Generalized Operational FLEXibility for Integrating Renewables in the Distribution Grid (GOFLEX)

D6.1 Integrated System Requirement & Interface Specification

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Executive Summary

This document provides an overview of complete GOFLEX integrated system. It contains requirements for data acquisition, exchange protocols and dependency of systems. Interactions between GOFLEX subsystems are described in textual and graphical way. D6.1 also provides prosumer structuring method, as well as a high-level integration process. Since WP6 is responsible for integration oversight, D6.1 also depicts demo case architecture for all three demonstration sites.

Document History

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0.1	19 Jan 2017	Draft	Sašo Brus	First draft
0.2	15 Mar 2017	Draft	Sašo Brus	Updated schematics, DOMS description
0.3	24 Mar 2017	Draft	Sašo Brus	Added FOA-DOMS interface
1.0	01 Apr 2017	Draft	Sašo Brus	Added data exchange table
1.1	09 Apr 2017	For internal review	Sašo Brus	Added impact indicators, implementation plan
1.2	23 Apr 2017	Final	Sašo Brus	Resolved minor review comments, added functional and non-functional req. tables

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List of Acronyms and Abbreviations

Abbre-viation	Definition
ATP	Automatic trading platform
EMS	Energy Management System
FOA	FlexOffer Agent
DMS	Distribution management system
DOMS	Distribution observability management system
xEMS	Any of the following Energy Management Systems: Factory, Home, Charging or Charging-Discharging EMS

1 Introduction

1.1 Purpose

The main objective of this WP is to supervise the integration across all technical levels of developed, innovated and tested solutions in WP2 to WP5 and to ensure that all subsystems are fully functional and aligned with each other. To achieve this the following activities shall be carried out:

- Define the overarching architecture and interaction concepts,
- Specify the concrete requirements towards the interfaces in terms of necessary data types, interaction mechanisms and frequency etc.,
- Generate the SW and HW (IoT) environment needed for the full supervision and control of the layers and components.
- Supervise and coordinate installations and integration on demonstration sites. Actual integration of components is done by system integrators, appointed by demo case managers on demo sites.

This data and control layer will enable distributed managing of the GOFLEX system and exposing information to different control systems. As the actual integration will be performed for and on several demonstration use cases (in WP7 - WP9), we will follow a balanced top-down and bottom-up approach, taking into account both the functional capabilities of the developed solutions and the technical requirements and constraints of individual demonstrated use cases as instances of customized application of the integrated system.

This document provides a high-level architecture, based on requirements of specific subsystems and defines overall integration requirements. Since solution work packages focus on specific problem solving, this WP is responsible for providing a structured way of inter-WP communication. Therefore, main focus of D6.1 is the definition of required execution environment for different solutions, data acquisition and data flow, exchange protocols and supervisory of integration.

1.2 Related documents

WP6 aims to integrate all of the technology components into single GOFLEX solution. Therefore D6.1 has to incorporate the technology deliverables, namely D2.1, D3.1, D4.1 and D5.1. In the design phase, WP6 will also include specific information, gathered on demo sites. This means including the D7.1, D8.1 and D9.1 specifications, as well as any other documents, related to demo site integration.

1.3 Document structure

Document is divided into several chapters, following the technology and integration process accordingly. In Chapter 2 we present the objective for integrated GOFLEX solution, based on the technology building blocks. In Chapter 3 we present the specific technologies from the integration angle. Functional and non-functional requirements of integrated GOFLEX solution are listed in Chapters 4 and 5. In Chapter 6 we present the connectivity requirements for demo sites, segmented by specific technologies and end users. In the Chapter 7 we present the data exchange table, which is the "meeting point" for WP2 trough WP5. We provide high level data description. Protocols for data acquisition and communication between systems are described in chapter 8. Chapter 9 contains high level integration description and is the basis for integration projects at demo sites. In Chapter 10 we describe the integration process and responsibilities. We also provide conceptual evaluation tests. Chapter 11 contains overall system schematics for all 3 demo sites and serves also as a consistency check for communication between different systems. Impact indicators are briefly described in Chapter 12. Implementation plan for integrated solution is described in Chapter 13.

2 Objectives

2.1 Automatic trading

Automatic trading platform (ATP) will serve as a facilitator between prosumer aggregate and the buyer of flexibility – DSO. It will combine the two existing systems KIBERnet and TotalFlex into a single platform, capable of addressing different scenarios on prosumer level. It shall not however, address any other scenarios on buyer level – all 3 demo cases will serve the goal of supplying Demand Response for optimization of grid operation by DSO.

Trading platform will utilize the FlexOffer structure, defined in WP2. The same structure will be used on both sides of trading platform:

- DSO side, where DSO places a bid for certain amount of flexible energy in time and space,
- Prosumer side, where all prosumers send their offers of flexible production and consumption

Trading platform therefore serves several functions:

- Offer disaggregation and aggregation
- Settling between DSO bid and prosumer offer aggregate
- Scheduling

- Disaggregation
- Validation
- Evaluation and feedback
- User and machine interfaces

2.2 Energy storage

GOFLEX will address two types of energy storage:

- Explicit storage, where special HW and software are used (e.g. batteries), and
- Virtual storage, where capacity is implicitly stored within process itself – energy storage and extraction is done by changing the process (move consumption in time and/or energy).

To utilize energy storage, regardless of the type, we will use the FlexOffer Agent – FOA, which will assess, capture and describe flexibility in FlexOffer format and trade it with the next level system – Automatic trading platform.

2.3 Energy management system

To utilize the virtual energy storage, the Energy Management Systems (EMS) will be used. EMS will perform several tasks, the most important being:

- Local data acquisition: capture readings, process variables, user inputs
- User interface, configurator, built into xEMS (mostly WEB GUI)
- Local control and optimization of energy systems, based on user, comfort and process constraints
- Supplying the flexibility to next level system – FOA
- Changing the schedules, based on success of trading the flexibility with next level system

In GOFLEX, we will address several types of EMS systems: FEMS (factory), HEMS (home), CEMS (EV charging) and CDEMS (charging-discharging). All existing solutions will introduce new functionalities that will allow intelligent management of prosumers, requiring modifications in structure, communication, cooperation, and algorithms, as well as the integration with DR interfaces (FOA).

2.4 Transport

Our goal is to integrate EVs as prosumers or consumers, either as a part of Home EMS (charging and discharging – called CDEMS) or on public/private parking area (only charging – called CEMS). For this, the charging infrastructure, EMSs at the prosumer level and trading interfaces will be further developed, adapted, and integrated. EVs will be treated as flexible loads with specific operation parameters. The operation of EV charging infrastructure, above all individual EV charging loads, will follow the requirements given by higher level EMS and will thus be fully integrated in DR schemes managed either by grid operators or energy market participants.

2.5 Observability

The reviewed solutions for distribution state estimators (DSE) are typically provided as part of DMS systems, which require often unavailable and economically infeasible heavy sensor equipment of the distribution grid (e.g. voltage/power at every transformer within every feeder). The ambition of this project is to further develop and demonstrate our technology for distribution observability and state estimation, with respect to providing estimates and short-term predictions of the state of the distribution grid (voltage, line/transformer loading) at the spatial resolution required to appropriately monitor the effects of distributed demand response and flexibility. Furthermore, the solution will complement any available, but often limited, real-time sensor data high-resolution energy forecasts of demand and generation at distribution transformers or substations and, where available, with high-resolution consumption data from smart meters.

The observability system – DOMS will act as an assessment tool, used by DSO to predict, where and when there will be a need for DSM. Therefore, DOMS system will be equipped with FOA, which will allow automatic placement of the bid onto the Automatic trading platform. From the ATP side, DOMS is regarded as an EMS system at prosumer, which places an offer for flexibility in reverse (buying).

2.6 Service platform

The ambition in this project is to further develop and demonstrate the capabilities Consortium partners' energy management platforms. We will integrate data from sources that traditionally were considered in isolation: network telemetry from SCADA/EMS, and fine-granular customer profiles from MDM/AMI. We will contextualize data with high-resolution weather information, physical properties of network assets, and information from electricity markets. We will customize views for different stakeholders (aggregators, DSOs, and prosumers) and perform ambitious real-world tests for robustness and portability in different geographies and demonstration sites.

3 Technologies

For integration of different systems, it is vital to know, how each of the systems manifests and interacts with the rest of the integrated system. This chapter provides specific architectural requirements and assumptions. Figure 1 depicts conceptual architecture and high-level interactions between GOFLEX systems.

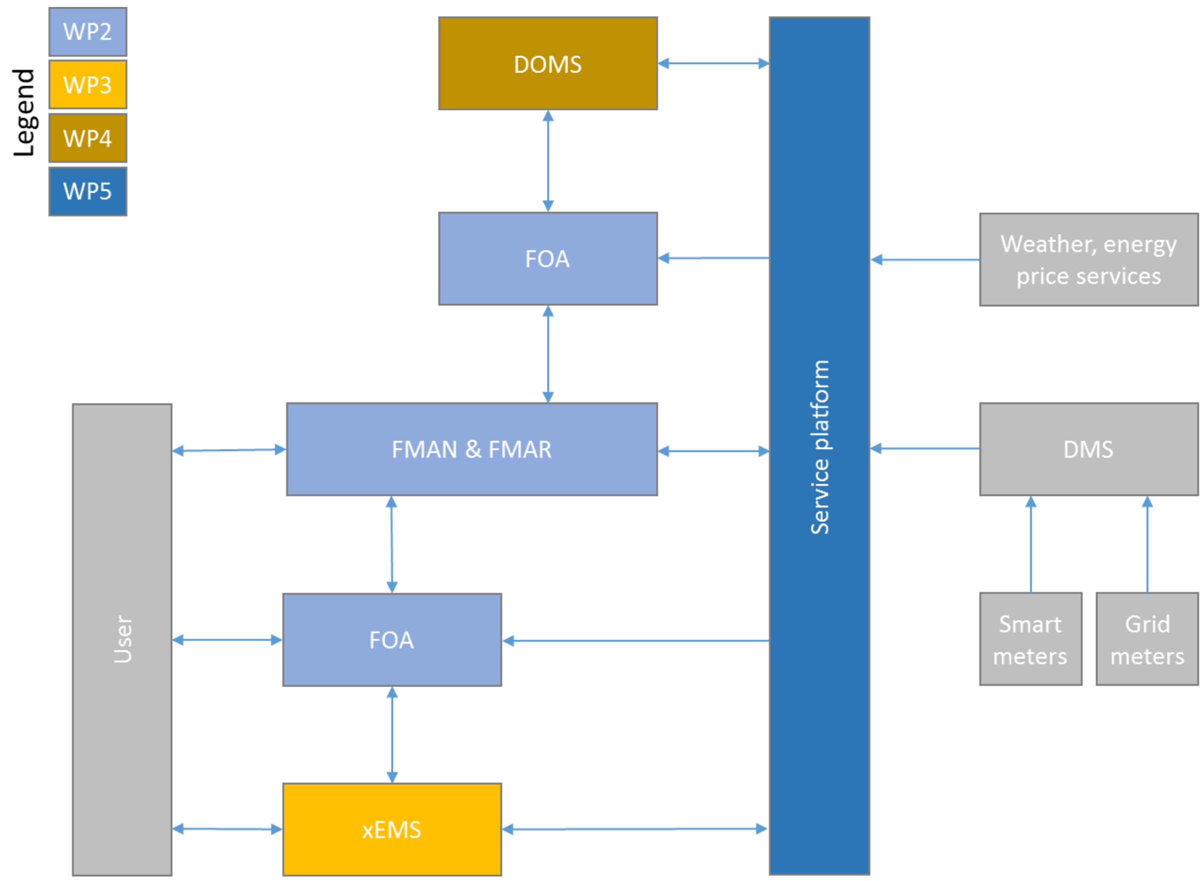


Figure 1: Conceptual GOFLEX architecture

3.1 FEMS – Factory Energy Management System

FEMS will be provided by INEA. It will consist of:

- Industrial grade PC
- PLC with algorithms for control and predictions,
- Communication equipment – communication cards (e.g. RS-485, Ethernet), network switches
- Power relays for connecting the loads
- Local panel display for visualization

- Analytics server with WEB interface

All the components will be installed within industrial cabinet. Size of the cabinet is dependent on the number of loads that will be controlled by FEMS.

3.2 HEMS – Home Energy Management System

HEMS will be provided by Robotina. It will consist of:

- CyBro controller for controlling the loads
- Monitor display
- Home linker for access to Robotina HEMS cloud system
- HIQ universe for communication with FOA

3.3 CEMS – Charging Energy Management System

CEMS will be provided by Etrel. It will consist of:

- Interfaces to charging stations with 1 or 2 charge points (connectors)
- CEMS system in the cloud with interface to FOA (in case of central control of several CS)
- Interface for communication with higer-level xEMS (in case of home or factory installation, where CS is considered as one of the loads for xEMS)

3.4 FOA – FlexOffer Agent

FlexOffer Agent will consist of two parts:

- Hardware
- Software

Hardware execution environment will be provided by INEA. The box will be the same for all types of prosumers and will have:

- ARM processor with at least 500Mhz of processing power
- At least 256MB of RAM
- At least 2GB of storage
- Linux OS
- Cellular and Ethernet communication interfaces
- USB and/or serial port for local communication

Software for the FOA will consist of common part for FlexOffer communication and specific drivers for each type of underlying system (xEMS or direct control of the loads).

Each prosumer will be equipped with FOA. Hardware will be expanded with appropriate communication interfaces, IOs, relays and meters during the installation projects at prosumers. In case of cloud communications, the cloud subsystem is considered as special case of IO and is therefore one of specific drivers on FOA.

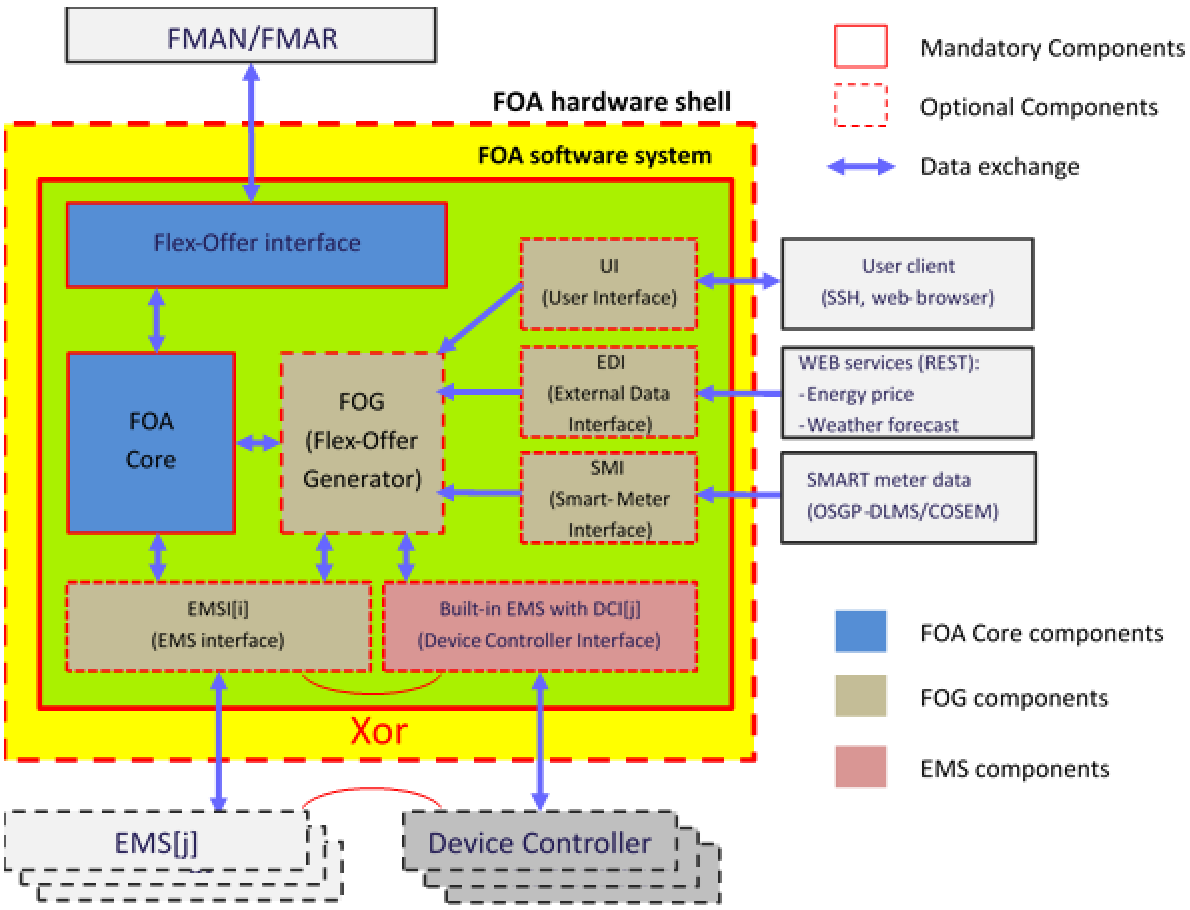


Figure 2: FOA architecture

3.5 Automatic Trading Platform - ATP

GOFLEX will support two types of trading mechanisms, both based on the FlexOffer concept:

- Direct trading, where price of flexibility is calculated based on incurred costs by the underlying process and is sent as part of the FlexOffer to the aggregator; and
- Delegated trading, where price is regarded as reward, based on the degree of offset from the base scenario. In this case, the price is defined post-festum, after the realization of the contract.

Functional relationships between two mechanisms are depicted on Figure 1. KIBERnet solution will be used as a top-level system, which will aggregate all types of prosumers, micro-grids and Delegated trading subsystem(s). For delegated trading, the TotalFlex solution will be used.

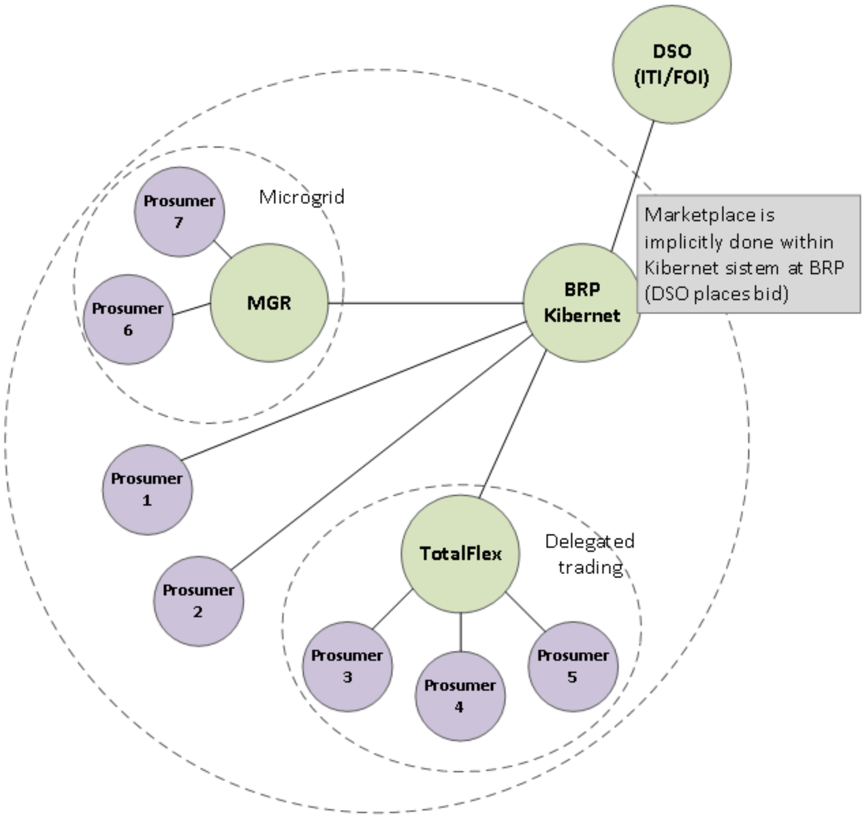


Figure 3: High level Automatic Trading Platform structure

Structure for describing flexibility is FlexOffer. The same structure will be used on both subsystems (KIBERnet and TotalFlex), therefore enabling the trading platform to function as a complex system with nested subsystems.

Each subsystem is therefore treated as a prosumer (real or aggregated), which allows to reach higher abstraction levels and therefore scalability.

ATP will reside on server environment, installed at each demonstration site. It will be used by the BRP (or equivalent). Hardware requirements for ATP are the following:

- HP ProLiant DL380 Gen9
- 2x Xeon E5-2680v4
- 64GB RAM
- 3TB of storage with SSD cache

Server operating system will be VMware ESXi 6.5. We will install at least 2 virtual machines, one for KIBERnet subsystem and one for TotalFlex subsystem. Both machines will require internet connection, as described in chapter 4.

3.6 DOMS – Distribution Observability Management System

DOMS is a data analytics software, used to predict grid states and congestions to help grid operators manage the grid better. It will utilize existing measuring points on the grid. Those measures can be gathered on grid connection points or on transformer substations, depending on available meters.

Data flow for DOMS system metering data:

- Network analyser on substation / grid connection point

  Data availability is dependent on available measuring equipment on demo site. Each network analyser needs data connection to DMS system. Update interval should be less than trading interval (e.g. 1 min). Data acquisition from network analysers is not part of GOFLEX project.

- Existing DMS system (SCADA) at DSO

  Each DSO already has some kind of Distribution Management System (DMS) system installed. This system is responsible for data gathering and historization.

- Anonymization of data

  We will upgrade DMS system with software client (WP5), which will be able to perform anonymization of metering data in order to be able to transmit it to the Service Platform.

- Transfer data via to Service platform (WP5) Data Acquisition API

  WP5 will provide sample code for client, which will exchange JSON packets of metering data. Each demo site integrator will have to integrate this sample code into existing DMS system – connect to data sources. DMS server will need internet connection in order to transmit data to the Service Platform.

- Fetch data from Service Platform by defined API

  Once metering data is present on Service Platform, DOMS will utilize API for data acquisition.

DOMS system will run as a service on the cloud platform. No dedicated local server for DOMS is required. Each demo site will get own instance of DOMS system.

Communication between DOMS and ATP will use the same architecture as on prosumer side. This means that DOMS will use FOA to communicate with other ATP components. Requirements for protocol are the following:

- FOA is the initiator of the request. This means that FOA triggers the communication request on regular basis. Interval should be short enough in order to achieve sufficient response time of the system.
- DOMS will provide an API, which will enable FOA to read all the required information and post response messages.
- FOA will use the gathered information from DOMS to construct special type of FlexOffer, which will then be sent to FlexOffer Manager (FMAN).

The required information from DOMS is the following:

Table 1: DOMS-FOA data exchange

Parameter	Description
StartTime	The parameter expressed as Timestamp describes the moment the schedule is going to be executed. The Start Time is in future. System uses UTC time. If not present, the schedule is to be executed immediately.
IntervalLength	Length of the interval in seconds. It describes the interval in ScheduleChange parameter (time series).
ScheduleChange	Time series, which describes the change of the ATP's total consumption regarding the operation prognoses. Negative values mean reduction of production or increase of consumption, positive values mean increase of production or decrease of consumption.
Energy price	Time series of prices of adapted energy. Each value is valid for the corresponding interval in the schedule change.

3.7 Service Platform

Service platform will reside on the cloud. It will supply several services that other GOFLEX system components will utilize. Each of the demo sites will get own instance of the service platform.

To communicate with Service platform, internet communication will be used. For sensitive data, the following requirements will have to be fulfilled:

- Anonymization of data has to be done before sending to the Service platform.

- Secure connection between systems shall be used for transporting sensitive data (even if anonymized)

Protocols for data exchange will be selected based on the specific technology requirements and availability on demonstration sites. The following protocols are envisioned:

- MQTT
- RESTful HTTP
- OPC UA
- AMQP

For data structure, the following standards shall be used:

- JSON
- XML

Service platform shall provide sufficient storage capabilities that will enable GOFLEX operation until the end of the project. Technology providers will define data retention periods for specific data types that will be used within GOFLEX.

Service platform will supply services and data to several GOFLEX components. Chapter 5 contains data exchange table with FROM-TO relations.

4 Functional requirements

WP6 does not provide any intrinsic functionality of its own. The role of this WP is to supervise the integration of individual components into complete GOFLEX solution. Therefore, the functional requirements of WP6 focus on interaction and exchange between building blocks.

Table 2 Functional requirements

Requirement Number	Requirement Description
F6.1	xEMS device interface: xEMS systems should be able to connect to several types of devices, loads, systems and processes. xEMS systems should provide relevant protocols and communication interfaces, relevant to specific environment (e.g. factory).
F6.2	FOA device controller: for simple domestic prosumers, FOA with device controller will be used. This controller should be able to connect to smart outlets and similar domestic-grade appliances.
F6.3	xEMS-FOA interface: xEMS and FOA should be able to communicate using the defined protocol in D3.1.
F6.4	FlexOffer interface: all the ATP components should communicate using FlexOffer protocol, defined in D2.1.
F6.5	Smart meter data: readings from smart meters should be transmitted from existing DMS system at DSO to Service platform using standard protocols (for example MQTT).
F6.6	Services on Service platform should be made available to appropriate GOFLEX systems using APIs.
F6.7	DOMS should be able to provide data, needed for FOA to prepare a FlexOffer. FlexOffer is defined in D2.1, exchange table is defined in chapter 3.6 of this document.
F6.8	Price for implicit capacity trading is added to each prosumer FlexOffer at FMAN/FMAR level. Calculator for this price should provided by DOMS and be available on Service platform.

5 Non-functional requirements

Table 3 Non-functional requirements

Requirement Number	Requirement Description
NF6.1	Transport layer between different systems is internet. If necessary, secure layer will be built on top of it.
NF6.2	Each building block system should handle the security locally. This means that data transmitted to other systems is either public or appropriately anonymized.
NF6.3	Each demonstration location should appoint a system integrator, who will install and integrate different GOFLEX systems. WP6 monitors and coordinates integrations on three demonstration sites.
NF6.4	Connectivity options, in accordance with chapter 6 of this document.
NF6.5	Interaction between GOFLEX systems: integrated system components should communicate between each other, as defined in chapter 7 of this document.

6 Connectivity

In order to communicate between different systems, which will be geographically dislocated, GOFLEX will require sufficient internet connections.

6.1 ATP in datacentre

ATP needs at least 100 Mbit/s symmetrical internet connection, present at datacentre (at BRP). At least **2** static public IP addresses will be needed. We would need complete control over firewall access to ATP server. We would need full cooperation from local IT departments to achieve this.

6.2 DOMS

DOMS will reside in the cloud. Therefore, internet access is implicitly there.

6.3 Service platform

Service platform will reside in the cloud. Therefore, internet access is implicitly there. Service platform may utilize RESTful architecture for data interaction, so HTTP and HTTPS ports are planned to be used.

Service platform may use MQTT protocol for acquisition of DMS sensory data. The Service platform shall provide necessary components, such as MQTT / messaging broker.

6.4 Prosumers

Each prosumer will need a broadband internet connection. It can be:

- xDSL
- Fibre optic
- Cellular (at least 3G)
- Cable (TV provider)

In case of cellular communications, there are two things to consider:

- Demo site manager has to cover the costs
- Solution providers for FOA (INEA) have to be informed to supply connectivity options within FOA

We will use client-server communication at prosumers. Each prosumer will be the communication initiator, therefore static IP addresses for prosumers are not needed = pull mode. For cases where push mode will be needed (access to the prosumer from server side without first connection from prosumer side), we will use software VPN, based on OpenVPN solution. It will be installed on FOA and will provide secure two-way communication.

7 Data exchange

This chapter provides an overview of systems interaction. It serves as a check-up for coherence and will provide a base for Factory Acceptance Test (FAT) evaluation.

7.1 Data exchange table

Data exchange table is also available in Excel form: Data_exchange.xlsx

Legend:

Private data	(semi) public data

Table 4: GOFLEX data exchange table

	to User (GUI)	to xEMS	to FOA	to other ATP subsystems (FMAN, FMAR)	to DOMS	to Service platform	to DMS server (1 per demo site)	to external provider
from User (GUI)	Private	xEMS configuration	FOA configuration	ATP configuration, parametrization, queries				
	Public							
from xEMS	User interface, charts, settings, other GUI functions	Private	Raw flex-offer parameters, full MPC (e.g., state-space) models	via FOA				
		Public				Reference values - "nice to have". Covered by a generic key-value store, which can map keys to ad hoc objects		
from FOA	FOA configuration, flexibility settings, prices, other constraints	Control parameters = selected schedule	Private	Flex-offer insert, update, and delete messages, (sub-) meter data if available	Offer acceptance feedback			
			Public					
from other ATP subsystems (FMAN, FMAR)	ATP operation, status, analytics	via FOA	Flex offer acceptance, assignment messages	Private	via FOA	Smart meter queries, offer validation queries ie. energy forecast for the time period and actual consumption data, energy transfer cost queries		
				Public		Weather queries, reference price queries		

from DOMS			Actual value of State Variable, Predictions of State Variable and Desired Energy Variation (e.g. Δkwh/h every 15 min over next 24 hours) and Desired price (e.g. € for each interval)	via FOA	Private	Subscribe to metering data and forecasts at grid points.		
					Public			
from Service platform			Smart meter data	Smart meter data, data for offer validation i.e. smart meter data and energy forecast	Historical/regular updates of metering data at grid point or prosumer. Regular updates of Energy forecasts at grid point.	Private		
		Reference values - "nice to have". Covered by a generic key-value store, which can map keys to ad hoc objects	Weather predictions, reference electricity prices, E	Weather predictions, reference electricity prices, Energy transfer cost service		Public		
from DMS server (1 per demo site)					Configuration (register state variables, set economic parameters etc)	Historical/regular updates of metering data at grid point or prosumer. Grid topology information?	Private	
							Public	
from external provider								Private
						Weather forecasts and observations. Electricity prices should be publicly available, need to check with each demo site		Public

7.2 Pair exchange details

7.2.1 User, xEMS

Data exchange is mostly use of the xEMS graphical user interface. Depending on the complexity of the system and user role, end-user may look at the reports, charts, real-time values. With appropriate permissions, user may configure the system settings, such as alarm thresholds, schedules, etc.

7.2.2 User, ATP components (FOA, FMAN, FMAR)

User should have option to configure the components. This may include defining the strategies, prices, constraints. Each ATP component should offer user a graphical interface, which should allow for querying, analysis, reporting and other insights into the system.

7.2.3 xEMS, FOA

xEMS constantly sends relevant information to FOA. Based on received data, FOA prepares FlexOffers. If one of the FlexOffers is selected, FOA sends command to xEMS to start adaptation process. Exchange protocol is defined in D3.1.

7.2.4 xEMS, Service platform

xEMS systems may send relevant consumption data to Service platform. This data should be appropriately anonymized on xEMS, using some kind of metadata (for example type of load within factory). Service platform may gather data from several prosumers and offer different aggregation functions on those readings, for example average consumption for certain type of load. Such aggregated data should be made available for other xEMS systems to benchmark to. All the communication is initiated by xEMS on different time intervals (e.g. day, month).

7.2.5 FOA, FMAN

If flexibility potential is available FOA sends FlexOffers to FMAN. FlexOffer protocol is defined in D2.1. FOA is the initiator of the communication. Requests are asynchronous, based on the state of the underlying system (xEMS).

7.2.6 FOA, Service platform

FOA may access the weather service and reference electricity prices on Service platform in order to use weather predictions and predictions of price acceptance level for FlexOffer construction. FOA may also require smart meter data for own prosumer. To secure this exchange, communication should be routed through FMAN system to Service platform.

7.2.7 (FMAN, FMAR), Service platform

FMAN and FMAR may use several services, available on Service platform. Needed data includes weather predictions, smart meter data for specific prosumer, forecast energy curve for specific prosumer, retail energy price and energy transfer calculator. All private data, available on the Service platform has already been anonymized.

7.2.8 DOMS, Service platform

DOMS will access all relevant metering data using Service platform. This data may include smart meter data, relevant grid point data from existing DMS system, relevant sub-meter data, GIS information, etc. Service platform will also offer forecasting services.

7.2.9 DOMS, FOA

DOMS will estimate the disbalances between energy supply and demand on grid segments/locations and consequently the likelihood of congestions on distribution grid. Based on that information, it will provide data required for FOA to prepare a FlexOffer. This FlexOffer will serve as a bid to FMAR system to activate demand response. The exchange information is defined in chapter 3.6 of this document.

7.2.10 Service platform, DMS server

Service platform will gather grid point readings and smart meter readings on existing DMS server (1 per demo site). Data will be anonymized and transmitted to Service platform using standard protocols (for example MQTT). Interval of transmission will be based on availability of metering data on DMS system.

7.2.11 Service platform, external provider

Service platform will gather weather information and spot energy prices from external databases and services.

7.3 Exchange diagram

The following diagram represents the high-level exchanges, occurring between GOFLEX components. Each exchange corresponds to chapter number of this document, describing the exchange data.

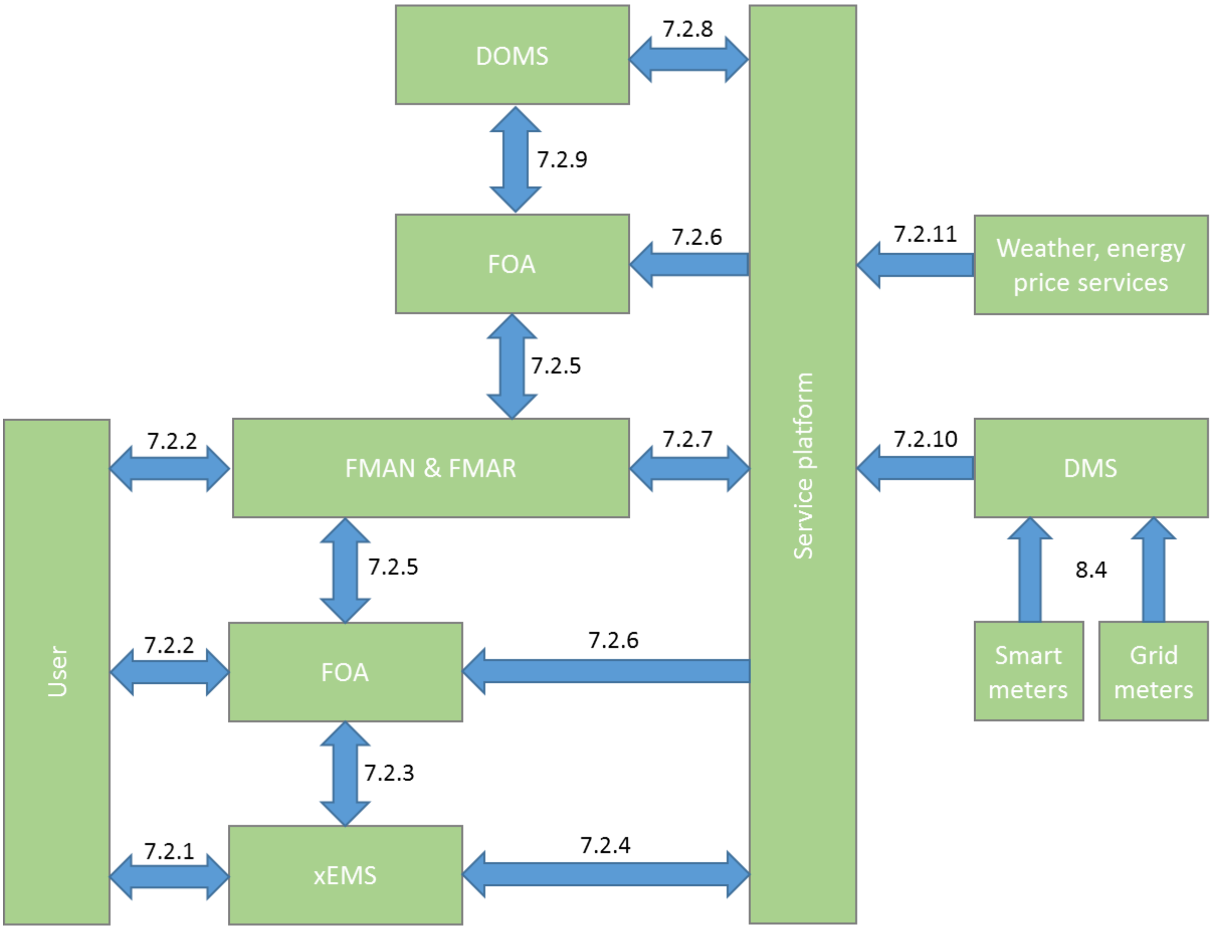


Figure 4: GOFLEX data exchange diagram

8 Interfaces and protocols

8.1 xEMS interface

xEMS interface is defined in the document D3.1. xEMS interface will handle communication between all GOFLEX EMS systems and FOAs. In order to be as interoperable as possible, we will use high-level protocols for exchange. Selected protocol for data exchange is HTTP. It will transmit and receive messages structured in JSON format.

xEMS is the initiator of communication. In order to get any data from FOA, xEMS first needs to send HTTP GET request to FOA. To achieve sufficient response times, interval for CommunicationRequest has to be as short as possible (e.g. from 1s to 1min).

Each CommunicationRequest contains one or more of the following information packets:

- OperationData
- FlexibilityData

- DemandCancelation

Each CommunicationRequest can induce reply containing the following responses:

- Administration control
- Ack/Nack (mandatory)
- ConfigParams
- DemandSchedule/DemandUpdate
- FlexibilityReject

All replies (if several) are packed into single response from FOA.

8.2 FlexOffer

FlexOffer is defined in the document D2.1.

FlexOffers are prepared by FOA and are sent to FMAN part of the ATP. Each FlexOffer can contain several parameters. FOA packs all the needed parameters into single XML or JSON structure. Since this data can be considered private, the communication between FOA and FMAN must be secure. Use of VPN or other encryption method is envisioned.

D.2. describes FMAN RESTful services. They are used by FOA to post, update, delete or read FlexOffers. The initiator of each communication is FOA.

Communication protocol for FlexOffer will be RESTful HTTP or HTTPS.

8.3 DMS sensory data

Topology for the sensory data acquisition is depicted on Figure 4.

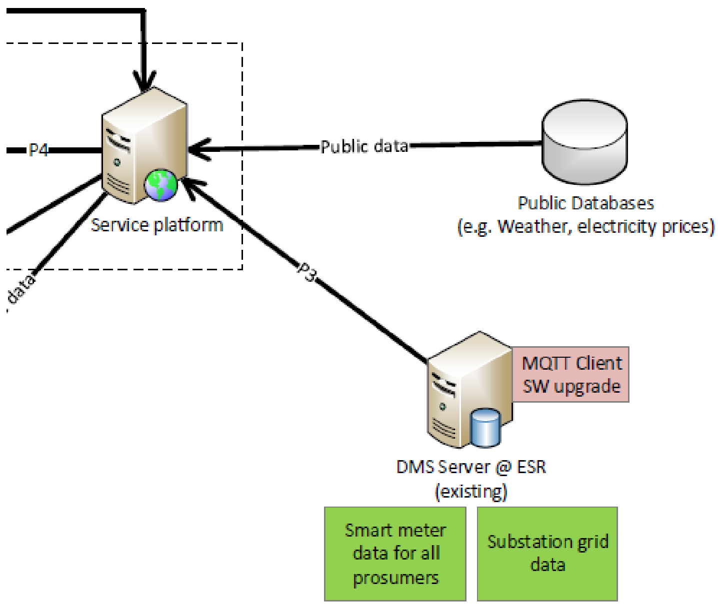


Figure 5: Sensory data acquisition

Exchange protocol for Data Acquisition API may use MQTT. It will transmit and receive messages, structured in JSON notation.

In order to be able to transmit to the Service platform, demo case managers will receive generic software code (Data Acquisition API client), which they will upgrade in order to interface with existing DMS system (e.q. database interface).

On the level of client, there will be additional processing – data anonymization. Every private data, that is to be sent to the Service platform (and further up the chain) has to be anonymized. There will be several layers of anonymization:

1. Transcribe private prosumer ID into anonymized ID: this is done using the classification IDs from chapter 9 of this document.
2. Encode transcribed ID using reversible hash algorithm (e.g. md5).
3. Encrypt complete message using asymmetric cryptography – RSA.
4. (optional) Use secure transmission channel - for communication between DMS and Service platform.

In order for DMS API client upgrade to be able to transmit to the Cloud platform, internet connection with sufficient bandwidth has to be present on DMS server itself. If this will not be possible (due to security policies), client shall be installed on separate (virtual) PC and local connection shall exist between this PC and DMS server.

8.4 Smart meter

In order for ATP to be able to confirm actual realization of contract (adaptation according to FlexOffer assigned), characteristic curve needs to be calculated for each prosumer. Characteristic curve is statistical model for certain prosumer, which tells us what prosumer would do at certain time, if no adaptation was required (flexibility offered and assigned). Difference between actual readings of certified meter and characteristic curve tells the system the correctness of adaptation, i.e. whether or not (or to what extent) the assigned flex-offers where carried out.

To compare with open contract consumption, the interval for data is standard tariff interval (typically 15min). This data is necessary for each prosumer, regardless of the two types defined above.

There are several ways of acquiring data (listed by descending order of preference):

1. <u>Access data via API at DSO</u>

   DSO needs operational smart metering infrastructure in place. If data is present on DSO SCADA, API needs to be prepared to access it. Anonymization must be done on DSO level in DMS, so that data transmitted to service platform is anonymized.

2. <u>Access readings on smart meter</u>

   Smart meter must allow readings (must not be closed or encrypted). Smart meter must offer interface for Modbus RTU or Modbus TCP protocol. If only M-bus output is supported, converter to Modbus must be installed as part of integration project. If only pulse output is enabled, digital counter with (at least) Modbus interface must be installed as part of integration project. Anonymization is done on FOA.

3. <u>Gather own readings on sub-meter and transmit them to service platform</u>

   This option is not preferred, since it utilizes non-certified metering data. It shall be used as a last resort, when none of the above options are possible. Anonymization is done on FOA.

8.5 Sub-metering

xEMS needs constant (power or energy) readings from electricity meter in order to optimize prosumer’s processes and make predictions on operation. Interval for data acquisition is from 1s to few seconds, depending on xEMS requirements.

We divide this case into two subcases:

1. Prosumers with xEMS: sub-meter (or more of them, if needed) is installed as part of integration project and supplied as part of xEMS by solution providers.
2. Prosumers without xEMS (delegated trading): only FOA is supplied by solution providers. Sub-meters with actuators (domestic type) are supplied by demo case managers as part of integration project. Technology providers will recommend equipment in order to simplify integration.

For option 1, the following devices are envisioned:

- Smart plugs, which contain metering and actuating functionalities. Smart plugs must be open – not locked to specific vendor, so that communication with FOA is possible.
- Power relays with metering function – those are meant to be installed into electrical cabinets. To be used when no electrical socket is present at the load – load is directly connected to fuse in electrical cabinet. Such is often the case with boilers and heat pumps.

In both cases the communication with FOA is to be considered. Ethernet connection is preferred, WiFi is possible, other types are not desirable.

8.6 Component Interaction Interfaces

This chapter provides a high-level overview of interconnecting APIs.

Table 5 GOFLEX APIs

API name	Systems involved	Describing document
xEMS-FOA	xEMS (client), FOA (server)	D3.1
FlexOffer API	FOA (client), FMAN (server) FOA (client), FMAR (server)	D2.1
DOMS-FOA	DOMS (server), FOA (client)	D6.1
Key/Value API	xEMS, Service platform	D5.1
Metering API	DMS, Service platform, DOMS, ATP	D5.1
Network Topology API	DMS, Service platform, DOMS	D5.1
Energy Forecast API	DOMS, Service platform, ATP	D5.1
Weather Forecast API	Service platform, ATP	D5.1

9 Prosumer classification and installation process

Notation for prosumer classification:

[**WPnum**]-[**P**rosumer][**R**esidential/**I**ndustrial/**P**arking/**B**uilding][e**X**isting EMS/New **E**MS/**D**irect control(no EMS)][Seq.**num**.]

Example: **7-PRE-001**

9.1 Residential prosumers without HEMS

Classification ID: WP-PRD-001

Those are prosumers, who will connect single load to GOFLEX system. Therefore, there is no need for EMS. They will use delegated trading mode.

Supplied equipment:

- FOA with Ethernet or cellular communication

Installation at prosumer:

- Supply smart sockets or smart relays
- Install FOA and sockets or relays
- Configure sockets or relays to communicate with FOA
- Configure FOA (trading algorithms)

9.2 Residential prosumers with existing HEMS

Classification ID: WP-PRX-001

Those are prosumers with several loads/production, already using some kind of HEMS. Those prosumers will use direct trading mode. There will be a need for interface adaptation (either on FOA or on existing HEMS), therefore detailed specifications of existing HEMS will be needed. If specifications are not available or if existing system is closed, we plan to run subset of Robotina HEMS in parallel or replace existing HEMS with Robotina's.

Supplied equipment:

- FOA with Ethernet or cellular communication
- (Robotina HEMS)

Installation at prosumer:

- Install FOA
- (install Robotina HEMS)
- Configure existing HEMS and FOA to communicate

- Configure FOA (trading algorithms)

9.3 Residential prosumers with Robotina HEMS

Classification ID: WP-PRE-001

Those are prosumers with several loads/production, who currently do not have any kind of HEMS. They will use direct trading mode. If cloud access to HEMS will be possible, prosumers will utilize virtual FOA.

Supplied equipment:

- FOA with Ethernet or cellular communication
- Robotina HEMS (controller and home linker)

Installation at prosumer:

- Install FOA
- Install HEMS
- Configure HEMS
- Configure HEMS and FOA to communicate (mostly preconfigured)
- Configure FOA (trading algorithms)

9.4 Residential prosumers with Robotina HEMS and Etrel EV charging station

Classification ID: WP-PRE-C-001

Those are prosumers with several loads/production, who currently do not have any kind of HEMS. They will also install Etrel charging station. They will use direct trading mode. If cloud access to HEMS will be possible, prosumers will utilize virtual FOA.

Supplied equipment:

- FOA with Ethernet or cellular communication
- Robotina HEMS (controller and home linker)
- Etrel charging station

Installation at prosumer:

- Install FOA
- Install HEMS
- Install CS
- Configure HEMS
- Configure CS, link it with HEMS

- Configure HEMS and FOA to communicate (mostly preconfigured)
- Configure FOA (trading algorithms)

9.5 Residential prosumers with Robotina HEMS and CDEMS

Classification ID: WP-PRE-CD-001

Those are prosumers with several loads/production, who currently do not have any kind of HEMS. They will also install a battery storage, which will be used as explicit storage – CDEMS. They will use direct trading mode. If cloud access to HEMS will be possible, prosumers will utilize virtual FOA.

Supplied equipment:

- FOA with Ethernet or cellular communication
- Robotina HEMS (controller and home linker)
- CDEMS system
- Battery for CDEMS

Installation at prosumer:

- Install FOA
- Install HEMS
- Install CDEMS
- Install battery
- Configure HEMS
- Configure CDEMS, link it to HEMS
- Configure HEMS and FOA to communicate (mostly preconfigured)
- Configure FOA (trading algorithms)

9.6 Industrial prosumers with existing FEMS

Classification ID: WP-PIX-001

Those are industrial prosumers with several loads/production, who have existing FEMS system. They have processes and/or storage that are manageable in both energy and time. They will use direct trading mode. There will be a need for interface adaptation (either on FOA or on existing FEMS), therefore detailed specifications of existing FEMS will be needed. If specifications are not available or if existing system is closed, we plan to run subset of INEA FEMS in parallel or replace existing system with Inea FEMS.

Supplied equipment:

- FOA with Ethernet or cellular communication
- (INEA FEMS (electrical cabinet))

Installation at prosumer:

- Install FOA
- (install INEA FEMS)
- Configure existing FEMS and FOA to communicate
- Configure FOA (trading algorithms)

9.7 Industrial prosumers with INEA FEMS

Classification ID: WP-PIE-001

Those are industrial prosumers with several loads/production, who currently do not have any kind of FEMS. They have processes and/or storage that are manageable in both energy and time. They will use direct trading mode.

Supplied equipment:

- FOA with Ethernet or cellular communication
- INEA FEMS (electrical cabinet)
- INEA analytics server

Installation at prosumer:

- Install FOA
- Install FEMS (installation project envisioned)
- Install analytics server
- Configure FEMS, connect the loads
- Configure analytics server
- Configure FEMS and FOA to communicate (mostly preconfigured)
- Configure FOA (trading algorithms)

9.8 Existing CEMS

Classification ID: WP-PPX-001

Those are prosumers, who already have some kind of CEMS, with connected EV charging stations. They will use direct trading mode. There will be a need for interface adaptation (either on FOA or on existing CEMS); therefore detailed specifications of existing CEMS will be needed. If specifications are not available or if existing system is closed, we plan to run subset of Etrel CEMS in parallel.

Supplied equipment:

- FOA with Ethernet or cellular communication
- (Etrel CEMS)

Installation at prosumer:

- Install FOA
- (install Etrel CEMS)
- Configure CEMS and FOA to communicate
- Configure FOA (trading algorithms)

9.9 Etrel CEMS

Classification ID: WP-PPE-001

Those are prosumers, who will install new ETREL EV charging stations with CEMS. They will use direct trading mode.

Supplied equipment:

- FOA with Ethernet or cellular communication
- Etrel CEMS

Installation at prosumer:

- Install FOA
- Install charging station(s) if not already present (installation project envisioned)
- Install CEMS
- Configure CEMS and FOA to communicate (mostly preconfigured)
- Configure FOA (trading algorithms)

10 Integration and evaluation

10.1 Integration process

WP6 is responsible for oversight of integration process on all three demonstration sites. To do so, WP6 will appoint integration manager for each demonstration case, who will be the link between solution providers and demonstration case managers.

Actual integration will be done by system integrators, appointed by demonstration case managers. Integration includes, but is not limited to:

- Analysis of prosumers, processes, limitations, regulations, relevant for integration execution
- Requirements for installations
- Electrical planning
- Communication with specific vendors, existing suppliers on-site
- Installation of supporting equipment (such as meters, actuators, relays)
- Electrical wiring
- Installation of GOFLEX innovative prototypes
- Performing necessary adaptations on existing systems
- Providing support to prosumers
- Connecting GOFLEX systems, according to specifications and manuals, tech support from solution providers
- Providing access to data, relevant for GOFLEX systems operation

To achieve successful integration, it is vital for system integrator- integration manager and demonstration case manager for each demo site to be in constant contact. Integration manager should have a complete insight into capabilities of different systems, so that he can route support directly to solution supplier. On the other side, demonstration case manager should know specifics of the demonstration case, requirements and limitations. If feasible, solution providers should make necessary adaptations of their systems in order for integration process to be smooth and successful. Integration manager and specific solution supplier should define criteria when needed.

Evaluation of the integrated system will be performed several times. We will perform the Factory Acceptance Test (FAT) at solution providers location at M18. This test will assure that all the interfaces exist and that the integrated system isn't missing any logical components. Since all solutions will be on prototype version, FAT will not test actual operation.

When FAT is successful, we will start shipping solutions to three demo sites to be installed. Installations are planned to be complete at M24. Then, we will perform Site Acceptance Test (SAT). SAT will be performed on real site, so there will be also a functional testing involved. When complete, integrated GOFLEX solution will start trial operations.

Based on information, gathered in integration and trial operation, specific solutions may require adaptations and redesign. If those changes are major, specific solution shall redo the SAT when new version is available.

WP6 will prepare more detailed FAT and SAT evaluation criteria. We envision participation of demonstration case managers at this definition.

10.2 Security

Each individual GOFLEX solution caters to security locally. These individual measures, which assure that each building block is properly secured, may be one of the following:

- User authentication: should be used on systems which require user interaction (xEMS, FOA, FMAN, FMAR).
- API authentication: should be used for logging-in into specific service where no HMI is involved (DOMS, Service platform).
- Secure tunnel: can be used for encrypting whole communication channel between two or more systems (FOA, FMAN).
- (PKI) encryption: can be used to encrypt specific files or data before transmitting them over unsecure link. Same method can also be used for validating the sender identity and message authenticity.
- Anonymization: before transmitting private data, system has to perform some kind of anonymization, which removes the link between data and private entity.

When integrating different solutions, it is vital to assure that we do not compromise security in any way. When data is leaving the system, it must be secured using appropriate measures. Nevertheless, security measures must not limit the integration or compromise the availability of some systems. We must select correct measures in order to remain functional. Data exchange table in Chapter 7 provides insight into data protection. It is a starting point for defining the data protection plan.

Besides the information security described above, GOFLEX must also cater to physical security. Systems that are installed at prosumers (xEMS, FOA) must be sufficiently physically protected if possible:

- Installation within electrical cabinet
- Locked electrical cabinet
- Installation within secure room with controlled access (key card, code)
- Redundant power supply
- Redundant connectivity options

11 Demonstration cases

This chapter provides a high-level architecture of three demonstration sites. Schematics include all components that will be used within GOFLEX project. Those schematics are the basis for defining components interconnections and co-dependency. They also depict number of different classes of prosumers that are planned for each demonstration case.

Schematics are a starting point for detailed installations and integration projects.

Protocols depicted on high-level architecture schematics:

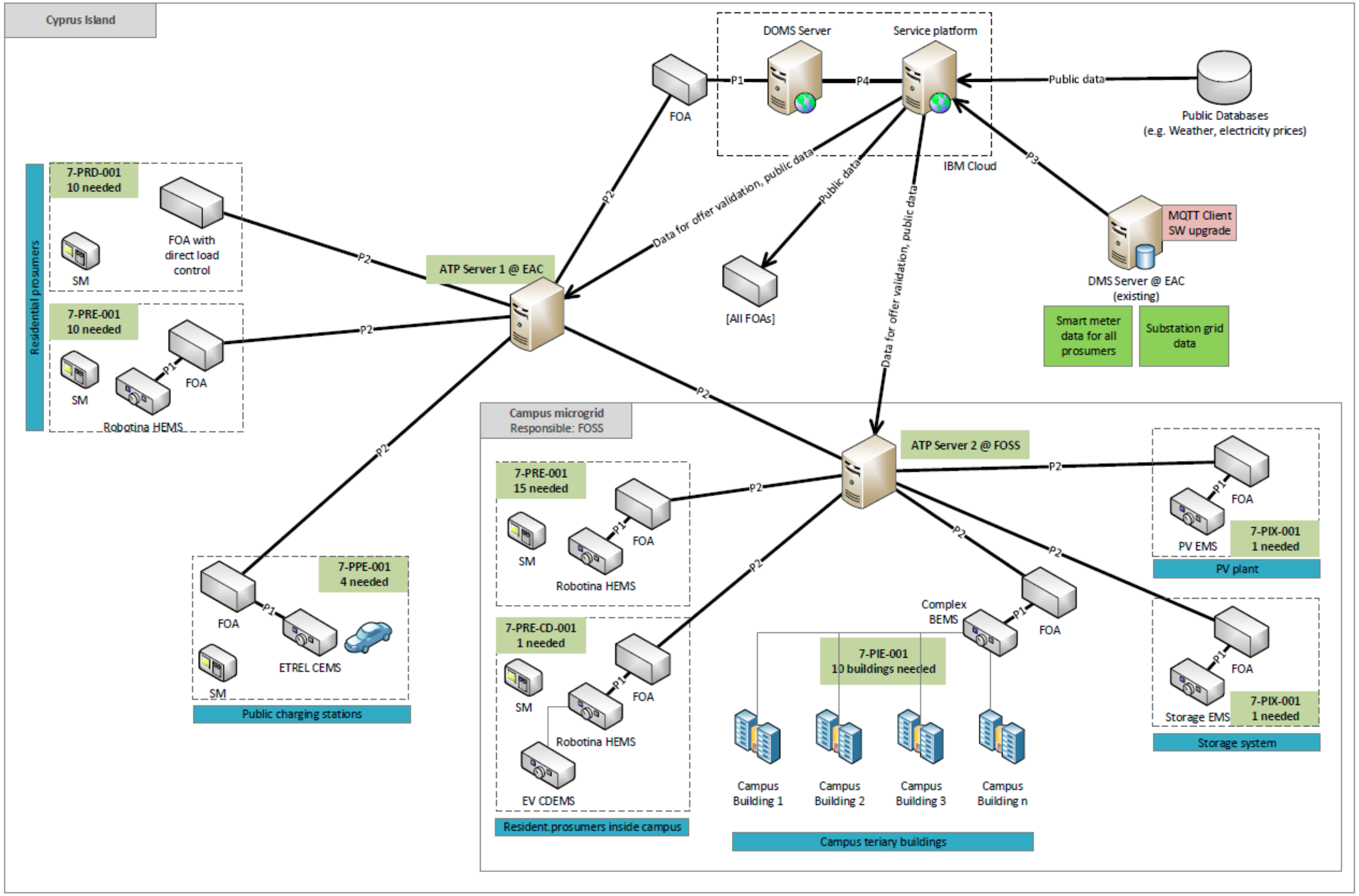
P1 Communication protocol between FOA and underlying xEMS (see also 7.2.3)

P2 FlexOffer protocol (see also 7.2.5)

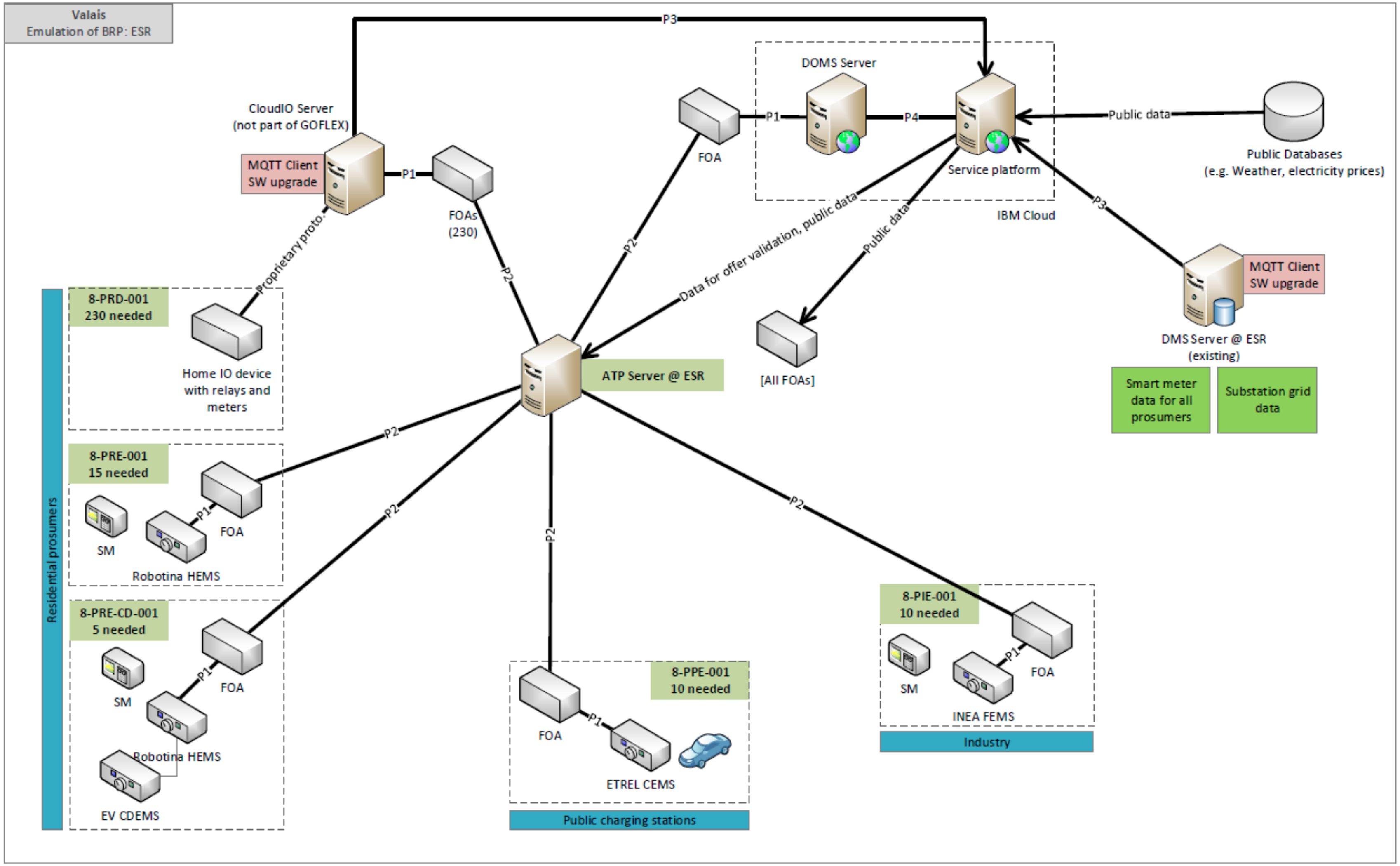
P3 DMS sensory data (see also 8.4)

P4 Internal cloud communication between DOMS and Service platform

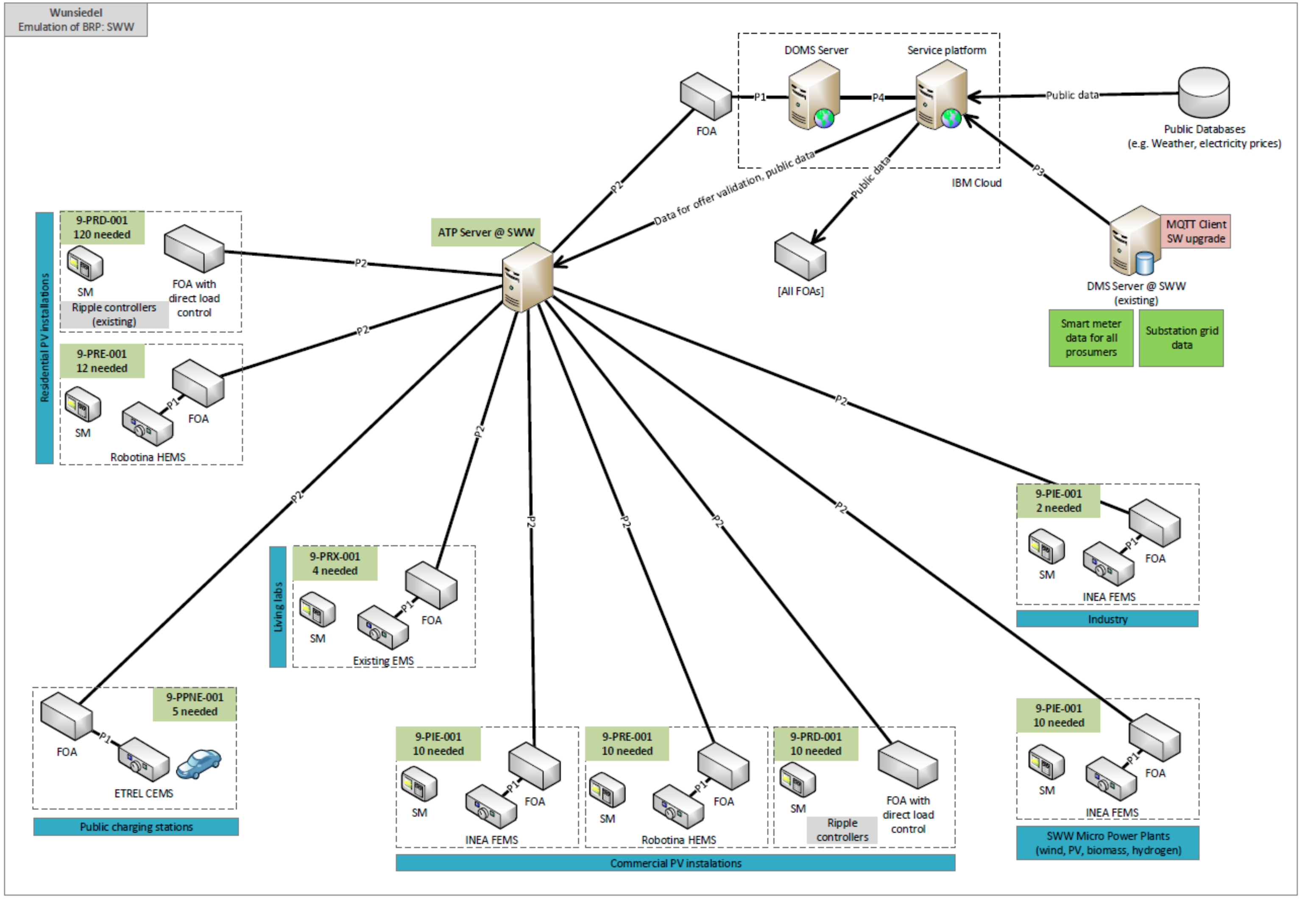
11.1 Cyprus case architecture



11.2 Swiss case architecture



11.3 German case architecture



12 Impact indicators

12.1 EU based companies will be able to deliver adequate competitive product and services on the market in 2-5 years after the end of the project

GOFLEX partners committed to keep all three demonstration cases operational even after the end of the project, subject to an appropriate agreement. This can be seen as the first step towards market launch, as the WP2, WP3, WP4 and WP5 companies will utilize working cases as show-case for marketing GOFLEX products.

12.2 Demonstrated solutions have the potential to be scaled (if needed) and replicated

Three selected demonstration sites offer several distinctly different aspects of electricity systems. Therefore, replication is already built into GOFLEX system. We aim to include every reasonable encountered prosumer and process, which gives the project replication component. To support scalability and replicability, several approaches were identified:

- Use of standard protocols and integration technologies
- Implementation of FlexOffer Agent to be able to include several types of xEMS systems and specific prosumer devices
- Cloud-based services for easier deployment and scalability
- Inclusion of end-users in the earlier stages of the project

Degree of potential for scalability and replication can be evaluated by:

- Counting the number of different prosumers on sites
- Counting the number of different devices / loads within prosumers
- Counting the number of different processes within prosumers
- Counting the number of different roles within electricity system
- Benchmarking the performance of specific crucial operations: aggregation, scheduling, forecasting

12.3 Integrated system impact indicators

WP6 will offer a structured way to integrate impact indicators from solution WPs (WP2, WP3, WP4 and WP5). Each WP is responsible for defining the metric and implementing it into the individual solutions. Each solution would then report those KPIs onto common GOFLEX impact tracking system.

Tracking system will offer:

- RESTful API for posting the KPI data
- Visualization and time plot
- Goal seek and alarming functionalities

Tracking system will be the same for all three demo sites, which will allow for comparison and benchmarking across complete GOFLEX integrated system.

13 Implementation plan

WP6 will be in charge of integration of the individual solutions into integrated GOFLEX solution. As project defines several levels of solution prototypes, WP6 aims to support the activities across all development cycles.

13.1 Prototype

In prototype development of solutions, WP6 will coordinate the interaction part of solutions – interfaces. Each individual solution will implement required functionalities separately. WP6 will assure, that prototypes will be able to communicate between each other once the integration starts.

We will prepare conceptual design of GOFLEX system, which will be the matrix for integration process. It will also serve as a validation tool for individual solutions to check & validate. Conceptual design will also induce additional requirements on specific solutions, especially for integration with other individual solutions.

13.2 Full version

Once the prototype versions of individual solutions are ready, WP6 will coordinate the integration of those prototypes into first integrated prototype of GOFLEX system. Full version will be built on prototype versions of individual solutions, with fixed bugs and reflecting the updated requirements.

Some of the functionalities will not be available on full version of the integrated system, especially those linked to demo sites. We aim to simulate missing functionalities in order to efficiently integrate the system.

We will perform Factory Acceptance Test (FAT) on full version of GOFLEX integrated system. FAT will be performed at solution providers’ locations.

13.3 Final version

Once GOFLEX integrated system passes the FAT, we will start the installation procedures on demo sites. The installation on demo sites will install the full versions of solutions that will later be updated to final versions. Installation and integration can also induce revisions of solutions.

Site Acceptance Tests (SAT) will be performed at each demo location. WP6 will provide integration tests for integrated system validation.

14 Conclusion

WP6 is responsible for oversight of integration process across all three demonstration sites. This document describes first steps towards integrated solution. It will iteratively grow and become more detailed, reflecting specific details from demonstration sites.

One of the key aspects of GOFLEX project is to deliver integrated solution, capable of solving problems on different sites, prosumers, systems and legal constraints. Since the integration process is in the hands of demonstration case managers, it is vital for WP6 to maintain overall integration concept. By constantly reflecting the overarching architecture and interfaces, we aim to support integration process from individual block development, integrated prototypes, site installation, and recursive cycles to final integrated prototype. We shall evaluate our progress using standardized tests like Factory Acceptance Test and Site Acceptance Test, which will assure successful integration and trial operation of GOFLEX integrated solution.