a set of clustered interfaces on the SGAM function layer. This can then be decomposed in lower and upper bound alternatives on the SGAM communication layer. For each communication layer clustered link, best-practice solutions, as well as an analysis of potential gaps will be performed.

2.9. Next steps

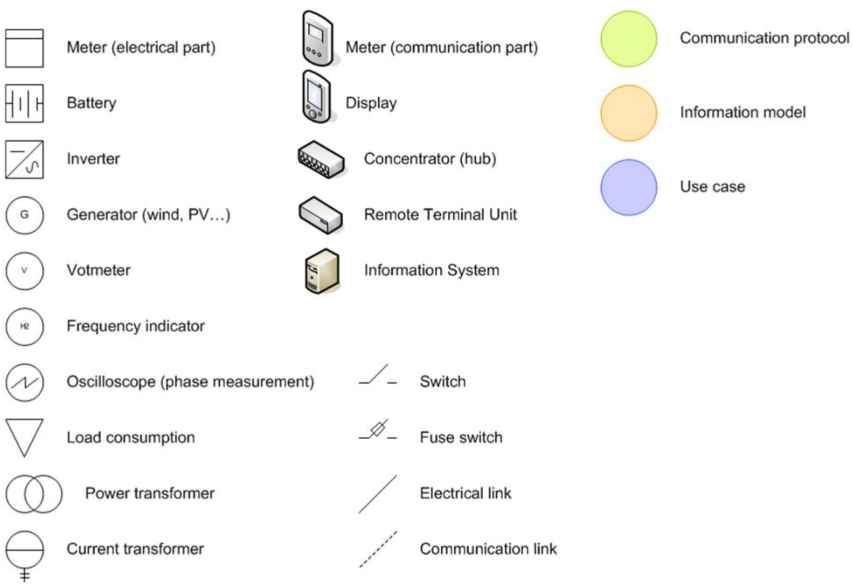
Based on the results of the above outlined study, an interoperability testing suite will be worked out and exemplary cases will be demonstrated in laboratory tests. For interoperability analysis, the main focus lies on (both lower and upper bound) horizontal interfaces since there is a cross-linking between different actors.

3. DEMONSTRATOR DESCRIPTIONS AND USE CASES

Use cases descriptions are integral copy/paste from the proposal, in order to give the context.

General keys used in SGAM scheme are the following:

Symbol	Description	Symbol	Description
	computer (CRM, DMS, HES, etc.)	G	generator
	gateway		substation
	HMI		information flow (wired)
	data collector		information flow (wireless)
	controller and IED		power grid
	transmitter		bus
			power line



3.1. Demo FR

3.1.1. General

Note: The information reflected in this document is based on a workshop held in Paris on May 17th, 2017 and the UCs description and SGAM diagrams provided by the French demo before April 30th 2019.
Also, it should be noticed that as Use Case 2 aims at maximizing the benefit of the storages developed for Use case 1 and Use case 3, a specific interoperability analysis of Use case 2 is not relevant.

3.1.2. Use case FR.1: As an alternative to grid reconfiguration and generators, DSOs can provide a continuous supply of electrical energy to industrial customers, thanks to electricity storage assets operated by the DSO or aggregators

Isolated areas and islands are often supplied with a single MV line, meaning that in case of an outage, fossil-fuelled auxiliary generators are today the quickest way to recover the supply of electricity. Islanding, which consists in partial disconnection of a district from the main grid for a limited duration of time, could proceed automatically through the DSO SCADA. It would then be an interesting, fossil-free and more effective alternative to traditional generators. An islanding scheme based on a DSO storage asset and an aggregator storage asset could be implemented and operated on islands such as Lérins islands in the frame of InterFlex, to supply customers for a limited duration.
During an islanding, the DSO storage system, as a grid forming unit, maintains the frequency and voltage by balancing consumption and generation until the main grid is restored. The aggregator storage system, as grid supporting unit, is used to provide energy and therefore maximize the potential islanding duration, thanks to a wireless communication system.

Description of the system:

- Islanding a Medium voltage area
- Storage system, islanding configuration, islanding system
- Flexibility allows to minimize the size of the storage or to increase the islanding duration (Target system, not tested during the demo)
- The distribution system will be kept working during the islanding period
- “Brain” of the islanding system has to communicate with the grid supporting unit and the PVs
- Communication to PVs: frequency signal based on PHY layer
- Communication to GSU: radio signal
- Main subjects: communication with supporting unit and with storage system
- Target: higher islanding duration, minimize size of storage

3.1.3. Use case FR.3: innovative flexibilities can be aggregated and bid either on a local DSO mechanism to reduce local grid constraints or on national market to ensure global stability

In the considered area of the demonstration, many potential flexibility sources coexist with very different load profiles and characteristics: industrial consumers, electrical vehicles, residential consumers and professional consumers (and/or prosumers), distributed generation (which injection could be modulated) ... All those flexibilities have different characteristics to be managed (notification time, minimum/maximum duration time, activation costs, number of activations by day, month, year). Besides the traditional mission to operate, maintain and develop an efficient electricity distribution system, DSOs are asked to fulfil a new role, “the neutral market enabler”. This requires in turn clear operational and organizational rules as the processes necessitate a multi-level of coordination between actors including technical standards, especially for flexibilities connected to the Distribution Grid.

Flexibilities can bid on a DSO aggregator platform named e-Flex covering 4 primary substations on a territory.
Local flexibilities can be used at several levels to increase their benefits to the community and foster their business case:

- Locally, they can be bought by the TSO in order to relieve the upstream transmission grid in a region at the edge of the electrical grid with constraints occurring in winter (peak time in France)
- Locally they can be also bought by the DSO in order to mitigate distribution grid constraints, especially due to intermittent energy such as PV or load peaks in N-1 configuration.
- They can also bid on the National markets organized by the TSO (ancillary services, balancing mechanism)
- They can be monetized on the energy markets and in a near future on the capacity market

This local energy mechanism (DSO e-Flex) managed by the DSO will be interfaced with the aggregators, allowing for a large number of diverse consumers to participate. For its own needs, the DSO could become a market enabler, delivering the order of merits for each of the candidate flexibilities and asking for bids in the day ahead, and able to activate intra-day actions. Such a system thus includes a flexibility certification process, day-ahead and intraday activation processes, as well as a market settlement in order to assess the effects of flexibilities as well as to pay aggregators. Aggregators, the two largest French electricity retailers, EDF Retail and Engie, manage the various types of flexibilities, including a multi-carrier approach where hybrid appliances (Gas/electric) are tested to validate the role of the gas carrier in supporting the local electricity system. The use case aims at demonstrating that DSOs are able to dynamically search for the optimal grid activation area which maximizes the expected flexibility efficiency for the distribution grid.

Description of the system:

- Located in Nice, Carros, Guillaumes and Isola
- Aggregator will pilot flexibility (hybrid boiler, CHP, EV pilot, PV and storage, backup diesel generator)
- One aggregator per site, connected to 1 smart meter per site
- Control comes from aggregator - via aggregator system
- Flexibility of aggregator valorised toward DSO
- Forward planning system (IS for forecast)
- HV separated from LV, different management (HV more instrumented, managed by a distinct entity)
- LV: Linky smart meter (help to manage LV network)
- Possibility to provide flexibility from Linky
- Flex system: aggregating, dispatching, re-optimization in order to find another way to provide the same service in case of unavailability
- Aggregators will connect and get data from the site and send data to the devices

3.1.4. Architecture

Two architectures are demonstrated in the French demonstrator, as depicted below. It has to be noted that UC2 is an "abstract" use-case which is demonstrated on both architectures.

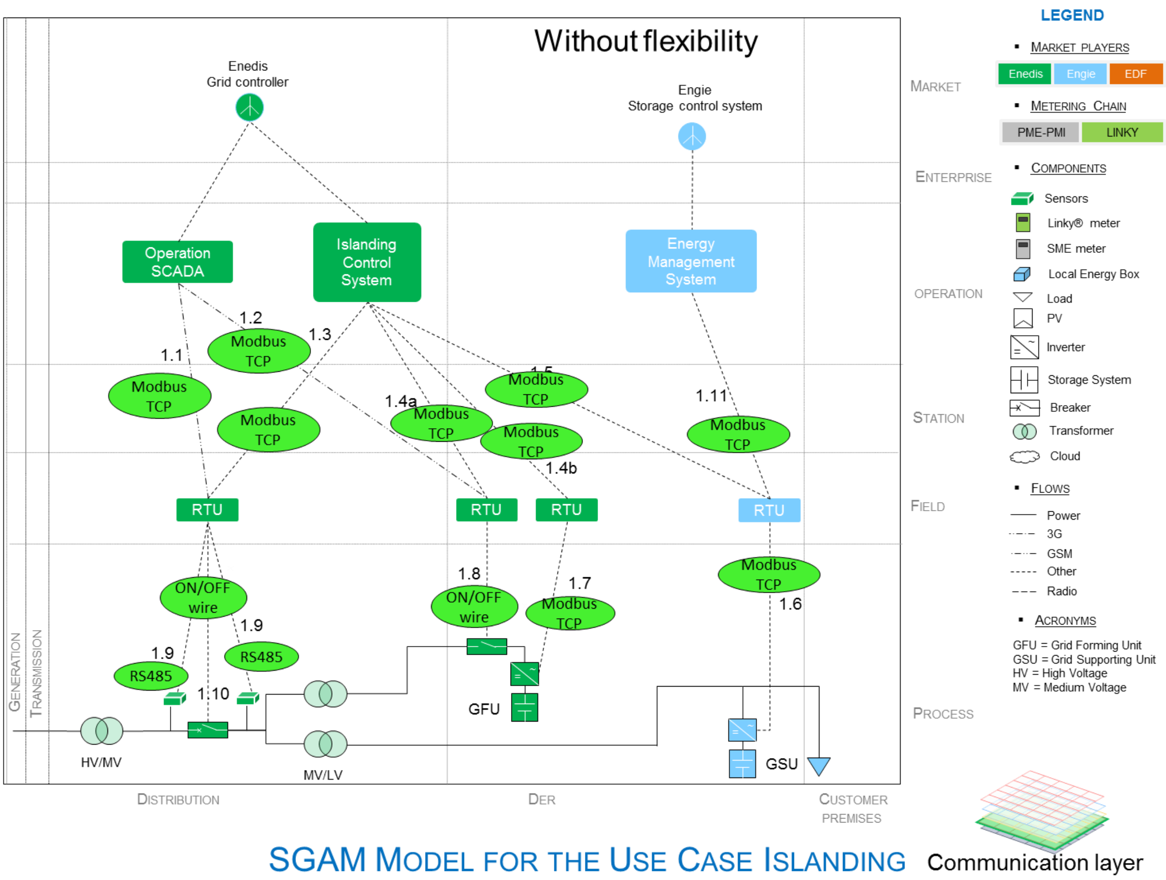


Figure 6. French demo - Uses-cases 1 and 2 - SGAM diagram - Communication layer

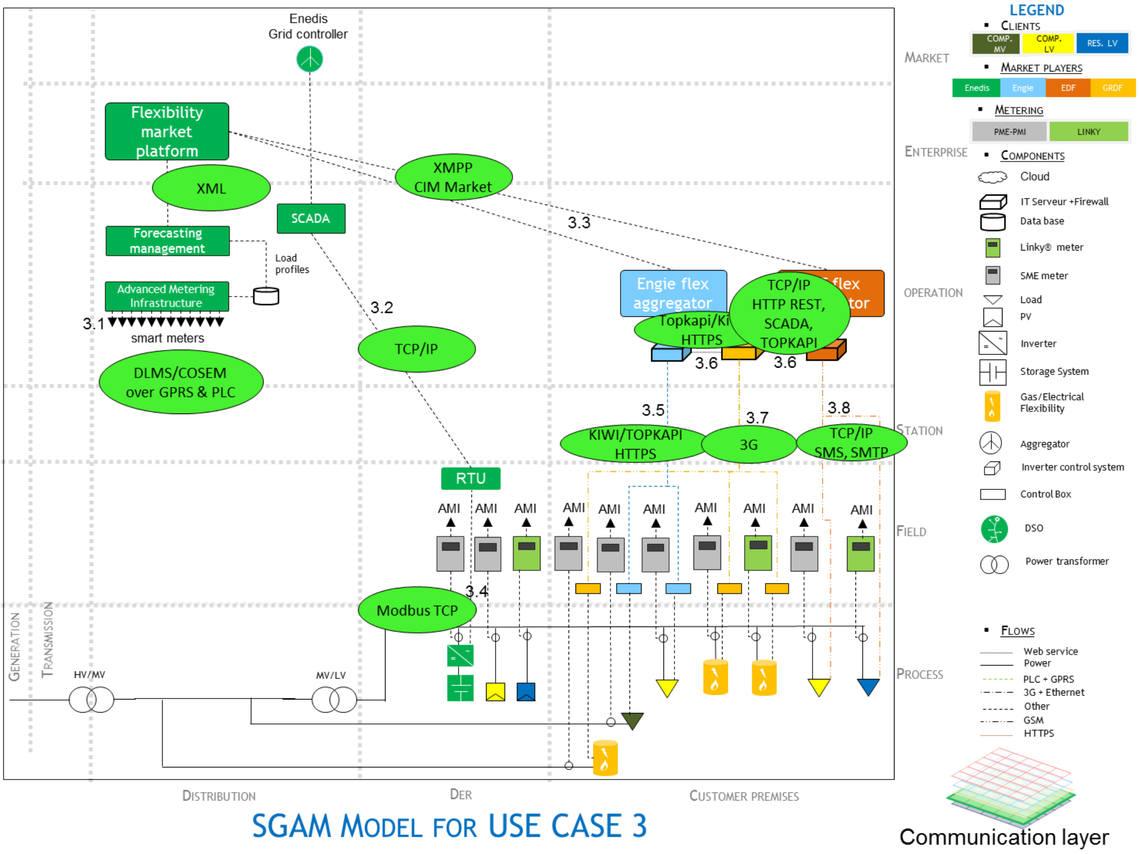


Figure 7. French demo - Uses-cases 2 and 3 - SGAM diagram - Communication layer

3.1.5. Interfaces

The table of interfaces for French demo can be found in annex 6.1 - Interfaces for French demo.

3.1.6. Solutions and standards

Name	Status	Foreseen standard
FR1.1	Defined	Modbus TCP
FR1.2	Defined	Modbus TCP
FR1.3	Defined	Modbus TCP
FR1.4	Defined	Modbus TCP
FR1.5	Defined	Modbus TCP
FR1.6	Defined	Modbus TCP
FR1.7	Defined	Modbus TCP
FR1.8	Defined	ON/OFF wire
FR1.9	Defined	RS 485
FR1.10	Defined	ON/OFF wire
FR1.11	Defined	Modbus TCP
FR3.1	Defined	DLMS/COSEM over GPRS & PLC

Name	Status	Foreseen standard
FR3.2	Defined	TCP/IP
FR3.3	Defined	XMPP & CIM Market
FR3.4	Defined	Modbus TCP
FR3.5	Defined	KIWI/TOPKAPI & HTTPS
FR3.6	Defined	KIWI/TOPKAPI, REST & HTTPS
FR3.7	Defined	3G
FR3.8	Defined	TCP/IP, SMS & SMTP
FR3.9	Defined	XML

3.2. Demo CZ

3.2.1. General

The information reflected in this document is based on a workshop held in Prague on March 8th, 2017 and the UCs description and SGAM diagrams provided by the Czech demo before November 30th 2017.

3.2.2. Use case CZ.1: Increase the DER hosting capacity of LV distribution networks by combining smart PV inverter functions (demonstration of Q(U) and P(U))

ČEZ Distribuce and its partners aim at increasing the network hosting capacity with smart PV inverter functions Q(U) and P(U)[1]. The focus is on demonstrating and gaining practical experience under real operating conditions within LV distribution networks. The challenge of the demonstration lies not only in constructing a validation environment to measure the effects of P(U) and Q(U) controls but also in the validation of the correct PV inverter configuration (activation function) for the inverters. A successful demonstration requires appropriate conditions for testing the accordance to the EN 50438 ed.2 power quality standard. New PV systems are installed under two preselected MV/LV secondary substations. These represent two areas with different grid topologies and high penetration of PV systems (expected 100kWp per MV/LV substation). Crucial tasks for this use case are the recruitment of customers within the above-selected areas, the installation of PV systems with smart PV inverters and the delivery of technical operational data and results from the PV inverter monitoring systems with the customer's consent.

Details about the system:

- Volt-var and volt-watt defined by EN50438:2013 and CENELEC TS 50549-1
- Smart PV inverters perform controls autonomously, there is no communication with the central system
- The smart PV inverters are provided by 2 manufacturers: Schneider Electric and Siemens
- PQ measurement are done with 1 sample per min
- No remote update of settings in the inverters is planned
- In 2040, ČEZ expects up to 800.000 small PV units in their grid

[1] Q(U) relates to a local control approach where reactive power is drawn from the grid with increasing voltage, having a damping effect on voltage variations. P(U) refers to a reduction of active power fed to the grid with increasing voltage at the feed-in point. Further details are discussed in Deliverable D6.1

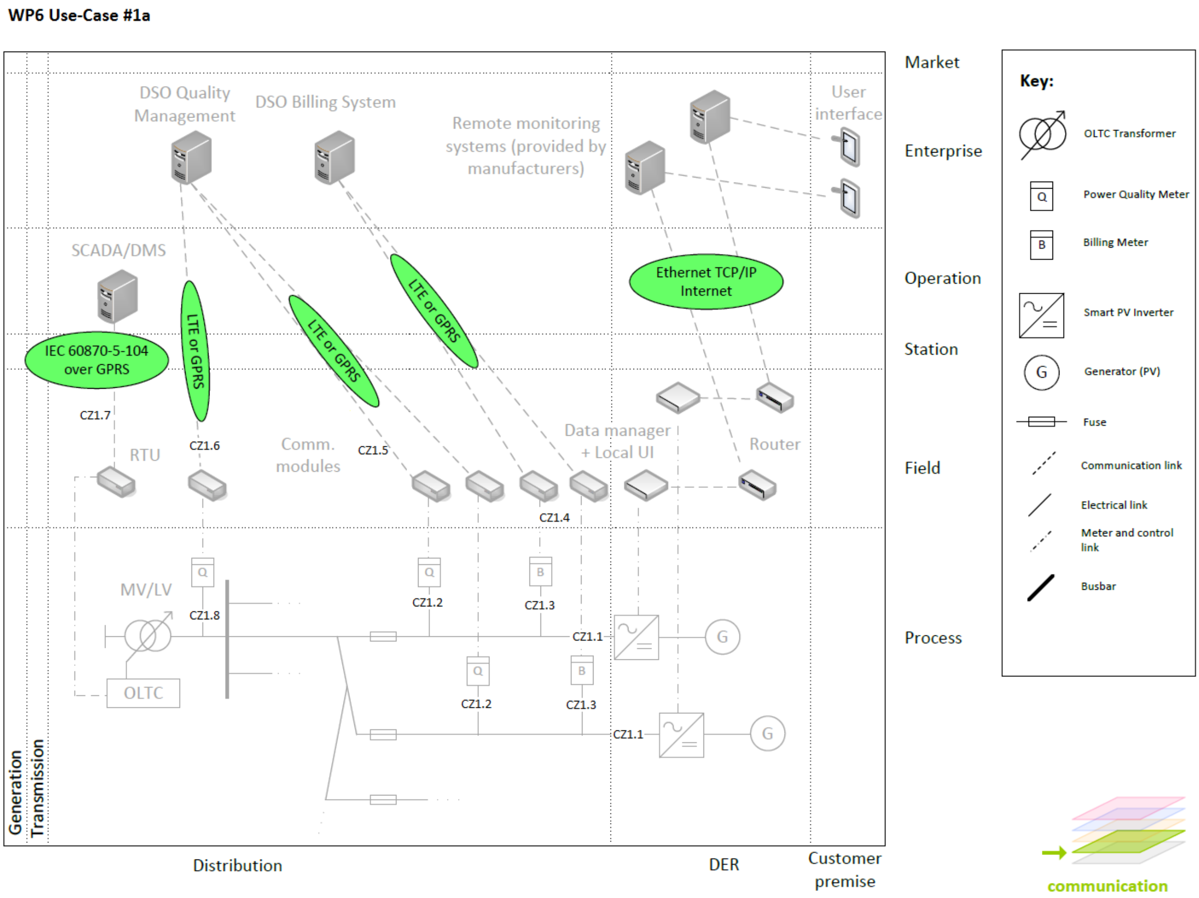


Figure 8. Czech demo - Use case 1a - SGAM diagram - Communication layer

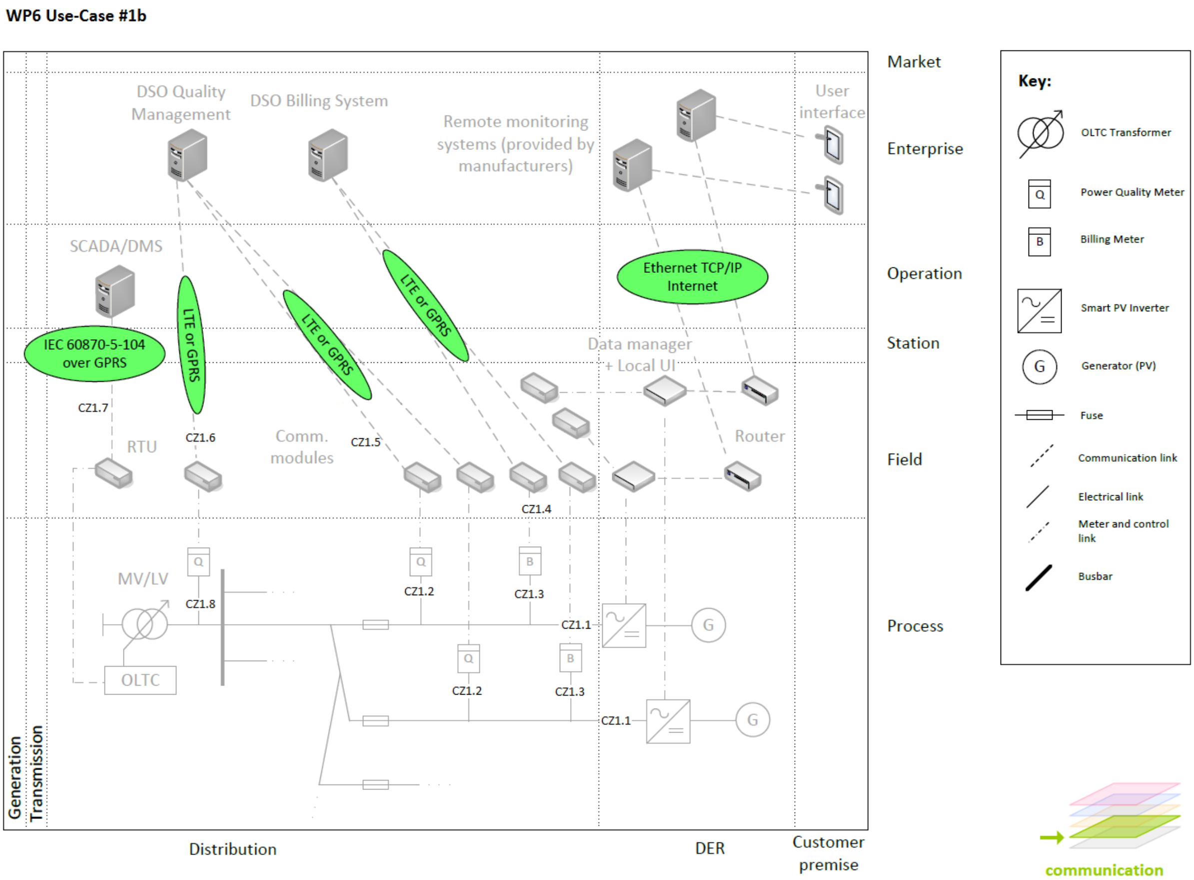


Figure 9. Czech demo – Use case 1b – SGAM diagram – Communication layer

3.2.3. Use case CZ.2: Increase the DER hosting capacity in MV distribution network by volt-var control (V/Q regulation)

ČEZ Distribuce integrates selected DER units connected to MV level into their volt-var control system (PV: 4.8MW, biogas station: 1.25MW, wind: 4.6MW). The DSO can send required voltage set points from its SCADA to DER unit, which then react and regulate at the required voltage set points (thanks to reactive power generation/consumption). For this volt-var control strategy, ČEZ Distribuce leans on existing DER over 100kW with communication capabilities (usually GPRS) towards the DSO dispatching control system (SCADA).

Details about the system:

- 3 types of DER units involved in the demonstration: PV, biogas, wind (PV Žamberk 1.1 MW, Biogas station Dětenice 1.25 MW, Wind park Kopřivná 4.6 KW)
- The DER unit operator has to provide a defined automation interface accepting set-points and communicating measurements.
- The SCADA sends voltage setpoints to MV generation units, these in turn will control reactive power accordingly
- Connection to ČEZ Distribuce DMS through existing GPRS for the RTU, using IEC 60870-5-104
- The control algorithm is up to the manufacturer/DER unit operator, based on ČEZ Distribuce recommendation

- The correct operation / adherence to the recommendation is checked during the commissioning (no standard for this functionality)
- The communication between the interface RTU and the local DER control systems is up to the manufacturer (the only defined interface is the upstream interface 60870-5-104 over GPRS)
- The interface between DSO measurement tools and DMS is also 5-104
- The power factor range between 0,95 ind to 0,95 cap should be featured by the units
- The GPRS Sim-Card is the border between DSO and unit operator

WP6 Use-case #2

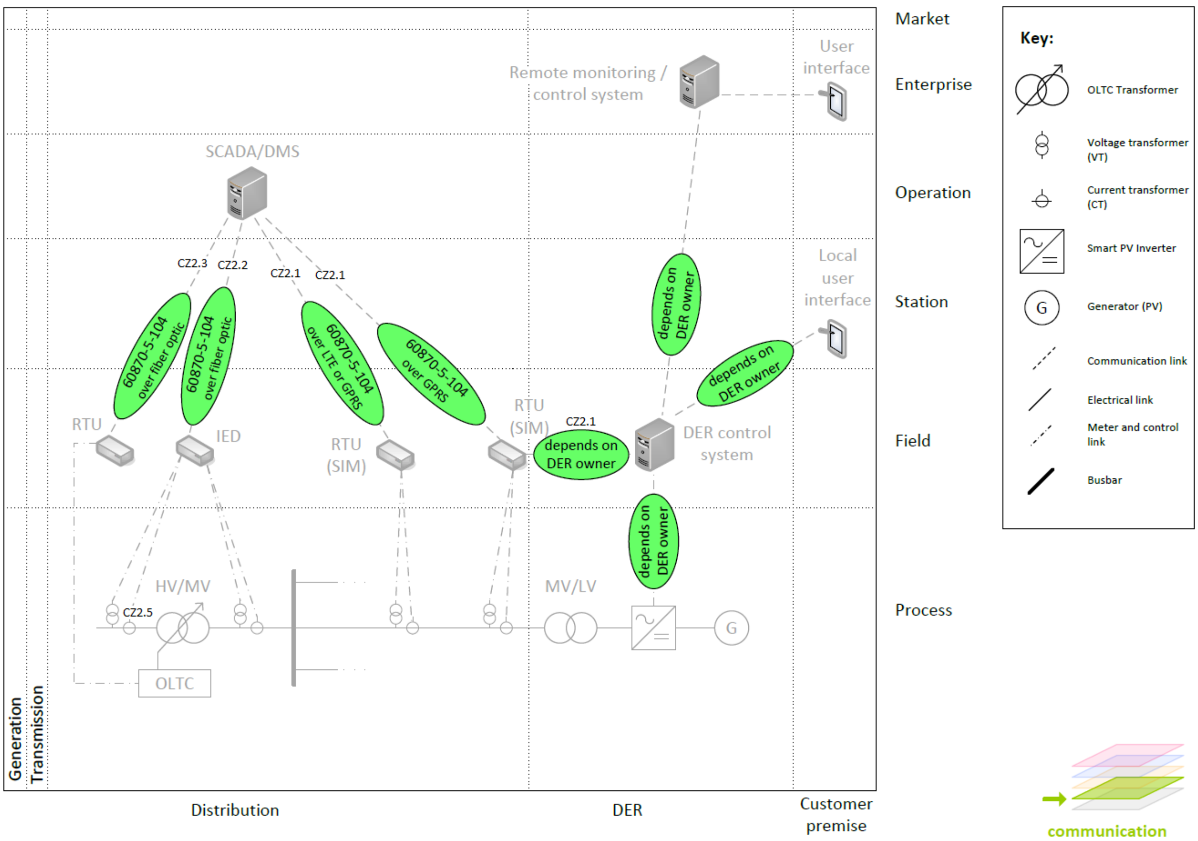


Figure 10. Czech demo - Use case 2 - SGAM diagram - Communication layer

3.2.4. Use case CZ.3: Smart EV charging

ČEZ Distribuce together with partners aim at testing the influence of smart EV charging stations functions. The aim is to show their capability to increase the network flexibility through improved EV charging station controls (services to the distribution network), and optimizing the future EV charging stations implementation to prevent from power quality issues. Charging stations are planned to contribute to the system stability and flexibility without reduction of customer comfort. The smart functions to be tested (first in a laboratory then in the field) are partial active power curtailment of EV charging in case of under frequency or under voltage in the DS and partial remote active power curtailment from DSO SCADA in case of emergency.

Details about the system:

- Charging stations from two manufacturers are involved (Schneider and Siemens)

- Charging output is limited to 50% in case of under-frequency or under-voltage, triggered using ripple control system based on narrowband powerline (NB-PLC) one-way communication
- PLC protocol is defined by ČEZ Distribuce
- NB-PLC transmitters and receivers are CEZ Distribuce's asset
- Emergency functions defined:
    - Underfrequency (local measurement)
    - Undervoltage (local measurement)
- Signal from ČEZ (ripple control 50%)
- Both manufacturers do not directly pick up the NB-PLC signal at the charging station but do this at substation level and use different means of communication (GPRS, direct wire) to the charging station.
- Realization of the connection for the Signal:
    - Ripple control to substation
    - Receiver in substation
    - Wire to charging station (Schneider)
    - Internet link from substation to charging station (Siemens)
- Site 1: Hradec Králové – 2 x Schneider 22kW with Mennekes connector + domestic socket
- Site 2: Děčín – 1 x Siemens with two 22 kW Mennekes outlets

WP6 Use-case #3a

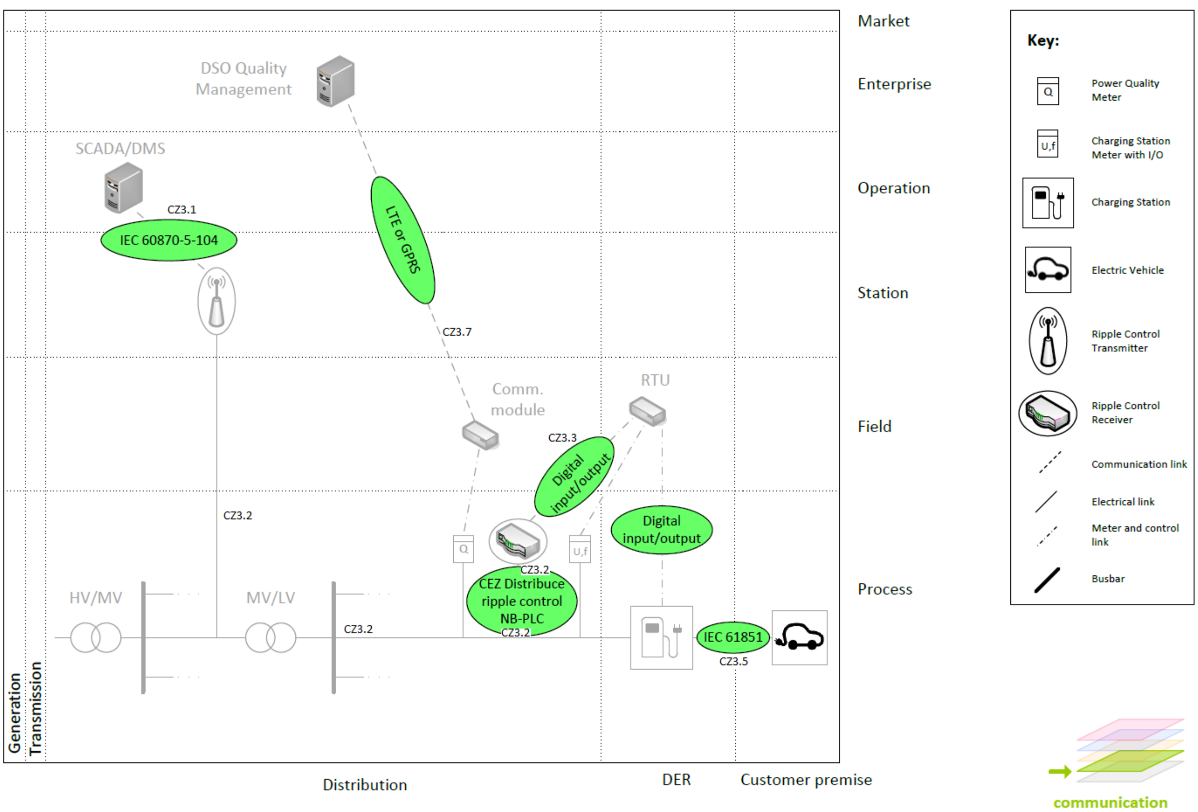


Figure 11. Czech demo – Use case 3a – SGAM diagram – Communication layer

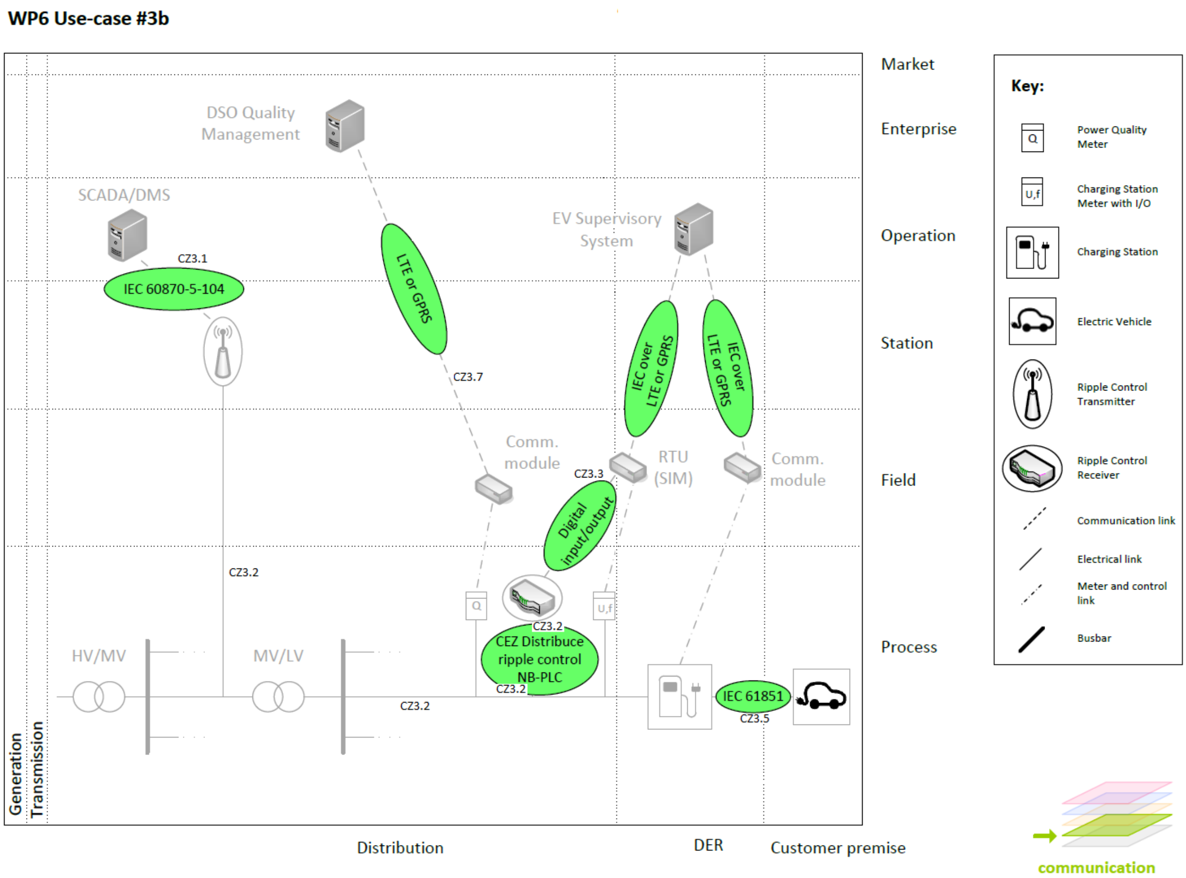


Figure 12. Czech demo – Use case 3b – SGAM diagram – Communication layer

3.2.5. Use case CZ.4: Smart energy storage

ČEZ Distribuce analyses the influence of residential energy storage systems (PV + battery) on LV distribution networks and also assesses the potential of grid-connected energy storage systems (for increasing the flexibility by providing grid services). The smart energy storage functions which are going to be tested are similar to the use case CZ.3: active power injection in case of DSO request and active power injection in case of underfrequency or undervoltage. Customer participation in this demonstration is essential. PV system together with battery will also allow limitation of feed in power to 50% of the PV installed capacity which helps to shave feed-in peaks and thus increase DER hosting capacity. Testing the influence of residential energy storage systems on solar peak shaving helps to determine how these systems affect the power quality and how they contribute to avoiding congestions in the distribution network.

Details about the system:

- Smart PV inverter with battery storages in customer premises
- Two manufacturers involved (Schneider and Fronius)
- Storage will provide power in case of under-frequency or under-voltage based on local measurement
- PV inverter will limit solar power feed in to 50% managed by additional meter provided by manufacturer
- Realisation of emergency functions triggered by:
  - Underfrequency

  - Undervoltage
- Signal from ČEZ Distribuce (ripple control will trigger active power injection
- Switch to allow islanding of the house in case of power loss. Interoperability question on islanding according to the grounding scheme in Czech Republic.
- Effect on net flow meter connection could be covered in WP3 (if meter is slow, there will be power peaks on the grid interface)
- Test area Lužany

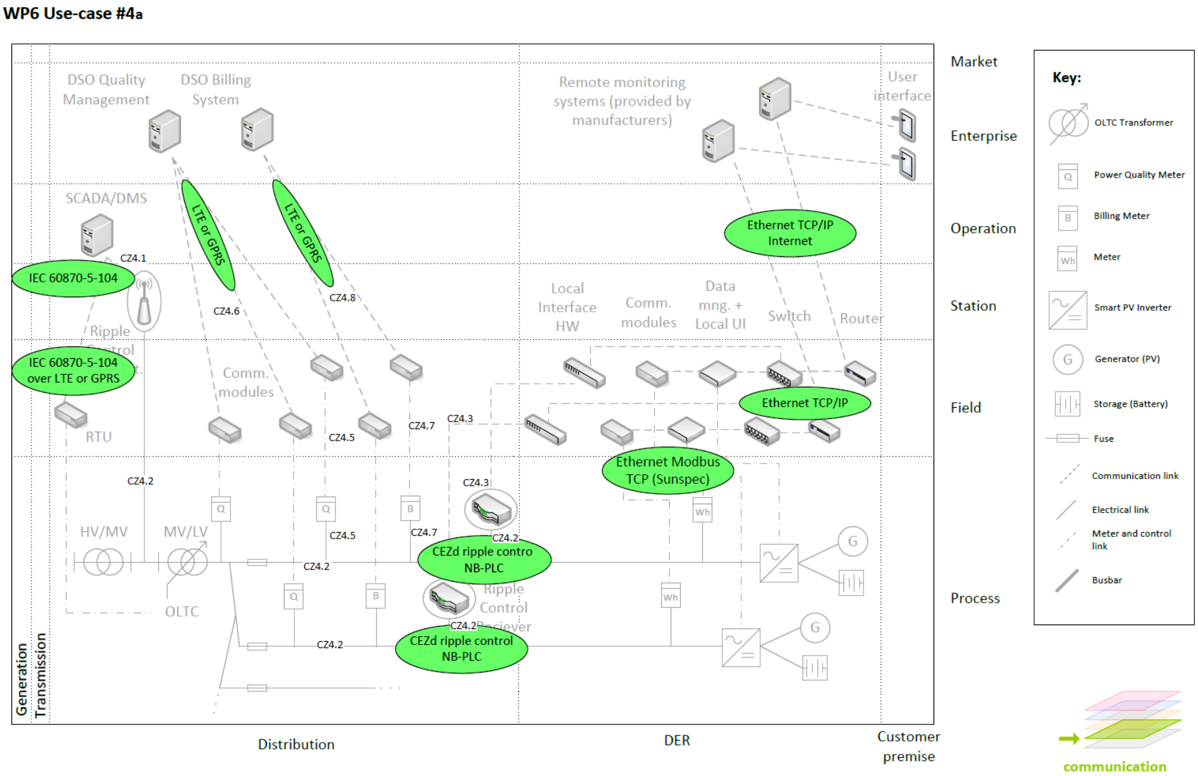


Figure 13. Czech demo – Use case 4a – SGAM diagram – Communication layer

WP6 Use-case #4b (Schneider)

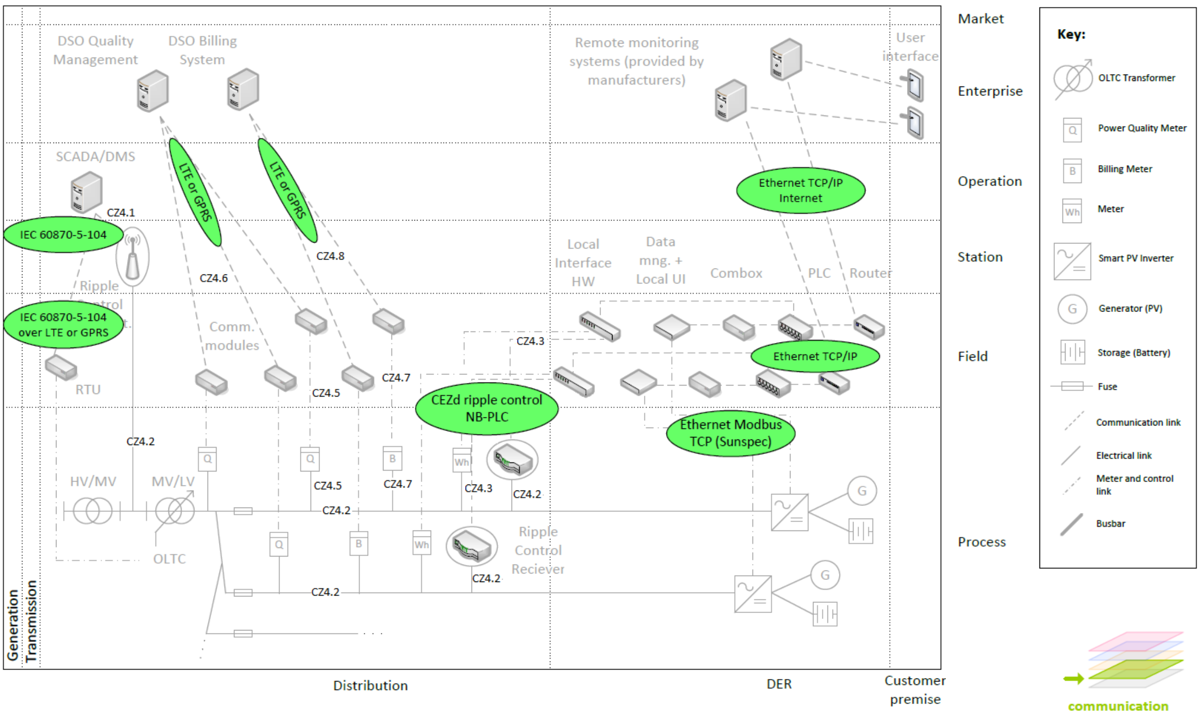


Figure 14. Czech demo - Use case 4b - SGAM diagram - Communication layer

3.2.6. Interfaces

The table of interfaces for Czech demo can be found in annex 6.2 - Interfaces for Czech demo.

3.2.7. Solutions and standards

Name	Status	Foreseen standard
CZ1.1	Decided	Relevant power quality standard: EN 50160 Q(U), P(U): EN50438:2013
CZ1.2	Decided	Relevant power quality standard: EN 50160
CZ1.3	Decided	Local metering legislation
CZ1.4	TBD	TBD (not in focus)
CZ1.5	TBD	TBD (not in focus)
CZ1.6	TBD	TBD (not in focus)
CZ1.7	Decided	IEC 60870-5-104 over GPRS
CZ1.8	TBD	TBD.
CZ2.1	Decided	IEC 60870-5-104 over GPRS

Name	Status	Foreseen standard
CZ2.2	Decided	IEC 60870-5-104 over GPRS
CZ2.3	Decided	IEC 60870-5-104 over GPRS
CZ2.4	Decided	Medium voltage power line
CZ2.5	Decided	Medium voltage sensor connection
CZ3.1	Decided	IEC 60870-5-104
CZ3.2	Decided	Medium and low voltage power line
CZ3.3	Decided	On-Off single wire interface
CZ3.4	Decided	Medium and low voltage power line
CZ3.5	Decided	IEC 61851
CZ3.6	Decided	low voltage power line
CZ3.7	TBD	TBD.
CZ4.1	Decided	IEC 60870-5-104
CZ4.2	Decided	Medium and low voltage power line
CZ4.3	Decided	On-Off single wire interface
CZ4.4	Decided	Medium and low voltage power line
CZ4.5	Decided	low voltage power line
CZ4.6	TBD	TBD.
CZ4.7	Decided	low voltage power line
CZ4.8	TBD	TBD.

3.3. Demo NL

3.3.1. General

The information reflected in this document is based on a workshop held in Eindhoven on March 24th, 2017 and the UCs description and SGAM diagrams provided by the Dutch demo before November 30th 2017.

3.3.2. Use case NL.1: enabling ancillary services, congestion management, and voltage support for PV integration using centralized, grid-connected storage systems which improve grid observability of prosumers, while promoting batteries in a multi-service approach.

The goal of this demonstration is to validate technically, economically and contractually the usability of a central storage unit embedded as a commercial storage. This paves the way for a multi service business model for the large scale battery which can:

- provide ancillary services to the TSO which reinforce system security, and is compensated according to existing market rules, with decentralized assets working as a virtual power plant
- enable congestion management, voltage support for PV integration and power quality improvement.

Developments include the upgrade of power converters to supply new services, with the involvement of a dedicated flexibility aggregator platform (FAP-DER) to dispatch the storage assets to foster their business model. Centralised storage must be valued with the support of all the players involved: the TSO, the DSO, the storage operator, the prosumers. This use case includes validating business models with DSOs, aggregators and communities. It demonstrates the applicability of large scale centralized storage units at the substation/street level to demand-side management. The deployed capacity of the centralized storage unit is in the range of 100-250 kWh. To assure that the DSO has access to the flexibility for congestion management this use case conceptualizes, implements and validates 'long-term flex purchase contracts' enabling the DSO to cover the flexibility need.

Details about the system:

- Using an existing device called "DALI box" (Implementation of a Smart Secondary Substation IEC 608070-5-104), that is measuring network and controlling exploitation scheme
- 250 kW Battery under control of an Aggregator, that provides flexibility service to DSO
- Communication with SCADA in -104 for indicating network load
- Datalake that collects different data from smart meter and SCADA
- Grid management system (GMS) bargains with aggregators, with USEF (for the interaction between BRP and aggregators, prediction proposed by aggregator and validated by DSO)
- Remote reading (with industrial meter) but data are private
- Smart meter through a central system to the whole country
- Central storage, linked to a battery management system (functionality provided by the LIMS)
- Controlled by aggregator through Modbus
- Bargain flexibility with EFI

- Use of a BMS ((functionality provided by the LIMS) between battery and aggregator because no standard protocol for direct battery control

3.3.3. Use case NL.2: enabling the optimal activation of all available local flexibilities, using interactions between the DSO and the Charge Point Operator (CSO) in the role of aggregator using the local installed EVSE's for congestion management and voltage control.

The CSO manages the charging of EV's applying different mechanisms to 'unleash' the EV's flexibility. It can aggregate the flexibility and offers it to the DSO, TSO and BRP via the flexibility aggregator platform (FAP-EV). This use case conceptualizes, implements and validates 'long-term flex purchase contracts' enabling to cover the DSO flexibility needs. The rest of the flexibility / capacity can be purchased by the BRP and TSO. This increase of local accessible flexibility allows for a large number of consumers to actively offer their flexibility for the DSO or within energy markets. The DSO becomes a market organizer by applying the FAP, delivering the order of merits for each of the candidate flexibilities, asking for day-ahead bids and able to activate intra-day actions. This is very likely the case in matters of congestion, but it is also possible that the BRP and/or TSO fulfils this role. Such a system includes market settlement to assess the flexibility effects and compensates the aggregators. Aggregator Jedlix manages various types of flexibilities.

Details about the system:

- Existing: Measurement in Substation, Remote Meter, Smart Meter (idem DALI box)
- Load flow estimator to be developed in the GMS
- Existence of charging with charging point management system for integration with aggregator
  - E.g OCPI between CPMS and Aggregator
  - E.g OCPP between CPMS and CP, including charge programming with OCPP 1.6
- Connection to the EV :
  - Rather IEC 61851 (Mode 3)
  - 15118 could suit, but specified and not implemented
- E-Car-Infrastructure - existing but not providing high level flexibility services
- Battery management interface to be developed

3.3.4. Use case NL.3: validating technically, economically and contractually the usability of an integrated flex market based on a combination of static battery storage and EV

This demonstration validates technically, economically and contractually the usability of an integrated flex market based on a combination of static battery storage and EV. One aggregator is operating the storage and another operating the EV (SE)'s. The two aggregators compete in the flexibility market, both offering flexibility to the different stakeholders (DSO, TSO and BRP). The two types of flexibility (storage and EV) have different characteristics and very likely different user constraints (e.g. EV drivers want their car to be charged within a given time), resulting in different marginal costs of flexibility and therefore a more dynamic merit order and more competition. Pricing mechanisms and market liquidity are analysed, including the usability for a given type of flexibility for the different purposes (congestion, market optimization (day-ahead and intra-day markets), ancillary services (balancing)). For instance, static storage may be better suited for Frequency Containment Reserve (FCR) than EVs. The rebound effect of different sources is analysed with impact on the merit order.

Details about the system:

- More exchanging of data items, physical protocols less important
- Combination of the two other use cases, with several integrators

3.3.5. Architecture

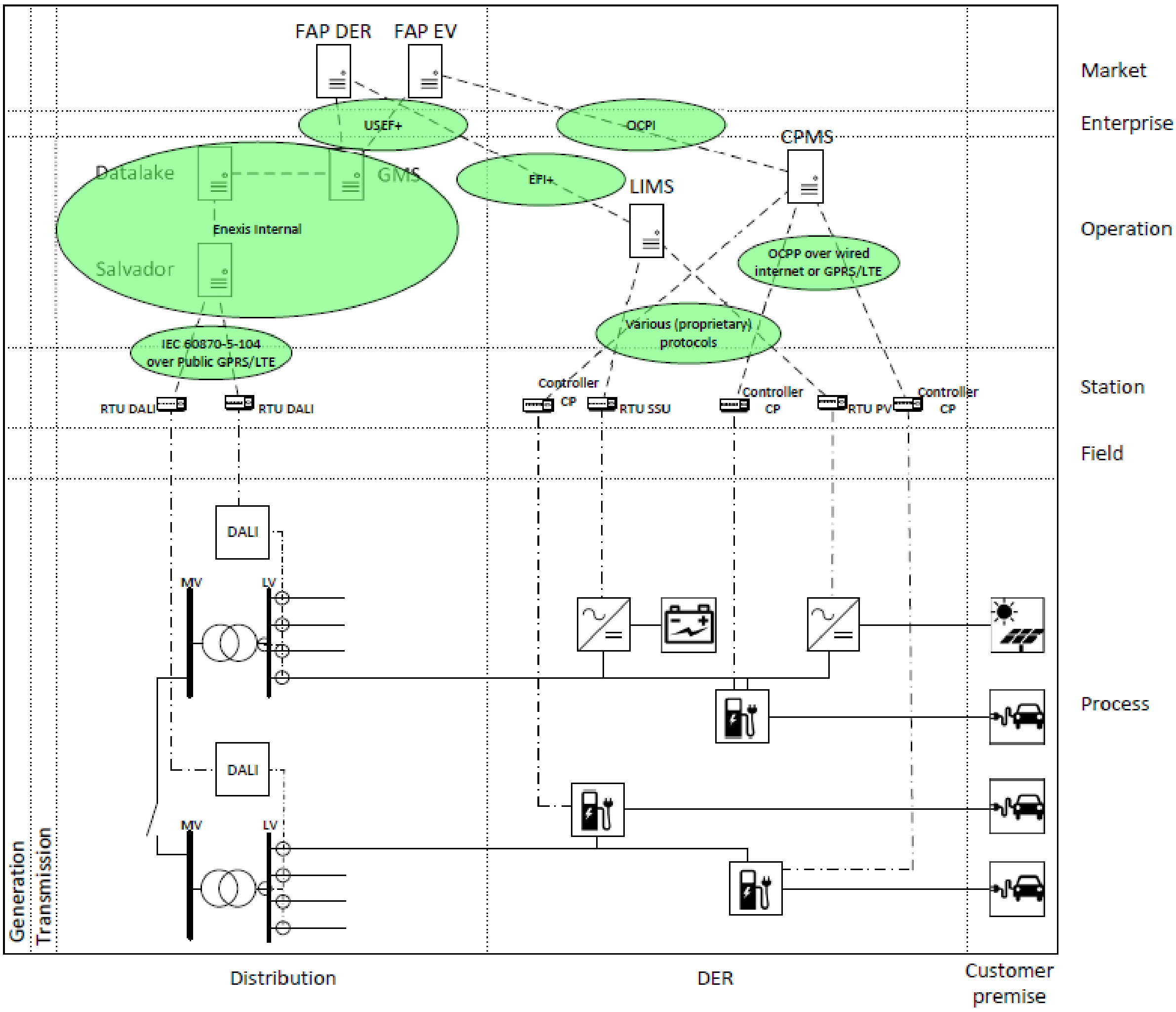


Figure 15. Dutch demo – Uses-cases 1, 2 and 3 - SGAM diagram - Communication layer

3.3.6. Interfaces

The table of interfaces for Dutch demo can be found in annex 6.3 - Interfaces for Dutch demo.

3.3.7. Solutions and standards

Name	Status	Foreseen standard
NL1.1a	Unknown	Enexis Internal
NL1.1b	Unknown	
NL1.2a	Defined	Various protocols eg IEC 61850-7-420
NL1.2b	Defined	Various protocols eg IEC 61850-7-420
NL1.3	Defined	EFI
NL1.4	Defined	USEF with minor addition
NL1.5	Unknown	Enexis Internal
NL1.6	Unknown	Enexis Internal
NL1.7	Defined	IEC 60870-5-104 over GPRS
NL1.8	Defined	IEC 60870-5-104 over GPRS
NL1.9	Unknown	Enexis Internal
NL2.1	Defined	OCPP
NL2.2	Defined	Control signal (OCPP)
NL2.3	Defined	OCPI
NL2.4	Defined	USEF with minor addition
NL2.5	Unknown	Enexis Internal
NL2.6	Unknown	Enexis Internal
NL2.7	Defined	IEC 60870-5-104 over GPRS
NL2.8	Defined	IEC 60870-5-104 over GPRS
NL2.9	Unknown	Enexis Internal
NL3.1	Defined	EFI
NL3.2	Defined	USEF with minor addition
NL3.3	Unknown	Enexis Internal
NL3.4	Unknown	Enexis Internal

3.4. Demo DE

3.4.1. General

The information reflected in this document is based on a workshop held in Hanover on April 19th, 2017 and the UCs description provided by the German demo before November 30th 2017 and the SGAM diagrams provided before April 30th 2019.

The German Demo revolves around the development and field testing of the Smart Grid Hub, a control solution which adds a layer of automation to enable the DSO SCADA-DMS to control and coordinate small scale flexibility in the segment of standard load profile customers. The SGH integrates seamlessly with DSO SCADA-DMS systems and builds upon the public smart meter infrastructure that is currently being rolled out across Germany. The SGH communicates with flexible devices on customers' premises via the smart meter infrastructure and the smart meter gateway on site, while a central gateway administration service is handling access rights and control and data requests. It is worth pointing out that smart meter infrastructure and SCADA are fully operational systems to which the SGH adds an additional set of functionalities. By focusing heavily on developing functional interfaces to live systems InterFlex seeks to maximize the chances of a later exploitation of the results beyond the scope of the project.
The major interfaces are towards SCADA, where operator input, control signals and data collection requests originate. This Interface is designed based on IEC 60870-6 or TASE.2 protocol. TASE.2 also known as ICCP or Inter-Control Center Protocol is widely used in utilities to exchange data between grid control center and devices and assets in the field or between multiple grid control centres. The second major interface is towards the gateway administration service. The GWA handles all requests for control or data of customer metering units or flexible devices and initiates the communication between the smart meter gateway and the requesting party. SGH and GWA communicate via encrypted Webservices.
On the side of the flexible device InterFlex is using a control box based on the long wave radio technology that is currently the standard in Germany for curtailment concepts of DSO´s. The control box in InterFlex however is not being addressed via longwave radio signal but is part of the intelligent metering system and integrates with the communication channel provided by the smart meter gateway. Towards the device the control box provides 4 12V relay switching contacts to control flexible devices via the standard curtailment and double tariff interface.

3.4.2. Use case DE.1: Controlling small RES-units

The DSO SCADA monitors the state of the grid and identifies critical situation in the distribution network such as imminent conductor overload or violations of voltage bands. It is the responsibility of the grid operator to maintain a safe grid operation. Whenever the local feed in of DG/DER is the cause of such a critical situation the grid operator can as a last resort curtail the momentary feed in by DG/DER. It is the objective of the DSO SCADA to identify the bottleneck and determine required actions to return the grid back to normal. In order to fully capitalize on a smart meter infrastructure and the flexibility of small scale generators Demo 4 develops the Smart Grid Hub (SGH) as the control engine for these small scale generators. It serves as an aggregation / disaggregation platform, which collects data from households and translates a high level curtailment request from SCADA (e.g. "reduce power in area XY by Z MW") into a set of individual control signals for small scale generators.

Details about the system (same architecture for all use case):

- The grid control system (eBase) monitors the state of the grid and accumulates data generated by DSO-owned sensors and handles input from grid operation engineers

- eBASE is connected to SGH (Smart Grid Hub)
- SGH is divided in process unit and data unit
- SGH has a connection to the intelligent meters gateway administration system (GWA)
- Process unit only stores information for a short amount of time
- GWA is handling access rights to smart meters and requests from external parties such as the SGH
- Smart Meter Gateway (SMGw) provides communication channel, transmits data and relays control signals to control box
- Control box execute SGH commands and controls flexible device via relay switches
- In Germany some DER have a dedicated meter.
- Smart meter gateway can be parametrized to send an alarm for instance in case of over-voltage

3.4.3. Use case DE.2: Ancillary services provided by generation, consumption and storage devices

Ancillary services (for instance balancing energy) may come from the aggregation of generation, consumption and storage devices (either as single units or pools of different types of units connected to different parts of the grid). The signals sent out for ancillary services have to be coordinated with other signals such as the ones for curtailment or demand response. The security and speed of data transmission as well as the speed of command execution and the respective confirmation signals are crucial.

3.4.4. Use case DE.3: Distributed sources of flexibility within the distribution grid

The lack of flexible of loads and the current German regulatory framework make demand response to serve the market or the grid purposes very limited. With the development and increasing deployment of battery storage and cross-sectoral technologies such as e-mobility or sophisticated electrical heating systems, the impact of demand response will rise substantially. Battery storage, e-mobility and novel electrical heating systems, provide flexibility to the distribution grid, where signals coming from different market participants are aggregated into the “Smart Grid Hub”, according to the least intervention possible.

3.4.5. Architecture

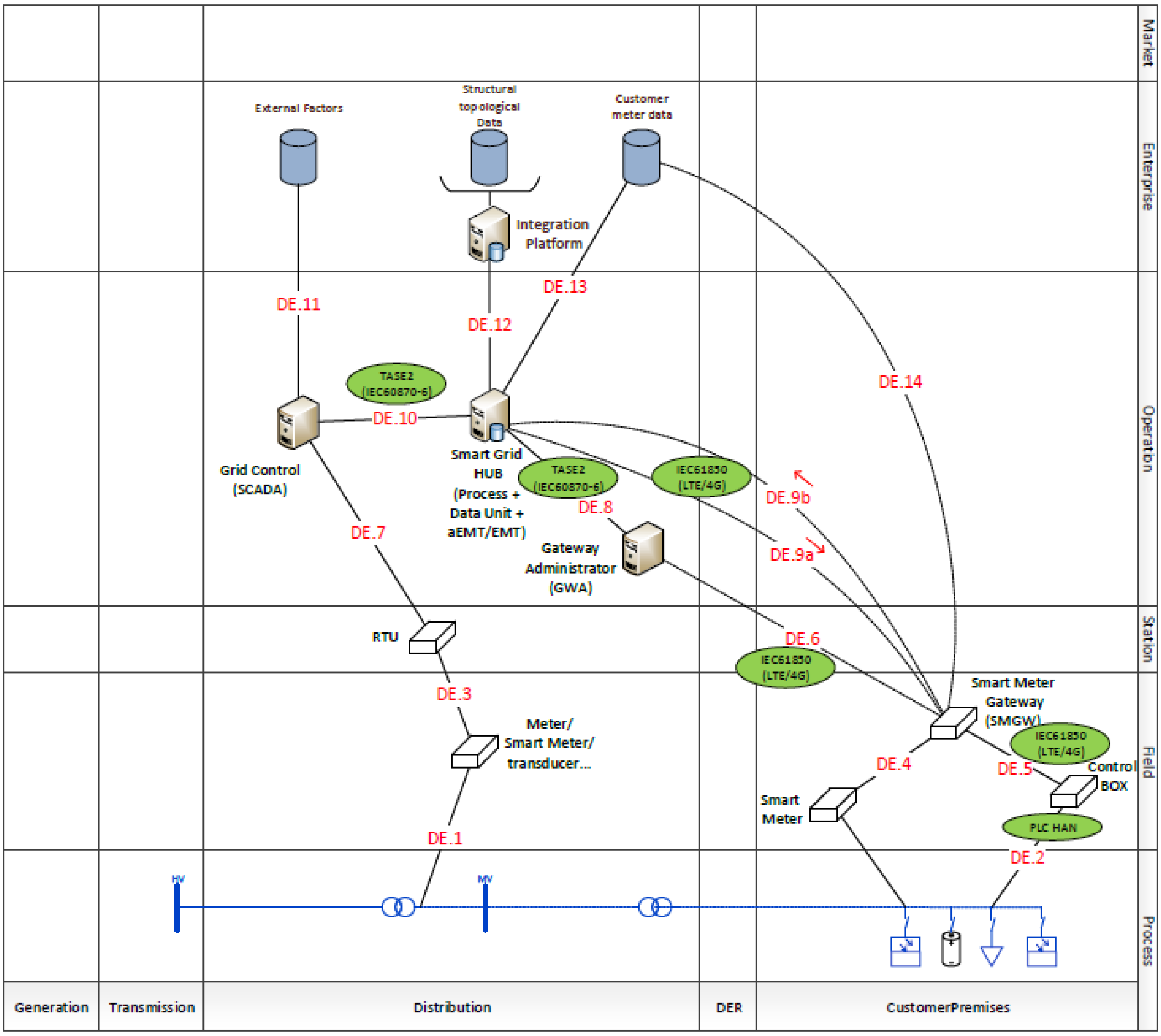


Figure 16. German demo - Use-cases 1, 2 and 3 - SGAM diagram - Communication layer

3.4.6. Interfaces

The table of interfaces for German demo can be found in annex 6.4 - Interfaces for German demo.

3.4.7. Solutions and standards

Name	Status	Foreseen standard
DE1	Unknown	Out of scope
DE2	Defined	PLC HAN
DE3	Unknown	Out of scope
DE4	Unknown	Out of scope
DE5	Defined	IEC 61850 (LTE/4G)
DE6	Defined	IEC 61850 (LTE/4G)
DE7	Unknown	Out of scope
DE8	Defined	TASE 2 (IEC 60870-6)

Name	Status	Foreseen standard
DE9	Defined	IEC 61850 (LTE/4G)
DE10	Defined	TASE 2 (IEC 60870-6)
DE11	Unknown	Out of scope
DE12	Unknown	Out of scope
DE13	Unknown	Out of scope

3.5. Demo SE

3.5.1. General

The information reflected in this document is based on a workshop held in Essen on April 27th, 2017. Any further developments have only partly been taken into account in the review of this document.

E.ON as a DSO and heat network operator addresses the enhancement of the distribution system flexibility in two different urban and rural demonstrations. The urban demo 4a implemented in Malmö includes use cases 1 and 2. Use case 1 uses district heating and cooling grids to create flexibility within the electricity distribution. Use case 2 focuses on the deployment of heat pumps to increase energy flexibility in the district heating grid. Demo 4b implemented in the rural area of Simris in Southern Sweden is a microgrid demonstration with the capability of going islanded and be powered by 100% of renewable sources. The core of the microgrid will contain curtailable wind power as the main generation, supported by PV, a central battery system, an additional flow battery system, backup generation and a dynamic load unit (P2H). The system has been dimensioned for aprox. 150 consumers. The total on-site renewable generation will be about 1MW (excluding the backup generator). The main central battery system (330kWh/800kVA) will operate as the grid forming unit and it will be in charge of the almost instantaneous balancing of the micro grid. In addition, the flow battery (1050kWh/300kVA) can be set in a mode where it supports the microgrid with frequency regulating services. This innovation project will use its installed assets to enable the execution of three use cases. Use case 3 manages a Local Energy System (LES) with 100% renewables and aims to transform passive customers into active ones. The focus is to deploy centralized and decentralized balancing technologies such as P2H and peer-to-peer system in the island and using this flexibility to enhance the power quality of the system and enable the creation of a local energy market. Use case 4 develops a demand side response program for customer participation within the LES. A local energy market is created by developing a peer-to-peer market platform to facilitate increased consumer participation within the microgrid by allowing real transactions to elicit an active demand side response and thereby increasing grid-friendly consumption/production behavior. Use case 5 with the aid of machine learning algorithms improves the management of district heating and electricity grids. In other words, it aims to make the Simris LES a smart one by developing smart algorithms that will target to improve the efficiency and operability of the microgrid as well as the use of the inherent flexibility by the DSO.

3.5.2. Use case SE.1: Use of DSR operation by exploiting the interaction with different energy carriers, such as district heating and district cooling

This use case aims at demonstrating and validating new business models for the optimization of DSO operations by exploiting the interaction with different energy carriers, such as district heating and district cooling In the case of the customers connected to the heating/cooling grid in Malmö, their thermal demand is 100% supplied by the thermal grid (i.e. there are no hybrid systems) as the networks have been built and further developed to have enough capacity to supply all of the customers connected.
Nevertheless, in spite of not having any physical energy carrier integration at the buildings, the thermal behaviour within the building is the same. This use case focuses on how much flexibility is inherently contained within the thermal envelope of a building and how using DSR for steering the heating systems of building functions in comparison to other sources of distributed flexibility (hot tap water, electrical batteries, etc.). From the grid perspective, it evaluates how the operation of DSR in a heating/cooling grid affects the electrical grid. For instance, how much energy [x kWh] could be shifted at the production side (P2H) if 1kWh

of heat is shifted at the customer´s side and how would be the time reaction between both systems?

Details about the system:

- Building Energy Management System (BMS): Local controller which controls and monitor the systems installed at the building. It takes care about the correct operation of the connected systems.
- Energy Manager (EM): Local Hardware which functions as a Gateway and a local controller. It translates activation schedules into optimal set points.
- EON Modular Platform (EMP): Cloud platform that acts as an aggregator (portfolio manager). It translates flexibility requirements into activation signals to the appropriate buildings.

3.5.3. Use case SE.2: Optimal use of a commercial heat pump asset providing the district heating grid with heat and electricity flexibility for grid management purposes

The objective of this use case is to enable optimal usage and multiple use cases for a commercial heat pump asset in Malmö providing a secondary district heating grid with energy (heat) and a small cooling grid with chilled water, while providing electric flexibility for grid management purposes. Similar to use case 1, use case 2 exploits the interaction with the heating grid. In this case though the key element is a large heat pump instead of involving direct customer interaction. The commercial-scale heat pumps in Malmö are estimated to have an output of 40 kW heat with the corresponding power consumption of 20 kW. If this system was scaled up to many more sites, the connected heat pumps would be able to provide a large amount of flexibility to the power grid. The total investment is likely to be in the region of 30 kEUR meaning that this is a truly scalable solution for the mass market segment. Potential commercial or technical interests can be identified within the following fields.
It is planned to steer a large amount of decentral heat pumps. Owing, by connecting and agreeing on possibilities to run heat pumps in a flexible mode, it would be sought as one the most important balancing technology for the grid service support. It would offer great opportunities for flexibility at the DSO level as it can react instantaneously as per the needs of Demo 4b-UC 3, when connected by a fibre-optic cable. But for the actual implementation of such steering functionality in the large number of heat pump requires significant efforts to overcome the IT security standards of the production site. Consequently, it will be modelled on the simulation platform, to replicate the characteristics. This simulation model will be validated by the real operational data. The control software for the steering logic will be developed for this simulated model of the heat pump, so that RES integration functionality can be verified in the simulation.

Details about the system:

- Simulation of industrial size commercial heat pumps: Mimics the behavior of the large Heat pump responsible for the energy carriers.
- Integration of the commercial Heat Pump model into the thermal network mode: Translated the real operational data into the modelled Heat Pump.
- Steering logic developed and simulated for the heat pump: Translates flexibility requirements into activation signals to the heat pump.

3.5.4. Use case SE.3: Technical management of a grid-connected local energy system that can run in an islanded mode with 100 % of renewable generation

This use case focuses on validating and testing how to effectively operate micro-grids with a significant proportion of RES. It requires flexibility in demand in order to reduce the costs related to the need for central batteries and also increase system resiliency. While being islanded, the micro-grid has to cope with relatively high-power fluctuations on the production (wind) and consumption sides. Keeping the islanded grid stable and balanced, an energy storage system executing the role of a grid forming unit measures and controls the active and reactive power flows within the micro-grid whilst setting the frequency value [Hz] of the islanded system. The testing of the distributed frequency support in islanded mode allows revealing the true impact of the technologies in a real operating environment. This allows the results to be scaled and applied in larger grid and energy systems. The demonstration essentially validates impacts of using diverse distributed balancing mechanisms to maintain load balance and frequency stabilization within the micro-grid, based on the following sub use cases. P2H units with a sub second reaction time to create artificial inertia in an inertia-less system (the available flexibility is monitored via sensors). Water boilers at customers' houses have a frequency measurement device and provide frequency response (the available flexibility is estimated via a statistical approach). Battery systems are installed at a number of specific customer houses. These are controlled from the central EMS in order to support the power balancing of the grid. These battery systems can also provide frequency response.

Details about the system:

- The DSR platform will be the place where data will be concentrated from most of the micro-grid relevant data points as well as from external services. This platform will host the advanced intelligence of the system and will interact with the other main components of the system e.g. P2P platform, micro-grid controller.
- Flexibility Request: Micro-grid controller sends a signal to the DSR platform requesting for the dispatch of flexibility (kW, kWh).
- Flexibility dispatch signal is produced by the microgrid controller and received by the DSR platform.
- Flexibility Activation: DSR Platform decides which of the enabled assets to dispatch and sends a steering signal to those.
- Dispatch schedule is produced by the DSR platform and received by the distributed assets/platform.
- Flexibility Dispatch: Asset gateway receives the dispatch schedule and creates an activation signal.
- Setpoint is produced by the local Gateway and received by the embedded controlled.

3.5.5. Use case SE.4: Microgrid Customer flexibility facilitated by a peer-to-peer market platform and enabled by Demand Side Response programs

This use case demonstrates and validates the ability of a peer-to-peer market platform to facilitate increased consumer participation within a micro-grid by offering direct incentives to elicit an 'active' demand side response and thereby increasing grid-friendly consumption/production behaviour. The peer-to-peer market platform must contain flexibility market mechanisms (demand side response programs) in a way adapted to the local energy system. The application of a peer-to-peer market platform is supposed to increase energy awareness by enabling the customer to visualize what is actually happening in the grid and by “revealing”/showing the influence of their participation. This increase in transparency/visibility is expected to create a higher implication/engagement of the customers in the microgrid. Furthermore, the possibility of market participation and incentivising grid-friendly behaviour by DSR programs would decrease the system imbalances. Thus, a peer-to-peer market platform with DSR programs would help decrease the system operation costs by reducing the imbalance penalties or the deployment of expensive central imbalance management technologies such as battery systems. For the development of the peer-to-peer market rules, some common rules applied in the conventional energy market are replicated and adapted to the requirements of the local energy system.

3.5.6. Use case SE.5: Increased ability to observe and steer the operations of a microgrid in response to distribution network constraints

This use case aims at demonstrating and validating the ability of a DSO to observe and then steer the operations of a micro-grid in response to distribution level network constraints, therein calling on a flexible response from the microgrid. The use case will rely on simulation and advanced power analytics to develop automation modules adapted to the requirements of the sub use cases. The focus of this use case is on testing the relationship between the DSO and microgrid.

Details about the system:

- Advanced control: The DSR platform will process input date (e.g. weather, measurements) and run advanced algorithms to create alternative enhanced schedules for the balancing technologies.
- Flexibility estimation: External information is processed by algorithms to improve the creation of flexibility schedules.
- Advanced algorithms implemented in this use case will aim to create a self-learning grid with minimal human-response requirement (including manual re-forecasting), increase the automation of the system and provide less reliance on human manoeuvring of the grid.
- Due to various monitoring devices, significant amount of data will be generated. This data will be instrumental for enriching the machine learning algorithms (either as self-learning or via offline modelling) and drawing/visualizing the patterns of energy management with Data-analytics.

3.5.7. Architecture

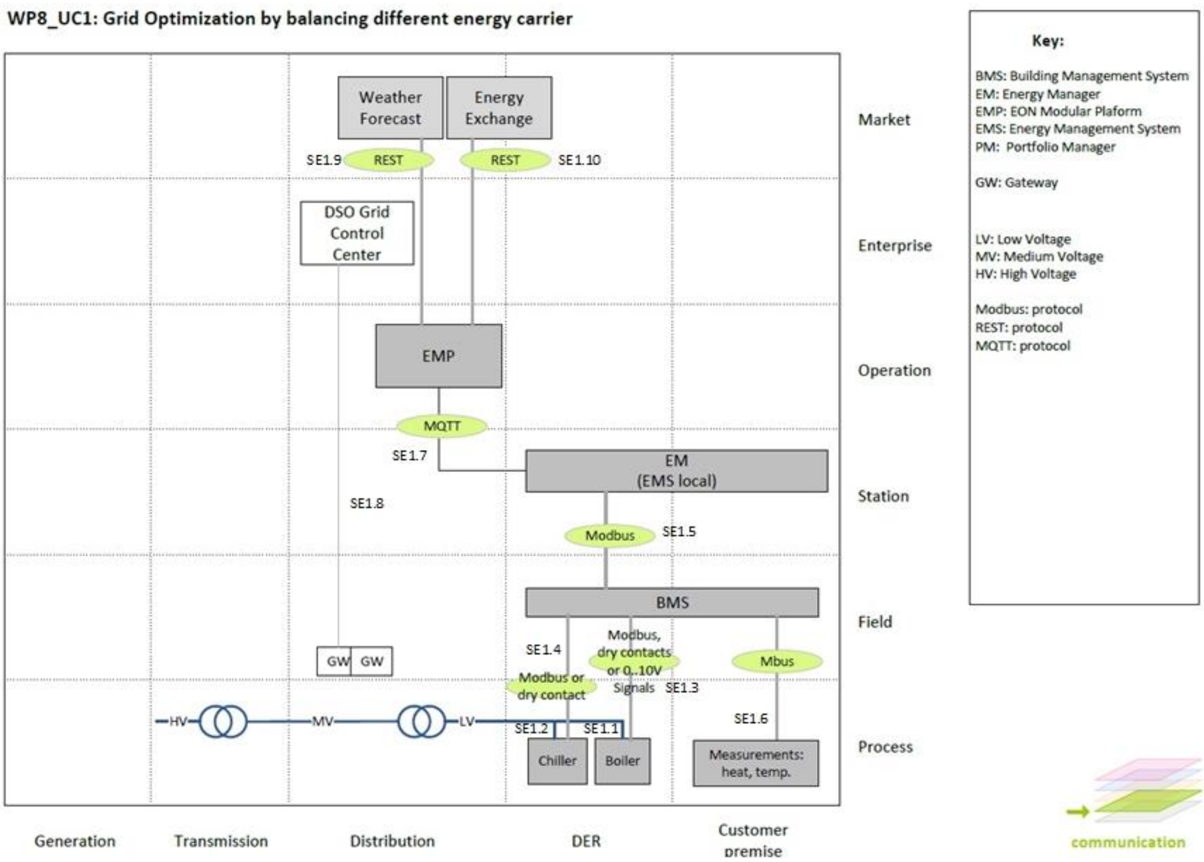


Figure 17. Swedish demo - Use-case 1 - SGAM diagram - Communication layer

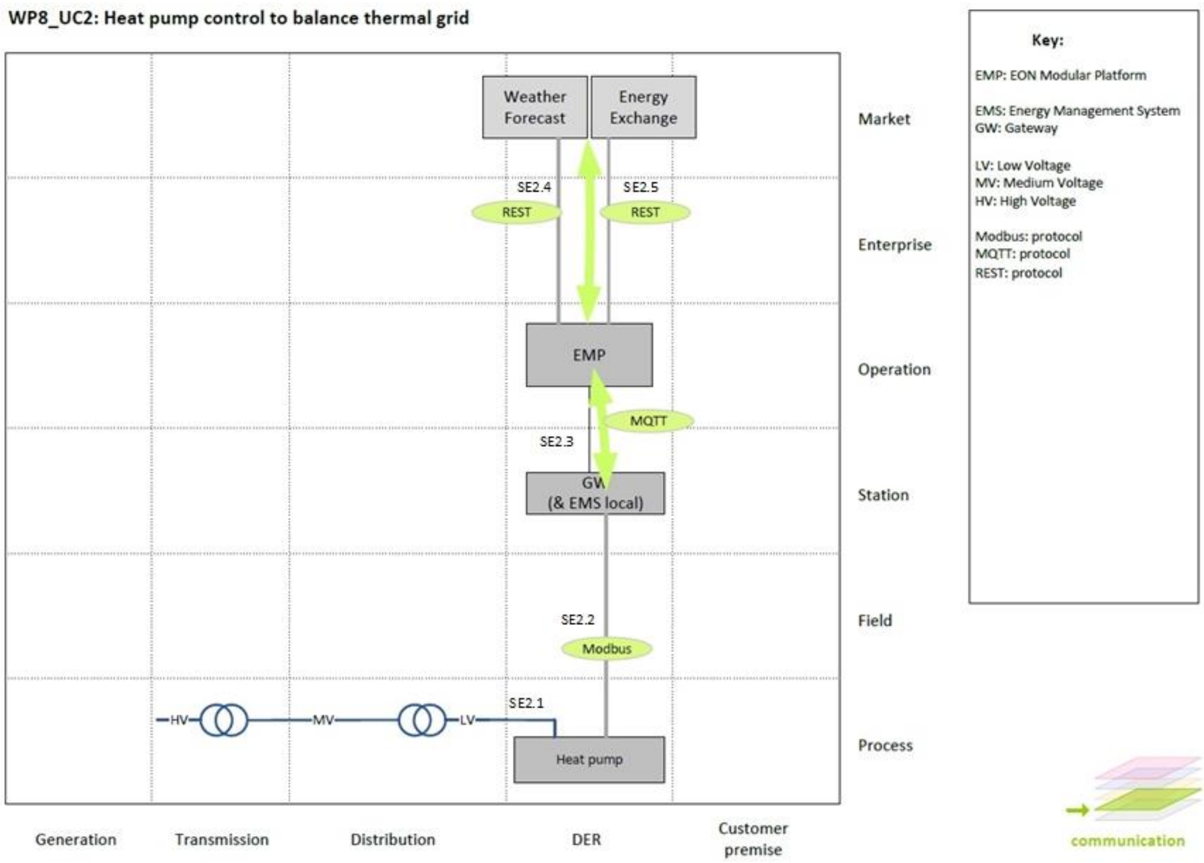


Figure 18. Swedish demo - Use-case 2 - SGAM diagram - Communication layer

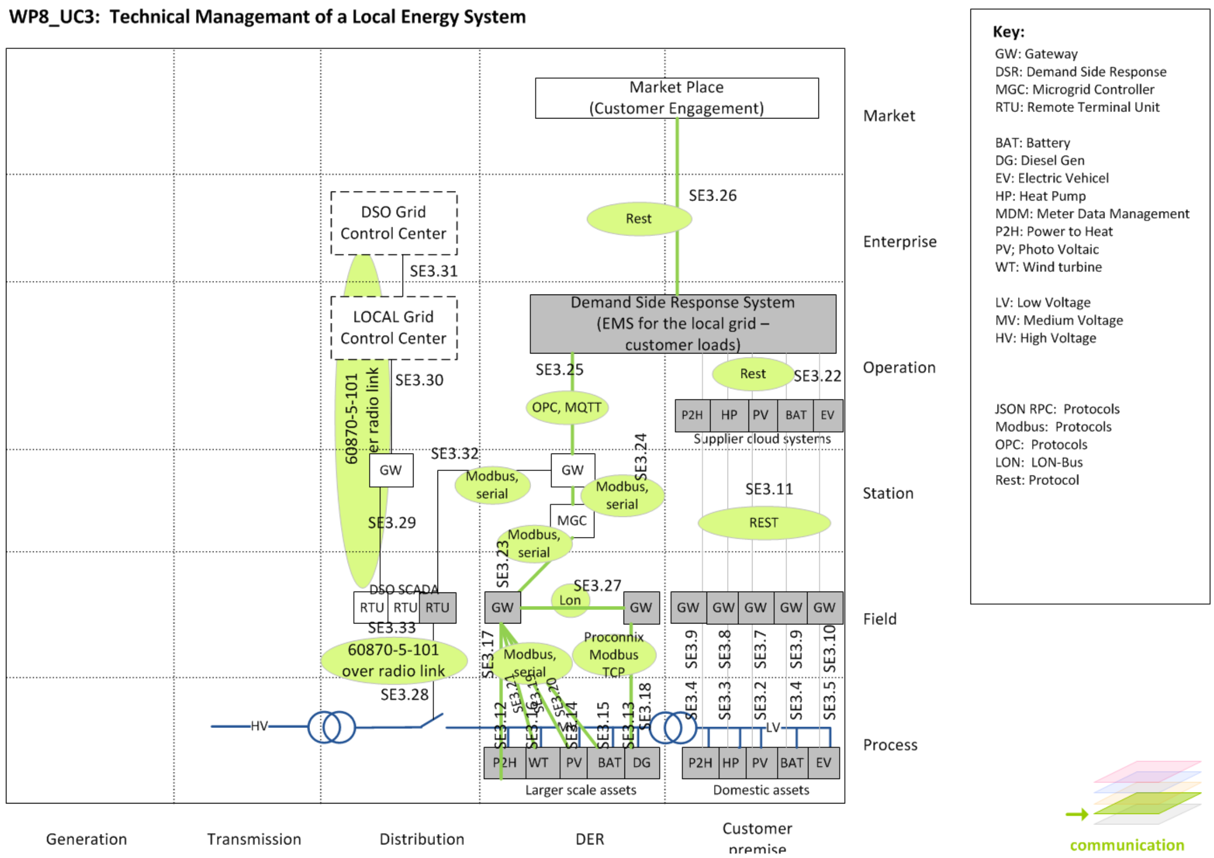


Figure 19. Swedish demo - Use-case 3 - SGAM diagram - Communication layer

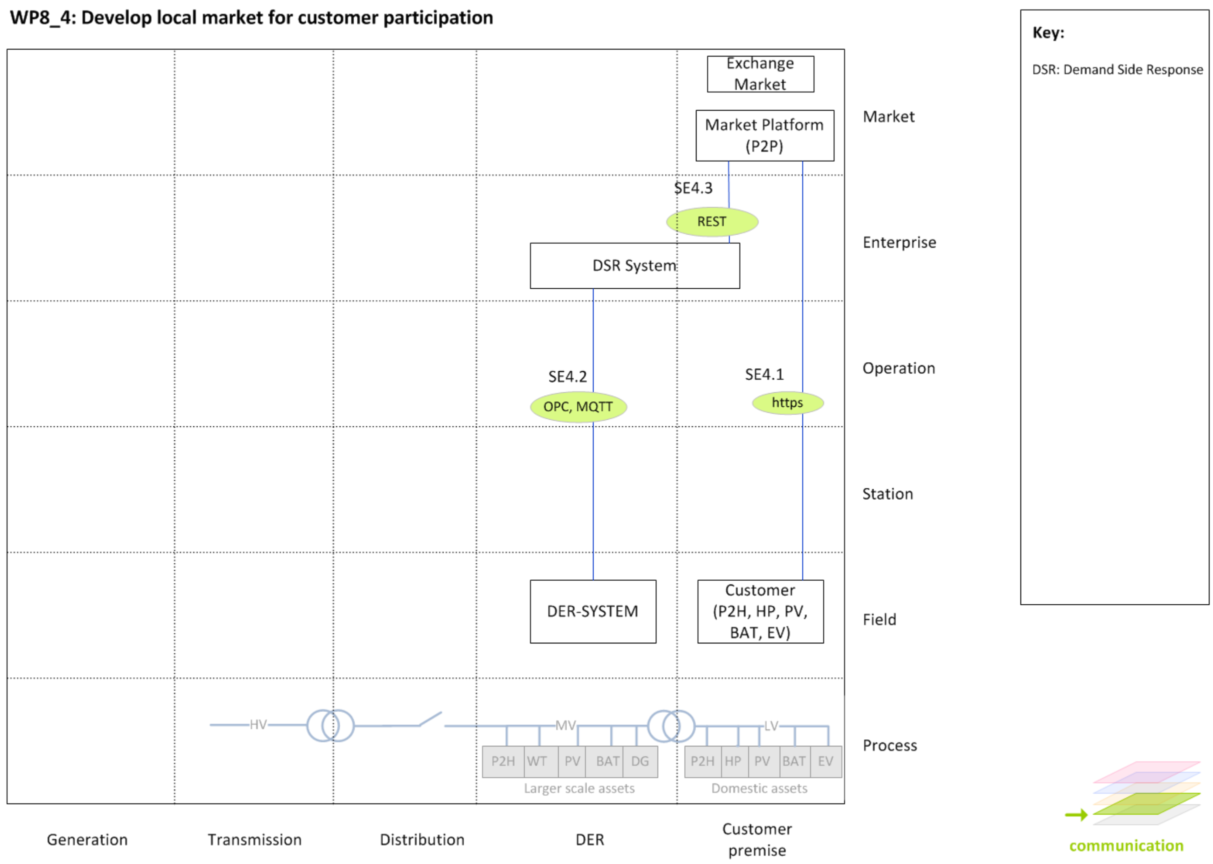


Figure 20. Swedish demo - Use-case 4 - SGAM diagram - Communication layer

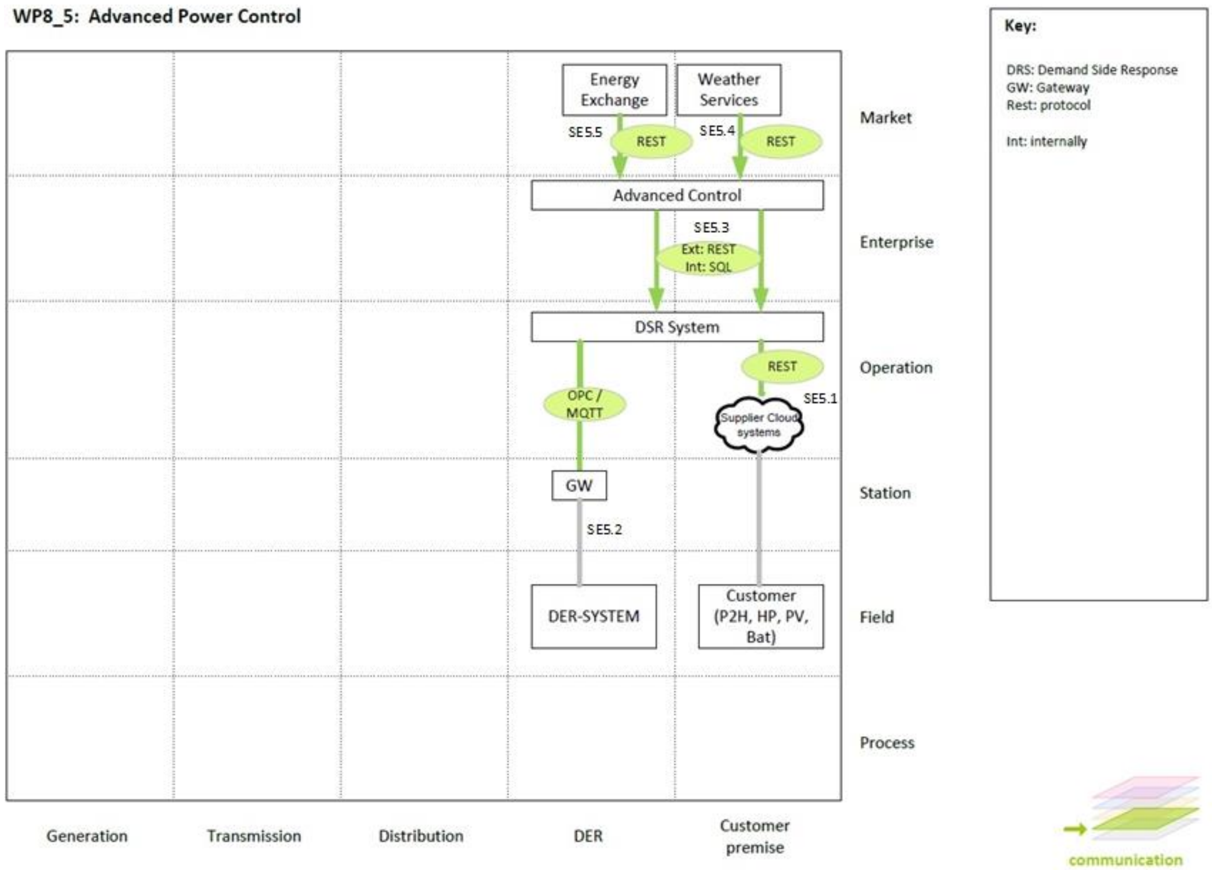


Figure 21. Swedish demo - Use-case 5 - SGAM diagram - Communication layer

3.5.8. Interfaces

The table of interfaces for Swedish demo can be found in annex 6.5 - Interfaces for Swedish demo.

3.5.9. Solutions and standards

Name	Status	Foreseen standard
SE1.1	Unknown	Out of scope
SE1.2	Unknown	Out of scope
SE1.3	Decided	Modbus, dry contact or 0...10V signals
SE1.4	Decided	Modbus or dry contacts
SE1.5	Decided	Modbus
SE1.6	Decided	Modbus
SE1.7	Decided	MQTT
SE1.8	Unknown	Out of scope
SE1.9	Decided	REST
SE1.10	Decided	REST
SE2.1	Unknown	Out of scope
SE2.2	Decided	Modbus
SE2.3	Decided	MQTT
SE2.4	Decided	REST
SE2.5	Decided	REST

Name	Status	Foreseen standard
SE3.1	Unknown	Out of scope
SE3.2	Unknown	Out of scope
SE3.3	Unknown	Out of scope
SE3.4	Unknown	Out of scope
SE3.5	Unknown	Out of scope
SE3.6	TBD	EON internal
SE3.7	TBD	EON internal
SE3.8	TBD	EON internal
SE3.9	TBD	EON internal
SE3.10	TBD	EON internal
SE3.11	Decided	REST
SE3.12	Unknown	Out of scope
SE3.13	Unknown	Out of scope
SE3.14	Unknown	Out of scope
SE3.15	Unknown	Out of scope
SE3.16	Unknown	Out of scope
SE3.17	Decided	Modbus, serial
SE3.18	Decided	Modbus TCP (Proconnix)
SE3.19	Decided	Modbus, serial
SE3.20	Decided	Modbus, serial
SE3.21	Decided	Modbus, serial
SE3.22	Decided	REST
SE3.23	Decided	Modbus, serial
SE3.24	Decided	Modbus, serial
SE3.25	Decided	OPC, MQTT
SE3.26	Decided	REST
SE3.27	Decided	Lon
SE3.28	TBD	EON Internal
SE3.29	Decided	60870-5-101 over radio link
SE3.30	Decided	60870-5-101 over radio link
SE3.31	Decided	60870-5-101 over radio link
SE3.32	Decided	Modbus Serial
SE3.33	Decided	60870-5-101 over fiber optic
SE4.1	Decided	https
SE4.2	Decided	OPC, MQTT
SE4.3	Decided	REST
SE4.4	TBD	EON Internal
SE5.1	Decided	REST
SE5.2	Decided	OPC/MQTT
SE5.3	Decided	EXT: REST Int: SQL
SE5.4	Decided	REST
SE5.5	Decided	REST

4. INTEROPERABILITY ANALYSIS

4.1. Criticality from the use-case perspective

Within the project, a wide range of different technical and organisational constellations of flexibility exploitation is realised for the efficient operation of (electric, partly also gas or thermal) energy systems. Therefore, interoperability is critical for numerous interfaces. As a first step on an interoperability analysis, the following question should be studied: which interfaces are most critical to make a use case work? Figure 22 gives a good impression on how broad the scope of the different demonstrators is, only focusing on high-level categories such as islanding, electric vehicle, demand response, energy storage, grid automation and cross energy carrier synergies.

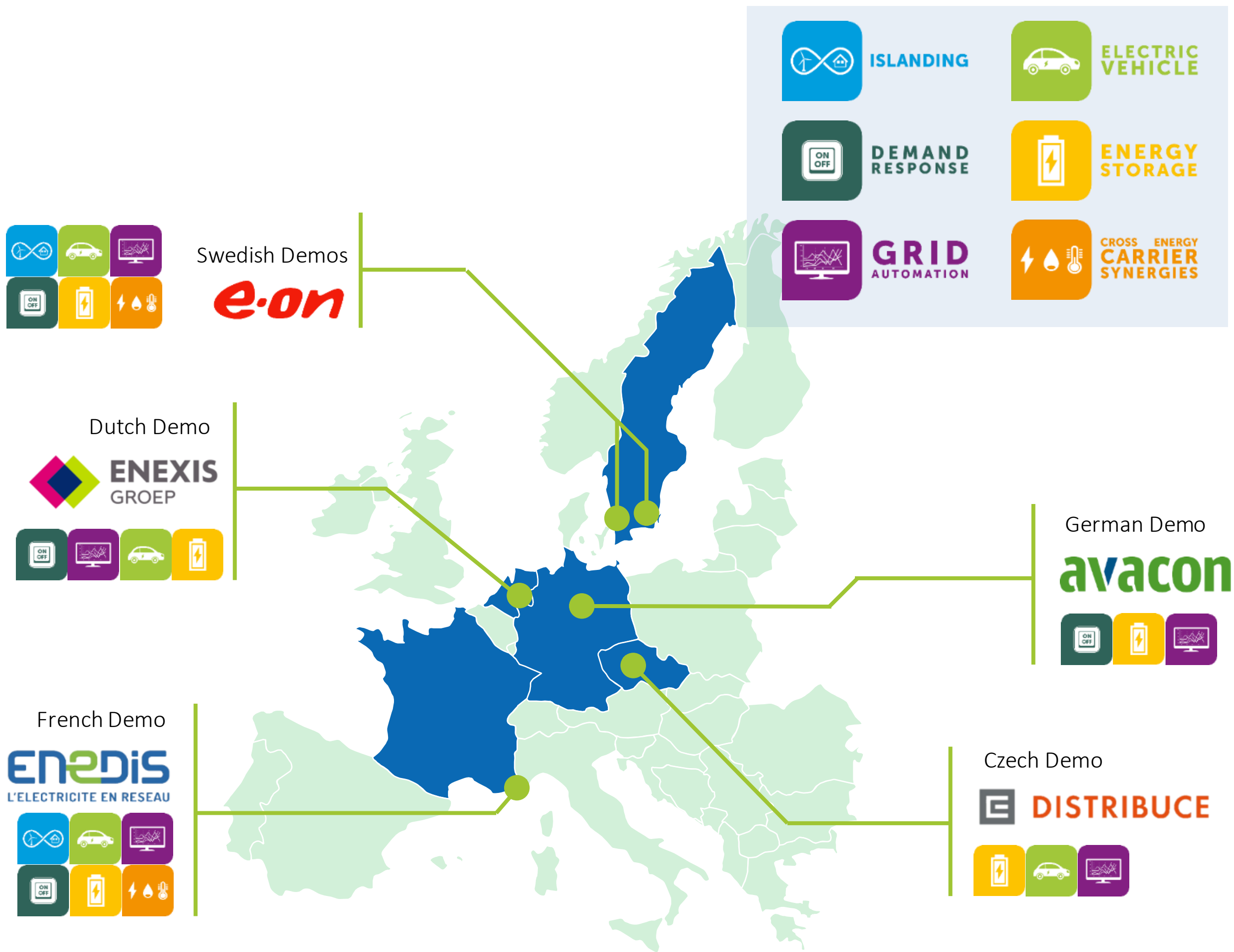


Figure 22. Overview of the realisation of the six different InterFlex innovation streams realised in the demonstrators across Europe.

Looking deeper in what is done in each individual use case, a set of generalized players in the context of flexibility can be identified, representing widely known concepts:

1. **The Distribution System Operator (DSO)**, making direct or indirect (via aggregators or microgrid interfaces) use of flexibility to operate its infrastructure more efficiently. Voltage control, congestion management and increased reliability of supply are the main motivators for this.

2. **Regional, national or trans-national markets** for flexibility and/or ancillary services bringing together providers and exploiters of flexibility. While the focus of InterFlex is on distribution networks, here also an interface to transmission network operators and their needs for flexibility can be realised (e.g. discussed in the H2020 Project SmartNet).
3. **Aggregators** building a pool of flexibilities and provide their activation as a service to e.g. DSOs or energy providers by direct contracts or via markets.
4. **Microgrid controllers** that take over the energy management in a locally distinct area, with the ability to independently operate a microgrid in an off-grid mode under certain circumstances.
5. **Flexibilities**, which can be of very different nature, including customer-side or grid batteries, electric mobility, small-scale (boilers, domestic heat pumps, smart appliances) or large-scale power-to-heat applications.

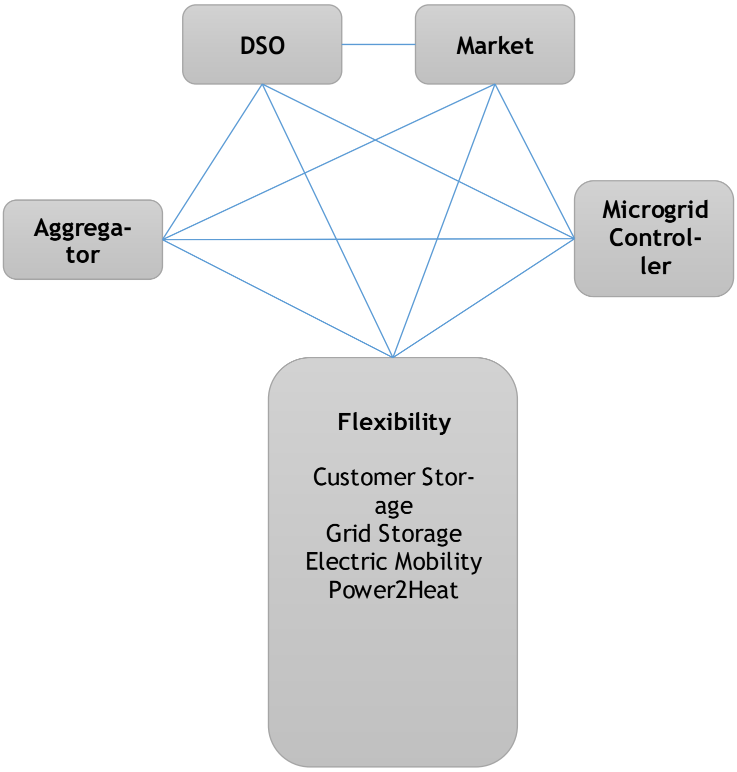


Figure 23. Overview of critical interfaces to realise the InterFlex use cases

As shown in Figure 23, communication between these generalized players is fully meshed, when taking together all InterFlex use cases. Each use case has a different constellation of critical interfaces. While the Czech demonstrator in use case CZ.3 for example uses ripple control narrowband power line communication between the DSO and the flexibility (charging station), the Dutch use cases NL.2 and NL.3 make use of an aggregator concept or even a market interaction on the connection DSO – Market – Aggregator – Flexibility.
Table 1 analyses in detail the involved generalized players in each InterFlex use case and explains the architecture choices selected for each use cases by the DSO leading the demonstrator.

Table 1. Flexibility resources and exploiters relevant in the InterFlex use cases.

		Flexibility exploiters				Flexibility resources				
Use Case	**Architecture choice**	**DSO**	**Aggregator**	**Markets**	**Microgrid Conntroler**	**RES**	**Customer Storage**	**Grid Storage**	**Electric mobility**	**Power to Heat**
Germany										
Use case DE1: Controlling small RES-units	Use of Smart Metering Infrastructure to access field devices	x				x				
Use case DE.2: Ancillary services provided by generation, consumption and storage devices		x		x		x	x		x	x
Use case DE3: Demand Side Management		x				x	x		x	x
Czech Republic										
Use case CZ.1: Increase the DER hosting capacity of LV distribution networks by combining smart PV inverter functions (demonstration of Q(U) and P(U))	Local controls based on grid measurements	x								
Use case CZ.2: Increase the DER hosting capacity in MV distribution network by volt-var control (V/Q regulation)	Set-point commands from DSO SCADA to DER units	x				x				
Use case CZ.3: Smart EV charging	DSO commands via ripple control system	x							x	
Use case CZ.4: Smart energy storage		x					x			
The Netherlands										
Use case NL.1: enabling ancillary services, congestion management, and voltage support for PV integration using centralized, grid-connected storage systems which improve grid observability of prosumers, while promoting batteries in a multi-service approach	Flexibility Aggregator Platform (FAP) as exchange point between players	x	x	x				x		
Use case NL.2: enabling the optimal activation of all available local flexibilities, using interactions between the DSO and the Charge Point Operator (CSO) in the role of aggregator using the local installed EVSE's for congestion management and voltage control		x	x	x		x			x	
Use case NL.3: validating technically, economically and contractually the usability of an integrated flex market		x	x	x				x	x	

based on a combination of static battery storage and EV										

		Flexibility exploiters				Flexibility resources				
Use Case	**Architecture choice**	**DSO**	**Aggregator**	**Markets**	**Microgrid Controler**	**RES**	**Customer Storage**	**Grid Storage**	**Electric mobility**	**Power to Heat**
Sweden										
Use case SE.1 - Use of DSR to optimize DSO operation by exploiting the interaction with different energy carriers, such as district heating and district cooling	Coordination on level of Energy Management Systems	x								x
Use case SE.2 - Optimal use of a large heat pump asset providing the district heating grid with heat and electricity flexibility for grid management purposes		x								x
Use case SE.3 - Technical management of a grid-connected Local Energy System that can run in an islanded mode with 100% renewable generation	Microgrid controller as local flexibility manager	x			x	x	x	x	x	x
Use case SE.4: Micro Grid Customer Flexibility facilitated by a peer to peer market platform and enabled by Demand Side Response Programs		x	x	x	x	x	x	x	x	x
Use case SE.5 - Increased ability to observe and steer the operations of a microgrid in response to distribution network constraints		x			x					
France										
Use case FR.1: As an alternative to grid reconfiguration, DSOs can provide a continuous supply of electrical energy to industrial customers, thanks to electricity storage assets operated by the DSO or aggregators	Microgrid controller as local flexibility manager	x	x		x			x		
Use case FR.2: DSOs could integrate large scale storage volume and enable multiservice electricity storage operated by storage aggregators or DSO, with a focus on PV integration	Flexibility Aggregator as exchange point between players	x	x					x		
Use case FR.3: innovative flexibilities can be aggregated and bid either on a local DSO mechanism to reduce local grid constraints or on national market to ensure global stability	Flexibility Aggregator as exchange point between players	x	x	x				x		

As a conclusion, it can be said that the set of critical interfaces in terms of interoperability and interchangeability are those shown in the meshed graph in Figure 23. When dealing with the question: *what are the critical interoperability issues from a use case perspective,* no further focus can be defined due to the diversity in use cases. It can, however, be observed that there are certain architectural patterns requiring interoperability on respective but different interfaces. We, therefore, add another viewpoint to the interoperability analysis, which is the criticality from the chosen solution and the occurrence perspective.

4.2. Criticality based on the chosen solution

In the analysis from the perspective of the chosen solution, the question will be to further investigate whether all the chosen solutions are similar or an interoperability risk can be seen from the selection of them.
In the first half-year of the project, workshops were arranged locally at each InterFlex demonstrator site with responsible people to establish a good understanding of the use cases and chosen architecture and solutions. In these workshops, interfaces were discussed that are critical in terms of interoperability, i.e. it was at that stage not fully clear how and based on which standards it would be the best way to achieve interoperability among the actors on both sides of the interfaces. During these workshops, for each use case the interfaces with open interoperability issues where marked.

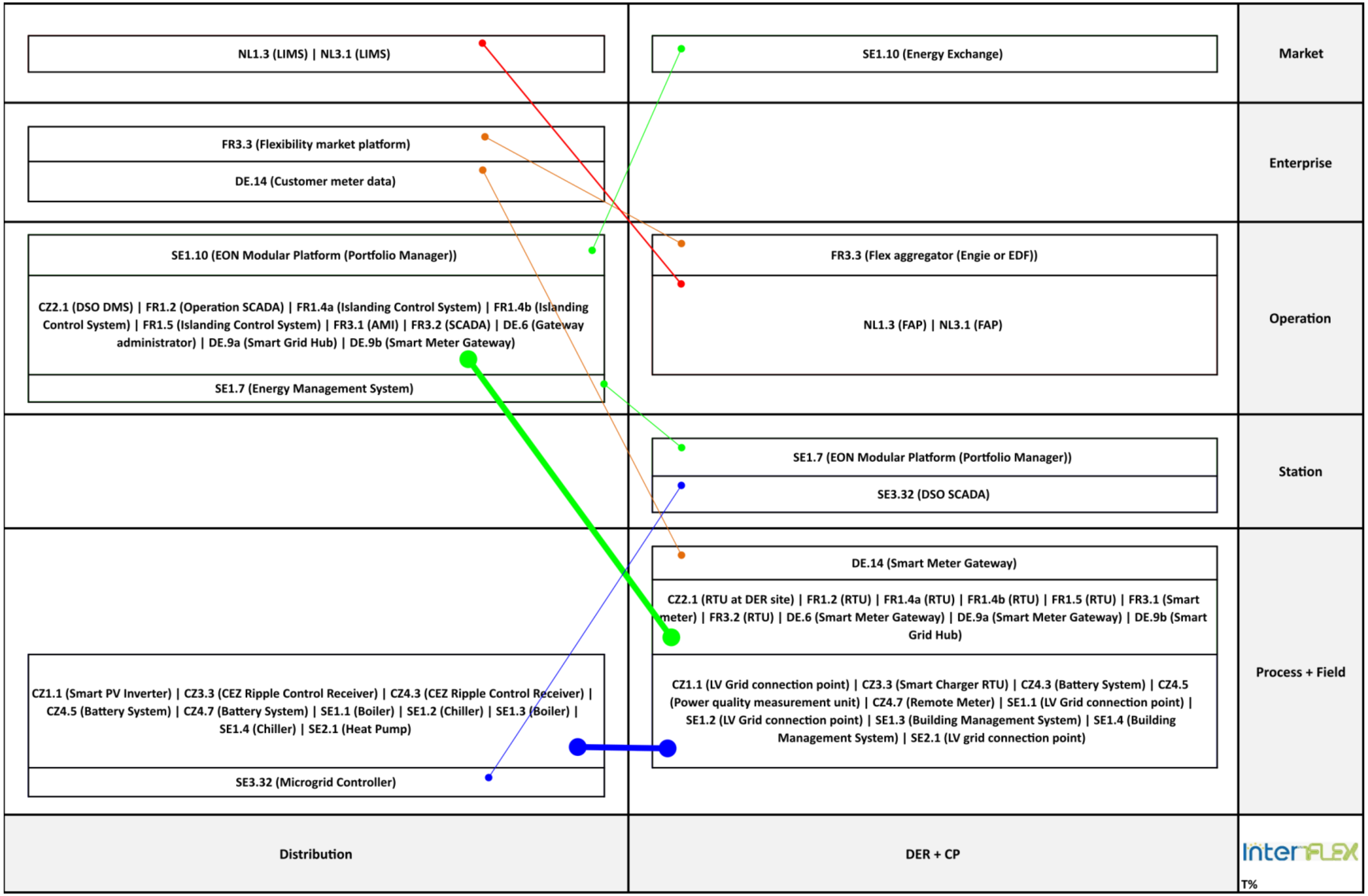


Figure 24. SGAM-based overview of the critical interfaces in terms of open interoperability issues

Figure 24 shows a SGAM-based overview of these selected critical interfaces. It can be observed that ten out of the twenty selected interfaces are associated with devices in the customer's field and process zone. The main motivation for the selection of those interfaces was that the current solution implemented in the demonstrator was chosen as a specific solution for use case due to the lack of a harmonized approach to realise functionalities on the respective interface. In Table 2, a detailed description of each of the selected interfaces with the current choice of protocols can be found.

Table 2. List of critical interfaces selected based on identification of open interoperability issues

Interface	Device-From	Device-To	Function	Data transmitted	Protocol used	Motivation for selection as critical interface
FR3.3	Flexibility market platform	Flex aggregator (Engie or EDF)	Request, offer and activate flexibility	Flex offer, flex activation	XMPP, CIM Market	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
FR3.5	Flex aggregator (Engie)	Load	Control load	ON/OFF, P meas.	KIWI/TOPKAPI HTTPS	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
FR3.7	Gas IT server	Hybrid load (water boiler)	Collect P meas., Control hybrid load	Flex control, P meas.	3G	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
FR3.8	Flex aggregator (EDF)	Load	Control load	Flex activation request (control load)	TCP/IP, SMS or SMTP	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
FR1.6	RTU	Inverter	Control of GSU inverter (P setpoint)	P setpoint	Modbus TCP	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
FR1.7	RTU	Inverter	Control of GFU inverter (P, Q setpoints)	P, Q setpoints	Modbus TCP	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
FR3.4	RTU	Inverter	Collect P meas. & SoC	P meas., SoC	ModbusTCP	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.

Inter-face	Device-From	Device-To	Function	Data transmitted	Protocol used	Motivation for selection as critical interface
CZ2.1	DSO DMS	RTU at customers' MV-connected DER	Communication of Power and voltage measurements, Voltage set point, other commands (disconnection, re-connection etc.)	Measurements Voltage set point Commands	IEC 60870-5-104 over GPRS	Solution is specific to use case and there is no harmonized approach for functionalities on this interface at EU level. Note: the solution is now business as usual in Czech Republic (CEZ Distribuce areas)
CZ3.3	CEZ Ripple Control Receiver	Smart Charger RTU	Activation commands	On/off	Switch contact	Solution is specific to use case and there is no harmonized approach for functionalities on this interface at EU level.
CZ3.5	Smart Charger	EV	Charging handshake	Maximum charging power	IEC61851	Many car manufacturers will connect to the charging spot, so correct implementation of the standard is crucial Note: this interface is out of scope of WP6. CZ demo only uses existing IEC 61851 for communication between charging stations and EVs.
CZ4.3	CEZ Ripple Control Receiver	Battery System	Activation commands	On/off	Switch contact	Solution is specific to use case and there is no harmonized approach for functionalities on this interface at EU level.
NL1.3	LIMS	FAP	Offers flexibility from the aggregator	flex data	EFI	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
NL2.3	CPMS	FAP	Offers flexibility from the aggregator	flex data	OCPI	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
NL3.1	FAP	LIMS	Offers flexibility from the aggregator	flex data	EFI+	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.

Inter-face	Device-From	Device-To	Function	Data transmitted	Protocol used	Motivation for selection as critical interface
NL3.2	FAP	GMS	Send the flexibility request data	flex data (re-quest)	USEF+	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
DE1.1	Smart Grid Hub Data Unit	Smart Meter Gateway	Allows the metering data provided by the GW to be stored in the Smart Grid Hub Data Unit	Grid KPI (I, I, P, f)	IEC 61850 (LTE/4G)	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
DE1.4	Smart Meter Gateway	Control box	Allow to control the relay	Power setpoint?	IEC 61850 (LTE/4G)	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
DE1.6	Gateway administrator	Smart Grid Hub	Manage authorisations to access data (certificate validity)	Gateway channel request	TASE 2 (IEC 60870-6)	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
SE3.11	Local Gateway	Supplier Cloud Sys.	Measuring data and commands to the PV, BAT, Heat Pump, EV managers and Meter Data Manager (MDM) of the Power-to-Heat	LV assets measurement data, commands	REST	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.
SE3.25	Gateway	Demand Side Response Sys.	Central monitoring and control of distributed balancing technologies	Monitoring and control	OPC, MQTT	Solution is specific to use case and there is no harmonized approach for functionalities on this interface.

Similar to the interoperability analysis from other viewpoints, the large variety in solutions selected in InterFlex also here results in a long list of very different interfaces, where interoperability analysis needs a close look on each of those interfaces. We therefore add another viewpoint to the interoperability analysis, which is the criticality from the occurrence perspective.

4.3. Criticality from the occurrence perspective

One other perspective to study interfaces within the InterFlex project is the occurrence-based analysis. The methodology described in 2.2 to 2.5 has been used in order to compare interfaces. Also, the Distributed Energy Resources and the Customer Premises domains have been merged, because we are focusing on the link between Distribution and Flexibilities, wherever they are placed (i.e. in the DER station or in the customer premises). Only the horizontal and diagonal links have been kept, as vertical links are within the same domain and there does not represent any cross-domain interoperability issue.
The following table contains the list of interfaces that are the most represented across all the use cases of all demonstrators.

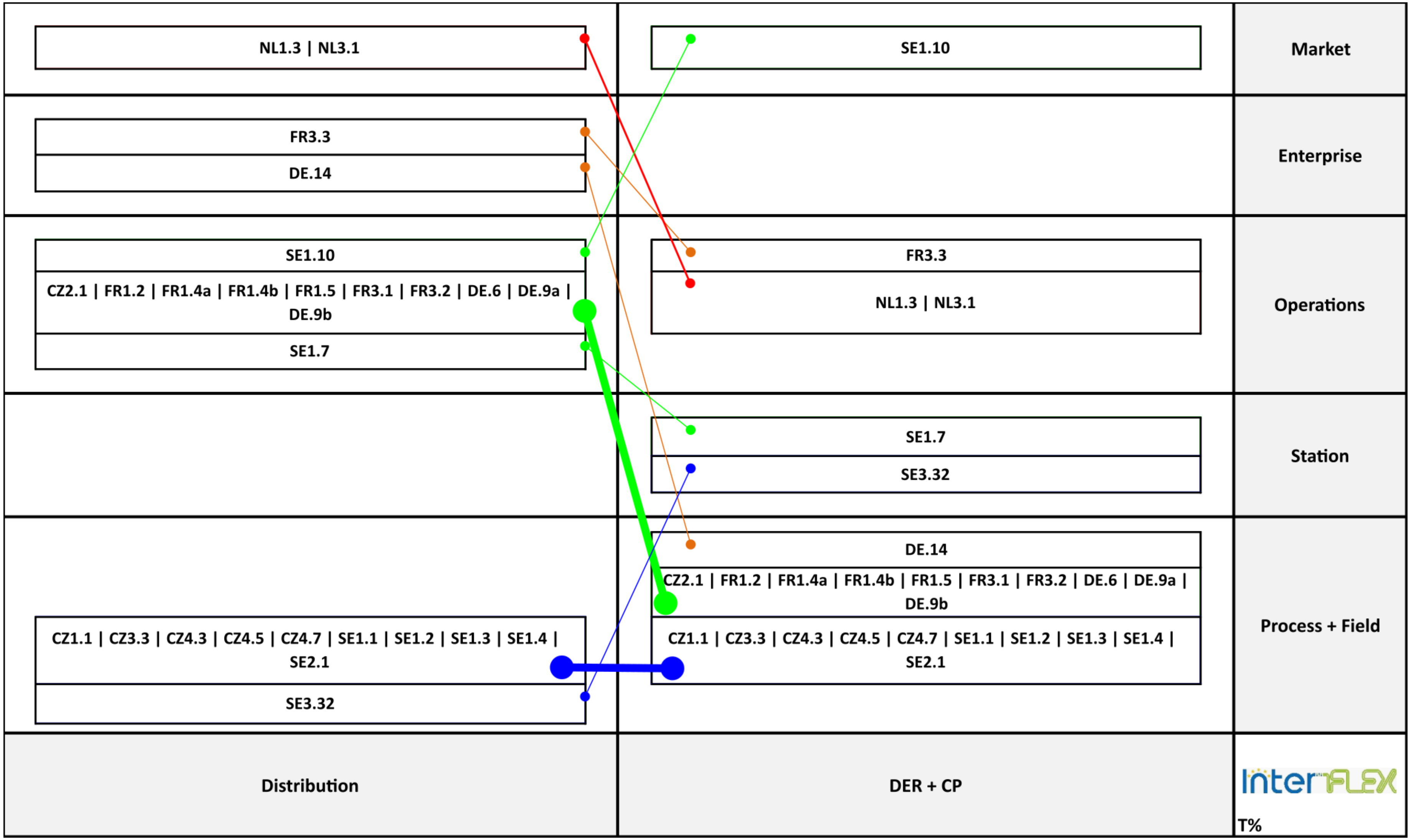


Figure 25. Use case mapping for interfaces. Bolder the link, the more interfaces.

Table 3: Criticality based on occurrence perspective

Interfaces concerned	Aggregated domain-from	Aggregated domain-to	Aggregated zone-from	Aggre-gated zone-to	Function	Number of occurrences
CZ1.1 CZ3.3 CZ4.3 CZ4.5 CZ4.7 SE1.1 SE1.2 SE1.3 SE1.4 SE2.1	Distribution	DER + CP	Process + field	Process + field	Tie line, activation command, power quality / energy measurement, translation of activation signal	10
FR1.2 FR1.4a FR1.4b FR1.5 FR3.1 FR3.2 CZ2.1 DE.6 DE.9a DE.9b	Distribution	DER + CP	Operations	Process + field	Control relay, collect metering data, collect load profiles, collect power and voltage measurements, control centralized storage switch, control centralized storage inverter, provide setpoints	10
NL1.3 NL3.1	Distribution	DER+CP	Market	Operation	Update centralized storage status, send power profiles	2
SE1.7	Distribution	DER + CP	Operations	Station	Collect grid measurements, control setpoints	1
SE1.10	Distribution	DER + CP	Operation	Market	Exchange energy price	1
SE3.32	Distribution	DER + CP	Process + Field	Station	Commands from the microgrid controller to the remote terminal unit for the connection to the grid (HV side)	1
FR3.3	Distribution	DER+CP	Enterprise	Operation	Request, offer and activate flexibility	1

Interfaces concerned	Aggregated domain-from	Aggregated domain-to	Aggregated zone-from	Aggre-gated zone-to	Function	Number of occurrences
DE.14	Distribution	DER+CP	Enterprise	Process + field	Transport metering data to MDM	1

We can clearly see that the most represented interface is from “Distribution domain / Process + field zone” to “DER + CP domain / Process + field zone”.

4.4. Selection of interfaces for interoperability and interchangeability testing

When combining the interfaces highlighted by several perspectives, the following interfaces show the most interest:

1. “Distribution/Process + Field” to “DER + CP/Process + Field”
2. “Distribution/Operation” to “DER + CP/Market”

When putting those interface into their context within InterFlex use-cases, we obtain the following couple of actors/devices:

1. For interface #1:
    a. Field gateway and storage
    b. Field gateway and smart appliances
2. For interface #2:
    a. DSO SCADA and aggregators

These interfaces are selected for the future interoperability and interchangeability tests to be performed in task 3.1.2.

5. CONCLUSION

In this deliverable, a methodology was proposed to compare interfaces within the demonstrators. In this regard, the abstraction level of domains and zones of the SGAM model has been used which led to eliminate different naming of same devices/actors among the demonstrators.
By selecting interfaces according to a different criticality viewpoint, two interfaces of interest, namely "Distribution/Process + Field" to "DER + CP/Process + Field" and "Distribution/Operation" to "DER + CP/Market" have been selected.
These interfaces correspond to the following couples of actors/devices: "field gateway and storage" and "field gateway and smart appliances" for the first interface, "DSO SCADA and aggregators" for the second interface.

The study of interoperability of these interfaces will be done in task 3.1.2, and the methodology to be applied will be described in the associated deliverable.

6. ANNEX – INTERFACE DATABASE

6.1. Interfaces for French demo

Name	Type	Between ...	And ...	Aim
FR1.1	Telecom / functional	Operation SCADA	RTU	Control of MV switches and Collect U & I measurements
FR1.2	Telecom / functional	Operation SCADA	RTU	Control of GFU switch (via RTU)
FR1.3	Telecom / functional	Islanding Control System	RTU	Control of MV switches and Collect U & I measurements
FR1.4a	Telecom / functional	Islanding Control System	RTU	Control of GFU switch (via RTU)
FR1.4b	Telecom / functional	Islanding Control System	RTU	Control of GFU inverter (P, Q setpoints, via RTU)
FR1.5	Telecom / functional	Islanding Control System	RTU	Control of GSU inverter (P setpoint, via RTU)
FR1.6	Telecom / functional	RTU	Inverter	Control of GSU inverter (P setpoint)
FR1.7	Telecom / functional	RTU	Inverter	Control of GFU inverter (P, Q setpoints)
FR1.8	Telecom / functional	RTU	LV switch	Control of GFU switch
FR1.9	Telecom / functional	RTU		Collect U & I measurements

Name	Type	Between ...	And ...	Aim
FR1.10	Telecom / functional	RTU		Control of MV switch
FR3.1	Telecom / functional	AMI	Smart meter	Collect load profiles
FR3.2	Telecom / functional	SCADA	RTU	Collect P meas. & SoC (via RTU)
FR3.3	Telecom / functional	Flexibility market platform	Flex aggregator (Engie or EDF)	Request, offer and activate flexibility
FR3.4	Telecom / functional	RTU	Inverter	Collect P meas. & SoC
FR3.5	Telecom / functional	Flex aggregator (Engie)	Load	Control load
FR3.6	Telecom / functional	Flex aggregator	Gas IT server	Request flexibility
FR3.7	Telecom / functional	Gas IT server	Hybrid load (water boiler)	Collect P meas., Control hybrid load
FR3.8	Telecom / functional	Flex aggregator (EDF)	Load	Control load

6.2. Interfaces for Czech demo

Name	Type	Between ...	And ...	Aim
CZ1.1	Functional / electrotechnical	Smart PV Inverter	LV Grid connection point	Tie line for PV power injection

Name	Type	Between …	And …	Aim
CZ1.2	Electro-technical	Power quality measurement	LV Grid connection point	Connection power, power quality measurement
CZ1.3	Electro-technical	Remote meter	LV Grid connection point	Meter connection to determine amount net energy flow from domestic installation
CZ1.4	Telecom / functional	Remote meter	DSO Converge System	Load profile communication to DSO operation centre
CZ1.5	Telecom / functional	Power quality measurement	DSO quality management	Communication of power quality parameters from on-site measurements to DSO operation centre
CZ1.6	Telecom / functional / electro-technical	Power quality measurement	DSO quality management	Communication of power quality parameters from substation measurements to DSO operation centre
CZ1.7	Telecom/ functional	RTU	DMS	Communication of commands to and measurements from voltage regulation transformer in substation.
CZ1.8	Electro-technical	Power quality measurement	LV Grid connection point	Connection power quality measurement
CZ2.1	Telecom / functional	DSO DMS	RTU at DER site	Power and voltage measurements, Voltage set point, other commands (disconnection, re-connection etc.)
CZ2.2	Telecom / functional	DSO DMS	Field measurement units	Voltage measurements
CZ2.3	Telecom / functional	DSO DMS	Primary substation	Measurements, OLTC setpoints, Commands
CZ2.4	Electro-technical	Primary Substation	DER site	Electrical connection
CZ2.5	Electro-technical	Primary Substation Busbar	Primary substation sensors	Electrical connection

Name	Type	Between …	And …	Aim
CZ3.1	Telecom / functional	DSO DMS	Primary Substation Ripple Control Transmitter	Activation commands
CZ3.2	Telecom / functional / electro-technical	Primary Substation Ripple Control Transmitter	CEZ Ripple Control Receiver	Electrical and ripple control connection (CEZ NB PLC)
CZ3.3	Functional / electro-technical	CEZ Ripple Control Receiver	Smart Charger RTU	Activation commands
CZ3.4	Electro-technical	Primary Substation	Smart Charger RTU	Energy provision
CZ3.5	Telecom / functional	Smart Charger	EV	Charging handshake
CZ3.6	Electro-technical	Smart Charger RTU	Power quality measurement unit	Power quality measurement
CZ3.7	Telecom	Power quality measurement unit	DSO Quality Management	Power quality measurement data
CZ4.1	Telecom / functional	DSO DMS	Primary Substation Ripple Control Transmitter	Activation commands
CZ4.2	Telecom / functional / electro-technical	Primary Substation Ripple Control Transmitter	CEZ Ripple Control Receiver	Electrical and ripple control connection (CEZ NB PLC)
CZ4.3	Functional / electro-technical	CEZ Ripple Control Receiver	Battery System	activation commands
CZ4.4	Electro-technical	Primary Substation	Battery System	Energy provision
CZ4.5	Electro-technical	Battery System	Power quality measurement unit	Power quality measurement
CZ4.6	Telecom	Power quality measurement unit	DSO Quality Management	Power quality measurement data

Name	Type	Between …	And …	Aim
CZ4.7	Electro-technical	Battery System	Remote Meter	Energy measurement
CZ4.8	Telecom	Remote Meter	DSO Converge System	Energy measurement

6.3. Interfaces for Dutch demo

Name	Type	Between …	And …	Aim
NL1.1 a	Electro-technical / Telecom / functiona	RTU SSU	Smart Inverter	SoC, set-points & actual values (re)active power, pahse voltage & current, energy throughput
NL1.1 b	Electro-technical / Telecom / functio-nal	RTU PV	Smart Inverter	Load profile, energy measurements
NL1.2 a	Telecom / function-nal	LIMS	RTU SSU	Monitor data, send configuration
NL1.2 b	Telecom / function-nal	LIMS	RTU PV	Monitor data, send configuration
NL1.3	Telecom / function-nal	LIMS	FAP	Update SSU status, send power profiles
NL1.4	Telecom / function-nal	GMS	FAP	Validate energy prognosis, Flex request, Flex of-fer, Flex procurement
NL1.5	Telecom / function-nal	Datalake	GMS	Monitor and store historical data for phase volt-age, (re)active power, phase current, harmonic distortion, up to PTU (t-1)
NL1.6	Telecom / function-nal	Salavador	Datalake	Provide U, I, P, Q and power quality data
NL1.7	Telecom / function-nal	Salavador	RTU DALI	Provide U, I, P, Q and power quality data
NL1.8	Telecom / function-nal	RTU DALI	DALI	Provide U, I, P, Q and power quality data
NL1.9	Electro-technical / Telecom / functiona	DALI	U/I/Q/P Power quality meter	Provide U, I, P, Q and power quality data

Name	Type	Between …	And …	Aim
NL2.1	Electro-techni-cal/Telecom/Func-tional	Controlller CP	Charging Station	Load profiles, energy measurements
NL2.2	Telecom / function-nal	CPMS	Controller CP	Allows the charge point to be connected to the CPMS, in order to manage charge wishes and flexi-bility.
NL2.3	Telecom / function-nal	CPMS	FAP	Update SSU status, send power profiles
NL2.4	Telecom / function-nal	GMS	FAP	Validate energy prognosis, Flex request, Flex of-fer, Flex procurement
NL2.5	Telecom / function-nal	Datalake	GMS	Monitor and store historical data for phase volt-age, (re)active power, phase current, harmonic distortion, up to PTU (t-1)
NL2.6	Telecom / function-nal	Salavador	Datalake	Provide U, I, P, Q and power quality data
NL2.7	Telecom / function-nal	Salavador	RTU DALI	Provide U, I, P, Q and power quality data
NL2.8	Telecom / function-nal	DALI	RTU DALI	Provide U, I, P, Q and power quality data
NL2.9	Electro-technical / Telecom / functiona	DALI	U/I/Q/P Power quality meter	Provide U, I, P, Q and power quality data
NL3.1	Telecom / function-nal	LIMS	FAP	Update SSU status, send power profiles
NL3.2	Telecom / function-nal	GMS	FAP	Validate energy prognosis, Flex request, Flex of-fer, Flex procurement
NL3.3	Telecom / function-nal	SCADA/DMS	GMS	Send configuration and get the load data
NL3.4	Telecom / function-nal	DaVinci	GMS	Send configuration and get the load data

6.4. Interfaces for German demo

Name	Type	Between …	And …	Aim
DE.1	Telecom / functional	Substation	Meter/Smart Meter/transducer	Electro-technical measurements
DE.2	Telecom / functional	Control box	Load	Control customer loads
DE.3	Telecom / functional	Meter/Smart Meter/transducer	RTU	Transport measurement data to Substation
DE.4	Telecom / functional	Smart Meter	Smart Meter Gateway	Transport metering data to gateway
DE.5	Telecom / functional	Smart Meter Gateway	Control box	Provide setpoints
DE.6	Telecom / functional	Gateway administrator	Smart Meter Gateway	Request data
DE.7	Telecom / functional	RTU	Grid Control (SCADA)	Transport measurement data to SCADA
DE.8	Telecom / functional	Smart Grid Hub	Gateway administrator	Requests data
DE.9a	Telecom / functional	Smart Grid Hub	Smart Meter Gateway	Provide setpoints
DE.9b	Telecom / functional	Smart Meter Gateway	Smart Grid Hub	Transport Grid KPIs

Name	Type	Between ...	And ...	Aim
DE.10	Telecom / functional	Grid Control (SCADA)	Smart Grid Hub	Request curtailment
DE.11	Telecom / functional	External Factors	Grid Control (SCADA)	Provide forecasting and estimation data
DE.12	Telecom / functional	Integration platform	Smart Grid Hub	Provide topological data
DE.13	Telecom / functional	Customer meter data	Smart Grid Hub	Provide customer estimation
DE.14	Telecom / functional	Customer meter data	Smart Meter Gateway	Transport metering data to MDM

6.5. Interfaces for Swedish demo

Name	Type	Between ...	And ...	Aim
SE1.1	Functional / electro-technical	Boiler	LV Grid connection point	Tie line for boiler power injection
SE1.2	Functional / electro-technical	Chiller	LV Grid connection point	Tie line for chiller power injection
SE1.3	Functional / electro-technical	Boiler	BMS	Translation of the activation signal to offset temperature values for the boiler

Name	Type	Between …	And …	Aim
SE1.4	Functional / electro-technical	Chiller	BMS	Translation of the activation signal to offset temperature values for the chiller
SE1.5	Telecom / functional	BMS	EMS	New Set point overwrites BMS temperature setpoints
SE1.6	Telecom / functional / electro-technical	Heat and Temp. Measurements	BMS	Communication of heat and temperature measured data
SE1.7	Telecom / functional	EMS	EON Modular Platform (Portfolio Manager)	Transferring multiple data of the thermal grid measurements to the portfolio manager (Local DSO energy manager). Activation of selected distributed buildings. Transferring thermal grid temperature setpoints from portfolio manager to the building management system (Creation of the inlet temperature setpoints for the heating/cooling systems. Dynamic load management by changing thermal inertia). Provide online grid performance indicators.
SE1.8	Telecom / functional / electro-technical	GW	DSO Grid Control Center	Microgrid operational condition monitoring
SE1.9	Telecom / functional	EON Modular Platform (Portfolio Manager)	Weather Forecast	Exchange of weather forecast data between portfolio manager and DSO
SE1.10	Telecom / functional	EON Modular Platform (Portfolio Manager)	Energy Exchange	Exchange of the energy price to the EMS at DSO (PM). Positive price indicates excess of renewables

Name	Type	Between …	And …	Aim
SE2.1	Functional / electro-technical	Heat Pump	LV grid connection point	Tie line for heat pump power injection
SE2.2	Telecom / functional	Heat Pump	GW (& EMS local)	Measurement data and commands communication to the heat pump
SE2.3	Telecom / functional	GW (& EMS local)	EON Modular Platform	Thermal grid measurement data from GW to the EON Modular Platform (EMP), Thermal grid temperature setpoints from EMP to GW
SE2.4	Telecom / functional	EON Modular Platform	Weather Forecast	Transfer weather forecast data
SE2.5	Telecom / functional	EON Modular Platform	Energy Exchange	Transfer energy prices data
SE3.1	Functional / electro-technical	BAT	LV grid connection point	Tie line for battery power injection
SE3.2	Functional / electro-technical	PV	LV grid connection point	Tie line for PV power injection
SE3.3	Functional / electro-technical	Heat Pump	LV grid connection point	Tie line for heat pump power injection
SE3.4	Functional / electro-technical	Power-to-Heat	LV grid connection point	Tie line for power-to-heat power injection

Name	Type	Between ...	And ...	Aim
SE3.5	Functional / electro-technical	EV	LV grid connection point	Tie line for electric vehicle power injection
SE3.6	Telecom / Functional	BAT	Local GW	Communication of residential battery measurements
SE3.7	Telecom / Functional	PV	Local GW	Communication of inverter measurements at customer side
SE3.8	Telecom / Functional	Heat Pump	Local GW	Communication of the measured data to the heat pump controller
SE3.9	Telecom / Functional	Power-to-Heat	Local GW	Communication of the measured data to the controller box of the Hot Water boiler
SE3.10	Telecom / Functional	EV	Local GW	Communication of the measured data to the charging station of the electric vehicles
SE3.11	Telecom / Functional	Local GW	Supplier Cloud Sys.	Measuring data and commands to the PV, BAT, Heat Pump, EV managers and Meter Data Manager (MDM) of the P2H
SE3.12	Functional / electro-technical	Power-to-Heat	MV grid connection point	Tie line for P2H power injection
SE3.13	Functional / electro-technical	Diesel Generator	MV grid connection point	Tie line for the diesel generator power injection

Name	Type	Between ...	And ...	Aim
SE3.14	Functional / electro-technical	PV	MV grid connection point	Tie line for PV plant power injection
SE3.15	Functional / electro-technical	BAT	MV grid connection point	Tie line for the main battery power injection
SE3.16	Functional / electro-technical	Wind Turbine	MV grid connection point	Tie line for the wind turbine power injection
SE3.17	Telecom / Functional	Power-to-Heat	GW	Communication of the measured data to the controller box of the large scale HTW boiler
SE3.18	Telecom / Functional	DG	GW	Communication of the diesel generator measured data
SE3.19	Telecom / Functional	PV	GW	Communication of PV plant measurements
SE3.20	Telecom / Functional	BAT	GW	Communication of the main battery measurements
SE3.21	Telecom / Functional	Wind Turbine	GW	Communication of the wind turbine measurements
SE3.22	Telecom / Functional	Supplier Cloud Sys.	Demand side response System	Data platform for the domestic assets
SE3.23	Telecom / Functional	GW	Microgrid Controller	Communication of large scale assets data to microgrid controller for monitoring the MV Network

Name	Type	Between …	And …	Aim
SE3.24	Electro-technical / Telecom / Functional	Microgrid Controller	GW	Control and steer all the decentralized assets. Master monitoring while keeping safety margins of generation
SE3.25	Electro-technical / Telecom / Functional	GW	Demand side response System	Central monitoring and control of distributed balancing technologies
SE3.26	Telecom / Functional	Demand side response System	Market Place	Customer engagement in the market
SE3.27	Telecom / Functional	GW	GW	Ethernet connection between gateways at the large scale assets
SE3.28	Electro-technical / Functional	DSO SCADA	Switch	Activation commands
SE3.29	Telecom / Functional	DSO SCADA	GW	Communication of DSO SCADA data to the local grid controller
SE3.30	Electro-technical / Telecom / Functional	GW	Local Grid Control Center	Use of DSO SCADA data to the local grid controller
SE3.31	Electro-technical / Telecom / Functional	Local Grid Control Center	DSO Grid Control Center	Communication of the local grid operation to DSO, Correct operation of the microgrid
SE3.32	Telecom / Functional	Microgrid Controller	DSO SCADA	Commands from the microgrid controller to the remote terminal unit for the connection to the grid (HV side)

Name	Type	Between ...	And ...	Aim
SE3.33	Telecom / Functional	Remote Terminal Unit	Remote Terminal Unit	Communication layer between the DSO SCADA units
SE4.1	Telecom / Functional	Customer Assets	P2P Market Platform	The communication link between the customer UI and P2P platform, requesting flexibility from connected assets, Interaction with active customer and visualization of the incentives
SE4.2	Telecom / Functional	Distributed Energy Resource System	Demand Side Response System	Flexibility provided by the larger scale assets
SE4.3	Telecom / Functional	Demand Side Response System	P2P Market Platform	Flexibility dispatch report. Report sent from Demand Side Response to P2P platform about Demand Side Response activation periods and activated assets.
SE4.4	Telecom / Functional	P2P Market Platform	Exchange Market	Generation of billing information (price)
SE5.1	Telecom / Functional	Customer Assets	Demand Side Response System	Activation commands between the intermediate management platform and the local assets. Exchange of the updated data from the intermediate management platform to the data platform.
SE5.2	Telecom / Functional	DER Station	Data Platform	Flexibility commands and data for the large scale assets
SE5.3	Telecom / Functional	Demand Side Response System	Advanced Control	Improve the estimation accuracy of the available flexibility in the system (both in terms of magnitude and timing. External information is processed by algorithms to improve the creation of flexibility schedules.

Name	Type	Between ...	And ...	Aim
SE5.4	Telecom / Functional	Advanced Control	Weather Services	Communication of weather forecast data to the advanced microgrid algorithm
SE5.5	Telecom / Functional	Advanced Control	Energy Exchange	Communication of price forecast data to the advanced microgrid algorithm

6.6. Complete interface database

Inter-face	Domain-From	Zone-From	Domain-To	Zone-To	Cross-Do-main	Direc-tion	Implicit type	Implicit cor-ner	Scope	Device-From	Device-To	Type	Data	Protocol
CZ1.1	Customer Premises	Field	Distribution	Field	yes	hori-zontal			inter cells	Smart PV Inverter	LV Grid connection point	Functional/ electro-technical	/	out of scope
CZ1.2	Distribution	Field	Distribution	Field	no	point			intra cells	LV Grid connection point	Power quality measurement	Electro-technical	/	/
CZ1.3	Distribution	Field	Distribution	Field	no	point			intra cells	LV Grid connection point	Remote meter	Electro-technical	/	/
CZ1.4	Distribution	Field	Distribution	Enter-prise	no	vertical			inter cells	Remote meter	DSO Converge System	Telecom/ functional	Billing data	TBD (not in focus)
CZ1.5	Distribution	Field	Distribution	Enter-prise	no	vertical			inter cells	Power quality measurement	DSO quality management	Telecom/ functional	Power quality data	TBD (not in focus)
CZ1.6	Distribution	Field	Distribution	Enter-prise	no	vertical			inter cells	Power quality measurement	DSO quality management	Telecom/ functional	Power quality data	TBD (not in focus)
CZ1.7	Distribution	Station	Distribution	Opera-tion	no	vertical			inter cells	RTU	DMS	Telecom/ functional	Measurements from RTU set points for tap changer	IEC 60870-5-104
CZ1.8	Distribution	Field	Distribution	Field	no	point			intra cells	LV Grid connection point	Power quality measurement	Electro-technical	/	/
CZ2.1	Distribution	Opera-tion	DER	Field	yes	diago-nal	lower	SIM-Modem in field	inter cells	DSO DMS	RTU at DER site	Telecom/ functional	Measurements Voltage set point Comands	IEC 60870-5-104 over GPRS or Fibre
CZ2.2	Distribution	Field	Distribution	Opera-tion	no	vertical			inter cells	Field measurement units	DSO DMS	Telecom/ functional	Measurements	IEC 60870-5-104 over GPRS or Fibre
CZ2.3	Distribution	Opera-tion	Distribution	Station	no	vertical			inter cells	DSO DMS	Primary substation	Telecom/ functional	Measurements OLCT set point Commands	IEC 60870-5-104
CZ2.5	Distribution	Station	Distribution	Station	no	point			intra cells	Primary Substation Busbar	Primary substation sensors	Electro-technical	/	/
CZ3.1	Distribution	Opera-tion	Distribution	Station	no	vertical			inter cells	DSO DMS	Primary Substation Ripple Control Transmitter	Telecom/ functional	Commands	IEC 60870-5-104
CZ3.2	Distribution	Station	Distribution	Field	no	vertical			inter cells	Primary Substation Ripple Control Transmitter	CEZ Ripple Control Receiver	Telecom/ functional/ elec-tro-technical	/	CEZ Ripple NB-PLC
CZ3.3	Distribution	Field	DER	Field	yes	hori-zontal			inter cells	CEZ Ripple Control Receiver	Smart Charger RTU	Functional/ electro-technical	/	Switch contact
CZ3.5	DER	Process	DER	Process	no	point			intra cells	Smart Charger	EV	Telecom/ functional	/	IEC61851
CZ3.7	Distribution	Field	Distribution	Enter-prise	no	vertical			inter cells	Power quality measurement unit	DSO Quality Management	Telecom	Power quality measurement data	TBD
CZ4.1	Distribution	Opera-tion	Distribution	Station	no	vertical			inter cells	DSO DMS	Primary Substation Ripple Control Transmitter	Telecom/ functional	Commands	IEC 60870-5-104
CZ4.2	Distribution	Station	Distribution	Station	no	point			intra cells	Primary Substation Ripple Control Transmitter	CEZ Ripple Control Receiver	Telecom/ functional/ elec-tro-technical	/	/
CZ4.3	Distribution	Field	Customer Premises	Process	yes	hori-zontal			inter cells	CEZ Ripple Control Receiver	Battery System	Functional/ electro-technical	Commands	/
CZ4.5	Customer Premises	Process	Distribution	Field	yes	hori-zontal			inter cells	Battery System	Power quality measurement unit	Electro-technical	/	/
CZ4.6	Distribution	Field	Distribution	Enter-prise	no	vertical			inter cells	Power quality measurement unit	DSO Quality Management	Telecom	Power quality data	TBD.
CZ4.7	Customer Premises	Process	Distribution	Field	yes	hori-zontal			inter cells	Battery System	Remote Meter	Electro-technical	/	
CZ4.8	Distribution	Field	Distribution	Enter-prise	no	vertical			inter cells	Remote Meter	DSO Converge System	Telecom	Billing data	TBD.
NL1.1 a	DER	Field	DER	Process	no	hori-zontal			inter cells	RTU SSU	Smart Inverter	Electro-technical / Telecom / functiona	Power quality data and load data	Enexis Internal
NL1.1 b	Distribution	Field	Distribution	Opera-tion	no	vertical			inter cells	RTU PV	Smart Inverter	Electro-technical / Telecom / functiona	Power quality data and load data	

NL1.2 a	DER	Opera-tion	DER	Field	no	vertical			inter cells	LIMS	RTU SSU	telecom / functionnal	Monitoring and configuration data	Various protocols eg IEC 61850-7-420
NL1.2 b	DER	Opera-tion	DER	Field	no	vertical			inter cells	LIMS	RTU PV	telecom / functionnal	Monitoring and configuration data	Various protocols eg IEC 61850-7-420
NL1.3	DER	Opera-tion	Distribution	Market	yes	diago-nal	upper	market gate-way	inter cells	LIMS	FAP	telecom / functionnal	monitoring data and power profiles	EFI
NL1.4	Distribution	Opera-tion	Distribution	Market	no	vertical			inter cells	GMS	FAP	telecom / functionnal	flex data	USEF with minor addition
NL1.5	Distribution	Opera-tion	Distribution	Opera-tion	no	hori-zontal			inter cells	Datalake	GMS	telecom / functionnal	Monitoring, load data	Enexis Internal
NL1.6	Distribution	Opera-tion	Distribution	Opera-tion	no	vertical			inter cells	Salavador	Datalake	telecom / functionnal	Configuration, load data	Enexis Internal
NL1.7	Distribution	Opera-tion	Distribution	Station	no	vertical			inter cells	Salavador	RTU DALI	telecom / functionnal	Power quality data	IEC 60870-5-104 over GPRS
NL1.8	Distribution	Station	Distribution	Opera-tion	no	vertical			inter cells	RTU DALI	DALI	telecom / functionnal	Power quality data	IEC 60870-5-104 over GPRS
NL1.9	Distribution	Field	Distribution	Process	no	vertical			inter cells	DALI	U/I/Q/P Power quality meter	Electro-technical / Telecom / functiona	Power quality data	Enexis Internal
NL2.1	DER	Station	DER	Field	no	vertical			innner cells	Controlller CP	Charging Station	Electro-technical/Tele-com/Functional		OCPP
NL2.2	DER	Opera-tion	DER	Process	no	vertical			inter cells	CPMS	Controller CP	telecom / functionnal	Charging data	Control signal (OCPP)
NL2.3	DER	Opera-tion	DER	Market	no	diago-nal	upper	market gate-way	inter cells	CPMS	FAP	telecom / functionnal	monitoring data and power profiles	OCPI
NL2.4	Distribution	Opera-tion	Distribution	Market	no	vertical			inter cells	GMS	FAP	telecom / functionnal	flex data	USEF with minor addition
NL2.5	Distribution	Opera-tion	Distribution	Opera-tion	no	hori-zontal			inter cells	Datalake	GMS	telecom / functionnal	Monitoring, load data	Enexis Internal
NL2.6	Distribution	Opera-tion	DIstribution	Opera-tion	no	vertical			inter cells	Salavador	Datalake	telecom / functionnal	Configuration, load data	Enexis Internal
NL2.7	Distribution	Opera-tion	Distribution	Field	no	vertical			inter cells	Salavador	RTU DALI	telecom / functionnal	Power quality data	IEC 60870-5-104 over GPRS
NL2.8	Distribution	Field	Distribution	Station	no	vertical			inter cells	DALI	RTU DALI	telecom / functionnal	Power quality data	IEC 60870-5-104 over GPRS
NL2.9	Distribution	Field	Distribution	Process	no	vertical			inter cells	DALI	U/I/Q/P Power quality meter	Electro-technical / Telecom / functiona	Power quality data	Enexis Internal
NL3.1	DER	Opera-tion	Distribution	Market	yes	diago-nal	upper	market gate-way	inter cells	LIMS	FAP	telecom / functionnal	monitoring data and power profiles	EFI
NL3.2	Distribution	Opera-tion	Distribution	Market	no	vertical			inter cells	GMS	FAP	telecom / functionnal	flex data	USEF with minor addition
NL3.3	Distribution	opera-tion	Distribution	opera-tion	no	point			intra cells	SCADA/DMS	GMS	telecom / functionnal	Configuration, load data	Enexis Internal
NL3.4	Distribution	opera-tion	Distribution	opera-tion	no	point			intra cells	DaVinci	GMS	telecom / functionnal	Configuration, load data	Enexis Internal
FR1.1	Distribution	Opera-tion	Distribution	Field	no	vertical			inter cells	Operation SCADA	RTU	telecom / functional	U, I meas., ON/OFF	Modbus TCP
FR1.2	Distribution	Opera-tion	DER	Field	yes	diago-nal	lower	DSO gateway	inter cells	Operation SCADA	RTU	telecom / functional	ON/OFF	Modbus TCP
FR1.3	Distribution	Opera-tion	Distribution	Field	no	vertical			inter cells	Islanding Control System	RTU	telecom / functional	U, I meas., ON/OFF	Modbus TCP
FR1.4a	Distribution	Opera-tion	DER	Field	yes	diago-nal	lower	DSO gateway	inter cells	Islanding Control System	RTU	telecom / functional	ON/OFF	Modbus TCP
FR1.4 b	Distribution	Opera-tion	DER	Field	yes	diago-nal	lower	DSO gateway	inter cells	Islanding Control System	RTU	telecom / functional	P, Q setpoints	Modbus TCP
FR1.5	Distribution	Opera-tion	DER	Field	yes	diago-nal	upper	Engie IS	inter cells	Islanding Control System	RTU	telecom / functional	P setpoint	Modbus TCP
FR1.6	DER	Field	DER	Process	no	point			intra cells	RTU	Inverter	telecom / functional	P setpoint	Modbus TCP

FR1.7	DER	Field	DER	Process	no	point			intra cells	RTU	Inverter	telecom / functional	P, Q setpoints	Modbus TCP
FR1.8	DER	Field	DER	Process	no	point			intra cells	RTU	LV switch	telecom / functional	ON/OFF	ON/OFF wire
FR1.9	Distribution	Field	Distribution	Process	no	point			intra cells	RTU	Sensor	telecom / functional	U, I meas.	RS485
FR1.10	Distribution	Field	Distribution	Process	no	point			intra cells	RTU	MV Switch	telecom / functional	ON/OFF	ON/OFF wire
FR1.11	DER	Opera-tion	DER	Field	no	vertical			inter cells	Energy Management System	RTU	telecom / functional	P, Q setpoints	Modbus TCP
FR3.1	Distribution	Opera-tion	Customer Premises	Field	yes	diago-nal	lower	data concen-trator	inter cells	AMI	Smart meter	telecom / functional	Load profiles	DLMS/COSEM over GPRS/PLC
FR3.2	Distribution	Opera-tion	DER	Field	yes	diago-nal	lower	DSO gateway	inter cells	SCADA	RTU	telecom / functional	P meas., SoC	TCP/IP
FR3.3	Distribution	Enter-prise	Customer Premises	Opera-tion	yes	diago-nal	upper	aggregator IS	inter cells	Flexibility market platform	Flex aggregator (Engie or EDF)	telecom / functional	Flex offer, flex activation	XMPP, CIM Market
FR3.4	DER	Field	DER	Process	no	point			intra cells	RTU	Inverter	telecom / functional	P meas., SoC	Modbus TCP
FR3.5	Customer Premises	Opera-tion	Customer Premises	Field	no	vertical			inter cells	Flex aggregator (Engie)	Load	telecom / functional	ON/OFF, P meas.	KIWI/TOPKAPI HTTPS
FR3.6	Customer Premises	Opera-tion	Customer Premises	Opera-tion	no	point			intra cells	Flex aggregator	Gas IT server	telecom / functional	Flex control	TCPIP HTTPS
FR3.7	Customer Premises	Opera-tion	Customer Premises	Field	no	vertical			inter cells	Gas IT server	Hybrid load (water boiler)	telecom / functional	Flex control, P meas.	3G
FR3.8	Customer Premises	Opera-tion	Customer Premises	Process	no	vertical			inter cells	Flex aggregator (EDF)	Load	telecom / functional	Flex activation request (control load)	TCP/IP, SMS or SMTP
SE1.1	DER	Process	Distribution	Process	yes	hori-zontal			inter cells	Boiler	LV Grid connection point	functional / electro-technical	/	out of scope
SE1.2	DER	Process	Distribution	Process	yes	hori-zontal			inter cells	Chiller	LV Grid connection point	functional / electro-technical	/	out of scope
SE1.3	DER	Process	Distribution	Field	yes	hori-zontal			inter cells	Boiler	Building Management System	Functional/Electro-tehnical	Offset temperature values	Modbus, dry contact or 0...10V signals
SE1.4	DER	Process	Distribution	Field	yes	hori-zontal			inter cells	Chiller	Building Management System	Functional/Electro-tehnical	Offset temperature values	Modbus or dry contacts
SE1.5	Customer Premises	Station	Customer premises	Opera-tion	no	vertical			inter cells	Building Management System	Energy Management System	Telecom/ functional	Temperature setpoints	Modbus
SE1.6	Customer Premises	Process	Customer premises	Station	no	vertical			inter cells	Heat&Temp. Measurements	Buidling Management System	Telecom/ functional/ elec-tro-technical	Measured data of heat and Temp.	Modbus
SE1.7	DER	Station	Distribution	Opera-tion	yes	diago-nal			inter cells	Energy Management System	EON Modular Platform (Portfolio Manager)	Telecom/ functional	Activation commands	MQTT
SE1.8	Distribution	Field	Distribution	Enter-prise	no	vertical			inter cells	Gateway	DSO Grid Control Center	Telecom/ functional/ elec-tro-technical	Monitoring	out of scope
SE1.9	Distribution	Opera-tion	Distribution	Market	no	vertical			inter cells	EON Modular Platform (Portfolio Manager)	Weather Forecast	Telecom/ functional	Weather forecast data	REST
SE1.10	Distribution	Opera-tion	DER	Market	yes	diago-nal	upper	market gate-way	inter cells	EON Modular Platform (Portfolio Manager)	Energy Exchange	Telecom/ functional	Energy price data	REST
SE2.1	DER	Process	Distribution	Process	yes	hori-zontal			inter cells	Heat Pump	LV grid connection point	Functional/Electro-tehnical	/	out of scope
SE2.2	DER	Process	DER	Station	no	vertical			inter cells	Heat Pump	Gateway(& EMS local)	Telecom/Functional	Measremetnd ata and commands	Modbus
SE2.3	DER	Station	DER	Opera-tion	no	vertical			inter cells	Gateway(& EMS local)	EON Modular Platform	Telecom/Functional	measurement data and setpoints	MQTT
SE2.4	DER	Opera-tion	DER	Market	no	vertical			inter cells	EON Modular Platform	Weather Forecast	Telecom/Functional	Weather forecast data	REST
SE2.5	DER	Opera-tion	DER	Market	no	vertical			inter cells	EON Modular Platform	Energy Exchange	Telecom/Functional	Energy price data	REST
SE3.1	Customer Premises	Process	Customer Premises	Process	no	point			intra cells	BAT	LV grid connection point	Functional/Electro-tehnical	/	out of scope

SE3.2	Customer Premises	Process	Customer Premises	Process	no	point			intra cells	PV	LV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.3	Customer Premises	Process	Customer Premises	Process	no	point			intra cells	Heat Pump	LV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.4	Customer Premises	Process	Customer Premises	Process	no	point			intra cells	Power-to-Heat	LV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.5	Customer Premises	Process	Customer Premises	Process	no	point			intra cells	EV	LV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.6	Customer Premises	Process	Customer Premises	Field	no	point			intra cells	BAT	Local Gatway	Telecom/Functional	residential battery measurements data	TBD
SE3.7	Customer Premises	Process	Customer Premises	Field	no	point			intra cells	PV	Local Gateway	Telecom/Functional	inverter measurements at customer side meas-urements data	TBD
SE3.8	Customer Premises	Process	Customer Premises	Field	no	point			intra cells	Heat Pump	Local Gateway	Telecom/ Functional	Heat Pump measurements data	TBD
SE3.9	Customer Premises	Process	Customer Premises	Field	no	point			intra cells	Power-to-Heat	Local Gateway	Telecom/ Functional	Hot Water Boiler measurement data	TBD
SE3.10	Customer Premises	Process	Customer Premises	Field	no	point			intra cells	EV	Local Gateway	Telecom/ Functional	EV measurement data	TBD
SE3.11	Customer Premises	Field	Customer Premises	Opera-tion	no	vertical			inter cells	Local Gateway	Supplier Cloud Sys.	Telecom/ Functional	LV assets measurement data, commands	Json RPC, others TBD
SE3.12	DER	Process	DER	Process	no	point			intra cells	Power-to-Heat	MV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.13	DER	Process	DER	Process	no	point			intra cells	Diesel Generator	MV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.14	DER	Process	DER	Process	no	point			intra cells	PV	MV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.15	DER	Process	DER	Process	no	point			intra cells	BAT	MV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.16	DER	Process	DER	Process	no	point			intra cells	Wind Turbine	MV grid connection point	Functional/Electro-tehnical	/	out of scope
SE3.17	DER	Process	DER	Field	no	point			intra cells	Power-to-Heat	Gateway	Telecom/ Functional	Hot Water Boiler measurement data	Modbus, serial
SE3.18	DER	Process	DER	Field	no	point			intra cells	Diesel Generator	Gateway	Telecom/ Functional	Diesel Generator measurement data	Modbus TCP (Proconnix)
SE3.19	DER	Process	DER	Field	no	point			intra cells	PV	Gateway	Telecom/ Functional	PV plant measured data	Modbus, serial
SE3.20	DER	Process	DER	Field	no	point			intra cells	BAT	Gateway	Telecom/ Functional	BAT measured data	Modbus, serial
SE3.21	DER	Process	DER	Field	no	point			intra cells	Wind Turbine	Gateway	Telecom/ Functional	Wind Turbine measured data	Modbus, serial
SE3.22	Customer Premises	Opera-tion	Customer Premises	Opera-tion	no	point			intra cells	Supplier Cloud Sys.	Demand Side Response Sys.	Telecom/ Functional	LV assets data	REST
SE3.23	DER	Field	DER	Station	no	vertical			inter cells	Gateway	Microgrid Controller	Telecom/Functional	MV assets data, monitoring	Modbus, serial
SE3.24	DER	Station	DER	Station	no	point			intra cells	Microgrid Controller	Gateway	Electro-technical/Tele-com/Functional	Master Monitoring, Control and command data for assets	Modbus, serial
SE3.25	DER	Station	DER	Opera-tion	no	vertical			inter cells	Gateway	Demand Side Response Sys.	Electro-technical/Tele-com/Functional	Monitoring and control	OPC, MQTT
SE3.26	DER	Opera-tion	DER	Market	no	vertical			inter cells	Demand Side Response Sys.	Market Place	Telecom/Functional	Market data	REST
SE3.27	DER	Field	DER	Field	no	point			intra cells	Gateway	Gateway	Telecom/Functional	MV Data	Lon
SE3.28	Distribution	Process	Distribution	Field	no	point			intra cells	DSO SCADA	Switch	Electro-technical/Functional	Activation commands	TBD
SE3.29	Distribution	Station	Distribution	Station	no	point			intra cells	DSO SCADA	Gateway	Telecom/Functional	Lon Protocol	60870-5-101 over radiolink
SE3.30	Distribution	Station	Distribution	Opera-tion	no	vertical			inter cells	Gateway	Local Grid Control Center	Electro-technical/Tele-com/Functional	DSO SCADA data	60870-5-101 over radiolink

SE3.31	Distribution	Opera-tion	Distribution	Enter-prise	no	vertical			inter cells	Local Grid Control Center	DSO Grid Control Center	Electro-technical/Tele-com/Functional	Local grid operation monitoring	60870-5-101 over radiolink
SE3.32	Distribution	Process	DER	Station	yes	diago-nal			inter cells	Microgrid Controller	DSO SCADA	Telecom/Functional	Commands	Modbus Serial
SE3.33	Distribution	Field	Distribution	Field	no	point			intra cells	Remote Terminal Unit	Remote Terminal Unit	Telecom/Functional	monitoring	60870-5-101 over fiber op-tic
SE4.1	Customer Premises	Field	Customer Premises	Market	no	vertical			inter cells	Customer	P2P Market Platform	Telecom/Functional	Flexibility request data (Command to domestic as-sets), Customer UI	https
SE4.2	DER	Field	DER	Enter-prise	no	vertical			inter cells	DER Sys.	Demand Side Response Sys.	Telecom/Functional	Generation flexibility data	OPC, MQTT
SE4.3	Customer Premises	Enter-prise	Customer Premises	Market	no	vertical			inter cells	Demand Side Response Sys.	P2P Market Platform	Telecom/Functional	Flexibility data	REST
SE4.4	Customer Premises	Market	Customer Premises	Market	no	point			intra cells	P2P Market Platform	Exchange Market	Telecom/Functional	Billing data (price)	TBD
SE5.1	Customer Premises	Field	Customer Premises	Opera-tion	no	vertical			inter cells	Customer	Demand Side Response Sys.	Telecom/Functional	Commands	REST
SE5.2	DER	Field	DER	Station	no	vertical			inter cells	DER Station	Gateway	Telecom/Functional	Flexibility commands and data	OPC/MQTT
SE5.3	Customer Premises	Opera-tion	Customer Premises	Enter-prise	no	vertical			inter cells	Demand Side Response Sys	Advanced Control	Telecom/Functional	Load forecast and schdule data	EXT: REST Int: SQL
SE5.4	Customer Premises	Enter-prise	Customer Premises	Market	no	vertical			inter cells	Advanced Control	Weather Service	Telecom/Functional	Weather forecast data	REST
SE5.5	Customer Premises	Enter-prise	DER	Market	no	vertical			inter cells	Advanced Control	Energy Exchange	Telecom/Functional	Price forecast data	REST
DE.1	Distribution	Process	Distribution	Field	no	point			inter cells	Substation	Meter/Smart Meter/transducer	functional / telecom	measurement data on distribution level	
DE.2	Customer Premises	Field	Customer Premises	Process	no	point			inter cells	Control box	load	functional / telecom	setpoints for customer premises	12 V relay switch
DE.3	Distribution	Field	Distribution	Station	no	vertical			inter cells	Meter/Smart Meter/transducer	RTU	functional / telecom	measurement data on distribution level	
DE.4	Customer Premises	Field	Customer Premises	Field	no	point			intra cells	Smart Meter	Smart Meter Gateway	functional / telecom	measurement data on customer premises	
DE.5	Customer Premises	Field	Customer Premises	Field	no	point			intra cells	Smart Meter Gateway	Control box	functional / telecom	setpoints	IEC 61850 (LTE/4G)
DE.6	Distribution	Opera-tion	Customer Premises	Field	yes	diago-nal			inter cells	Gateway administrator	Smart Meter Gateway	functional / telecom	data channel request	IEC 61850 (LTE/4G)
DE.7	Distribution	Station	Distribution	Opera-tion	no	vertical			inter cells	RTU	Grid Control (SCADA)	functional / telecom	measurement data on distribution level	
DE.8	Distribution	Opera-tion	Distribution	Opera-tion	no	point			intra cells	Smart Grid Hub	Gateway administrator	functional / telecom	gateway channel request	Webservice
DE.9a	Distribution	Opera-tion	Customer Premises	Field	yes	diago-nal			inter cells	Smart Grid Hub	Smart Meter Gateway	functional / telecom	power setpoints	IEC 61850 (LTE/4G)
DE.9b	Customer Premises	Field	Distribution	Opera-tion	yes	diago-nal			inter cells	Smart Meter Gateway	Smart Grid Hub	functional / telecom	Grid KPI (V, I, P, f)	IEC 61850 (LTE/4G)
DE.10	Distribution	Opera-tion	Distribution	Opera-tion	no	point			intra cells	Grid Control (SCADA)	Smart Grid Hub	functional / telecom	Flex volume (power correction request)	TASE 2 (IEC 60870-6)
DE.11	Distribution	Enter-prise	Distribution	Opera-tion	no	vertical			inter cells	External Factors	Grid Control (SCADA)	functional / telecom	Forecasting and estimation data	
DE.12	Distribution	Enter-prise	Distribution	Opera-tion	no	vertical			inter cells	Integration platform	Smart Grid Hub	functional / telecom	structural topological data	
DE.13	Distribution	Enter-prise	Distribution	Opera-tion	no	vertical			inter cells	Customer meter data	Smart Grid Hub	functional / telecom	customer estimator (measurements)	
DE.14	Distribution	Enter-prise	Customer Premises	Field	yes	diago-nal			inter cells	Customer meter data	Smart Meter Gateway	functional / telecom	measurement data on customer premises	Webservice