Ref. Ares(2020)8016064 - 31/12/2020

Grant Agreement N° 872592

PLATOON

Digital platform and analytic tools for energy

Deliverable D6.1
Large Scale Pilot implementation strategy and validation plan

Contractual delivery date:
M12
Actual delivery date:
30th December 2020

Responsible partner:
P01: ENGIE, France

Project Title	PLATOON – Digital platform and analytic tools for energy
Deliverable number	D6.1
Deliverable title	Report on Large Scale Pilot implementation strategy and validation plan
Author(s):	ENGIE, VUB
Responsible Partner:	P01 - ENGIE
Date:	31.12.2020
Nature	R
Distribution level (CO, PU):	PU
Work package number	WP6 – Large Scale Pilot Implementation and Validation

Work package leader	VUB
Abstract:	Considering the business cases defined in WP1 and the specificities of each pilot site, this task defines the detailed implementation and validation plan for each LSP, where specific reference implementations of the PLATOON architecture will be instantiated, and specific data analytical tools will be demonstrated on each local site and within the local context. An implementation plan is drafted for each location to break the strategy into identifiable steps that will ensure a timely start and completion of each pilot activity. A common framework is initially defined and then used across all locations. An initial monitoring plan and set of Key Performance Indicators (KPIs) is identified as part of the Validation Plan, and during this task the baselines values will be clearly measured. The validation plan has a specific chapter for the validation of each component of the PLATOON architecture, with special emphasis on the interoperability, governance and data security components, Edge Computing and Real Time Processing solutions or Big Data Collection (if applies to pilots), as well as the features of the Data Analytics Toolbox.
Keyword List:	Implementation, Validation, Pilots, KPIs

The research leading to these results has received funding from the European Community's Horizon 2020 Work Programme (H2020) under grant agreement no 872592.
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Document Description

Version	Date	Modifications Introduced	
		Modification Reason	Modified by
V.01	17/09/2020	D6.1 general structure	ENGIE
V0.2	10/12/2020	PLATOON reference architecture section	ENGIE
V0.3	11/12/20	Executive summary, introduction and methodology and Pilot 3#a sections	ENGIE
V0.4	14/12/20	Structured the document and updated formatting	VUB
V0.5	18/12/2020	Added Pilot 2b KPIs et 3C section	VUB
V0.6	22/12/2020	Document total structure review and updates , update 4a,3C,2b requirements	ENGIE
V0.7	23/12/2020	Added abbreviations	VUB
V0.8	28/12/2020	Last modifications after review	ENGIE

Acknowledgements

The following people are hereby duly acknowledged for their considerable contributions, which have served as a basis for this deliverable:

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Executive Summary

This deliverable lies under the scope of work package WP6 - Large scale pilot implementation and validation. Its content is based on the work of the Task 6.1-Implementation & Validation Plan lead by ENGIE. The deliverable D6.1 has been divided into two main chapters.

The first chapter covers the main steps and the actions planned to allow a smooth and successful implementation of each Pilot, where specific reference implementations of the PLATOON architecture will be instantiated, and specific data analytical tools will be demonstrated on each local site and within the local context .To achieve this objectives an implementation plan is presented here for each low level use case (identified in WP1) and demonstrator, addressing functional requirements, the provider of each component and the implementation timeline.

Another crucial objective of this implementation plan is to ensure that the results will be in future stage measurable and fitting the expected from PLATOON outcomes. To comply with this objective, this chapter presents a detailed Key Performance Indicators (KPIs) measurement and monitoring plan regarding each one of the low-level use Cases KPIs that each pilot owner intends to measure.

The **part II** of this document is a placeholder for the validation test plan, it will be further developed in the second version of this document and delivered on M24 of the PLATOON project. This second chapter will develop a validation test plan for each component of the PLATOON architecture that will be implemented in the demo sites, with special emphasis on the interoperability, governance and data security components, Edge Computing and Real Time Processing solutions or Big Data Collection (if applies to pilots), as well as the features of the Data Analytics Toolbox.

The validation plan will help the pilot owner and the project partners to minimize the risks involved in the implementation in their pilot-compliant component and to assure a correct functionality and operability.

The implementation and validation plan, described in this deliverable, depended strongly on the results of different work packages, namely:

- WP1-Energy system management challenges
- WP2-Reference Architecture, Interoperability and Standardization
- WP3-Data Governance, Security and Privacy
- WP4-Analytical Toolboxes

The outcomes of the aforementioned WPs were crucial for the implementation preparation related to all PLATOON's Pilots. The business cases defined in WP1 and the specificities of each pilot was the base line of the implementation and validation plan, reference architecture and specifications and associated components to be implemented within the context of each pilot were provided by the tasks carried out in WP2, data governance framework that ensures data security and respects data privacy and sovereignty were provided by the work conducted in WP3 and WP4 will the analytical toolbox component of the PLATOON platform formed by

both generic big data tools and energy specific analytical tools for different application related to PLATOON pilots objectives. The interactions between WP6 participants and PLATOON-technical core were an important key to fulfill the requirements of each demonstrator and to define the compliance of each component of the PLATOON reference architecture with each demonstrator.

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Terms and abbreviations

SCADA	Supervisory Control and Data Acquisition
IPP	Independent producers
DER	Producers from distributed and renewable sources
PV	Photo voltaic
RES	Renewable energy source
NTL	Non technical losses
NZEB	Non zero energy building
TP	True postive
FP	False postive
FN	False negative
TN	True negative
BMS	Building Management System
BtM	Behind the Meter
BESS	Battery Energy Storage System
HyESS	Hydrogen hybrid Energy Storage System
HVAC	Heating, Ventilation and Air-Conditioning
B2B	back-to-back
EV	Electric Vehicles
E-Bike	electric bikes
LMC	Laboratory of Micro-Cogeneration
PC	Power Centers
CHP	Combined Heat and Power
HMI	Human Machine Interface
MC	Master Controller

Part I: Implementation Plan

1. Introduction

Having the use case definition completed in WP1 and while PLATOON reference architecture, its different layers and their specifications are being elaborated in WP2, the basis for secure data sharing are being identified in WP3 and the platoon analytical toolbox are being designed and its mains tools development begun within WP4 activities. PLATOON consortium during T6.1-Large Scale Pilot implementation strategy and validation plan first phase (M06-M12) initiated the implementation of the innovative tools and services to be offered by PLATOON reference architecture. In PLATOON's Task 6.1 Large scale pilot implementation plan is considered as of major importance, since it really integrates all projects dimensions.

The implementation perspectives regarding interoperability, governance and data security components, Edge Computing and Real Time Processing solutions or Big Data Collection , as well as the features of the Data Analytics Toolbox are described in the next sections aiming a smooth and successful implementation as specified in PLATOON GA in pilot local for the next twelve months of the project, also assuring that the implementation results will be in future stage measurable and fitting the expected from PLATOON outcomes.

Reminding PLATOON objectives:

1. To enhance the role of the energy sector stakeholders to let them reliably, fairly, and securely extract knowledge from their own data.
2. To foster new business models in the energy sector using digital technologies.
3. To enhance the multi-party cooperation between technology providers and data owners.
4. To contribute to standardization of the energy management systems by assessing whether current standards offer the proper roles interfaces to enable business processes, including new ones and identify where new standards may be needed.

To achieve these objectives, PLATOON will be demonstrated in seven pilots in five different countries and implemented in 19 different low level use cases as depicted in the next figure (from D1.1).

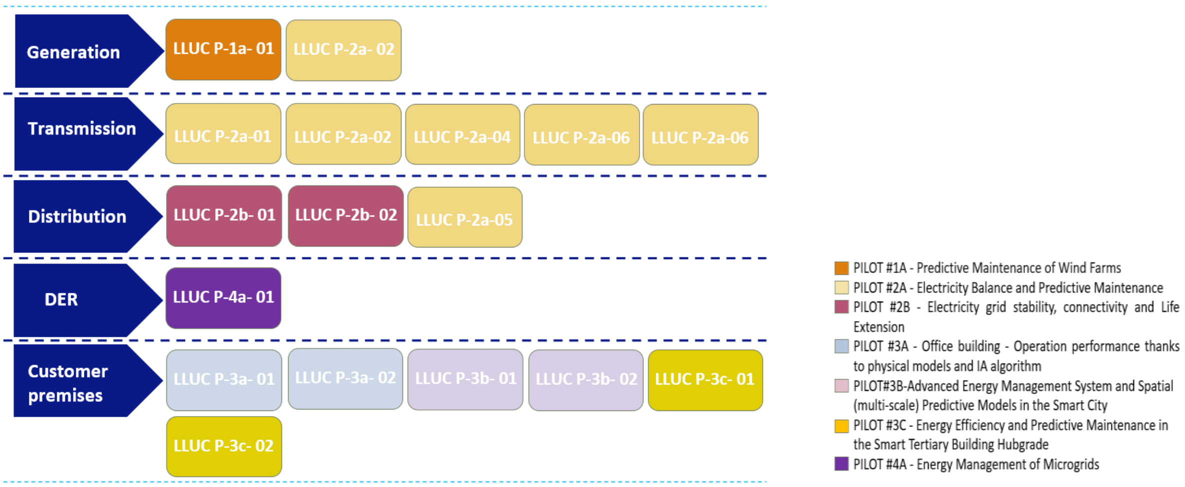


Figure 1: PLATOON's LLUC classification according to SGAM – domains from D1.1

Another crucial objective of this implementation plan is to ensure that the results will be in future stage measurable and fitting the expected from PLATOON outcomes. To comply with this objective, this chapter presents a detailed Key Performance Indicators (KPIs) measurement and monitoring plan regarding each one of the low-level use Cases KPIs that each pilot owner intends to measure.

2. Methodology and work process

PLATOON implementation plan described in this document main objective is to achieve the demonstrations conditions for each pilot and build a big data platform for each large-scale demonstration based on the reference architecture on the one hand, and on the other hand, to guarantee that the results are measurable and comparable, enabling effective tests and evaluations using the KPIs defined in section 2.1 of PLATOON GA.

In this sense, general objectives of the implementation methodology are the following:

1. Promote discussion between PLATOON-core (WP2-WP3-WP4-WP5 leaders) and pilots Teams to discuss specific PLATOON components implementation.
2. Have a detailed implementation plan for each pilot Considering the LLUC defined in WP1 to:
    - Instantiate specific reference implementations of the Platoon architecture on each demonstrator.
    - Demonstrate specific data analytical toolbox on each local site and within the local context.
3. Determine strategy steps addressing implementation objectives to ensure a timely start and completion of each pilot activity.
4. Specify a monitoring plan for each KPI to be measured.
5. Detail a validation & tests Plan (to be detailed in Chapter II) of each component of PLATOON architecture: the interoperability, governance and data security components, Edge Computing and Real Time Processing solutions or Big Data Collection (if applies to pilots).

Having the objectives identified, the proposed implementation methodology has been divided into four main steps, as next described:

1. **Preparation phase**
   - Review and update if needed the requirements of each use cases targeting pilot's conditions defined in WP1-D1.1 and D1.2
   - Determine concerns and risks from pilots' leaders and T6.1 participants regarding pilot implementation.
   - Issue of Pilot preparation template to characterize implementation requirements and concerns from the partners, having as final objectives to anticipate risks and capability needs and clarify concepts and ideas.

2. **Conditions definition phase**
   - Organize workshops with PLATOON-core (WP2-WP3-WP4-WP5 leaders) and pilots Teams to discuss specific PLATOON components implementation. This first step was undertaken in two separate workshops.

   2.1. Pilot's specific workshop-part 01:

   This interaction was between each pilot leader, pilot participants and PLATOON-technical Core leaders (WP2-WP3-WP4-WP5 leaders) to:
   - Clarify concepts, ideas and identify any concerns around the pilot and its objectives
   - Promote discussions for each dedicated workshop. These discussions will help to describe from functional and technical point of view the pilot.
   - Focus on implementation / validation plan for the considered pilot.
   - Clarify specific PLATOON components implementation considered for the specific pilot, the information to be provided by the pilot to PLATOON-technical core and the expected from each of them to fulfill the pilot's UCs goals.

   2.2 Pilot's specific workshop-part 02

   This interaction was between each pilot leader, pilot participants and PLATOON technical Core leaders (WP2-WP3-WP4-WP5 leaders) to:
   - Provide technical feedback from the perspective of WP2, WP3, WP4, WP5 to the pilot owners regarding the results of the first workshop
   - Identify PLATOON pilot- compliant components.
   - Define the requirements related to the implementation of each of this component as well as their provider.
   - Define implementation timeline where possible: For this second part of the pilot's specific workshops, an updated implementation template has been used to comply with the workshop objectives.
   - Issue of a final implementation plan template, to be used as an interaction tool by each pilot leader and component provider to update implementation conditions and refine timeline if needed.

3. **Commitment Phase**
   - List of KPIs, previously defined in WP1, was issued, to be confirmed or not, for future measurement and evaluations defined in PLATOON GA, by each pilot leader

- KPI template was issued for demonstration leaders to fill it for each of the KPI above confirmed.
- The level of agreement between demonstration leaders and technology providers on equipment/software tools' requirements was not total in some cases.
- Each use case implementation timeline, equipment and resources constraints were done, and alternatives were proposed when needed.
- First valuation of implementation risks was made.

4. **Validation test definition phase (detailed in chapter II of the present document)**
   - Description of each component to test and its main functionalities.
   - High-level testing approach that defines the validation methods to be used.
   - Explanation of the test protocol, which constitutes a pass/fail criterion, test setup and test program.
   - Issue of Pilot Full Validation Plan template.

The outputs of Task 6.1, illustrated in the figures below, translates its evolution along the four mentioned phases along the task lifetime (M06-M24).

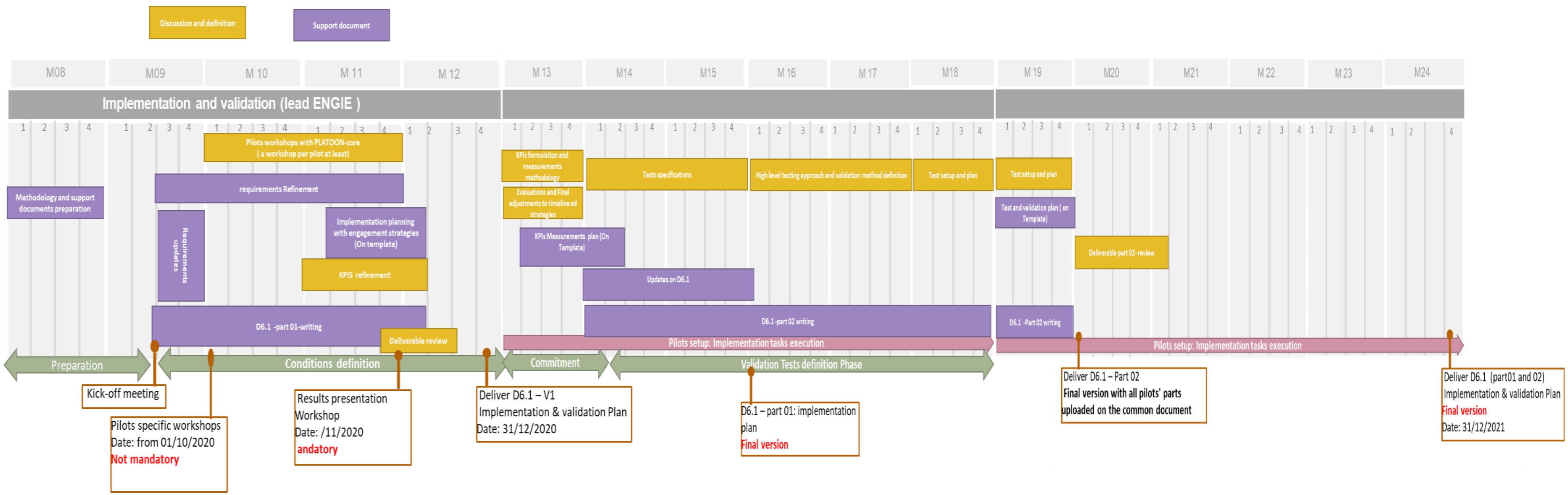


Figure 2: course of the implementation methodology

3. PLATOON reference architecture's components - Global overview

The figure below depicts a high-level view of PLATOON architecture defined in D2.1 - PLATOON Reference Architecture. It shows the main building blocks of PLATOON platform and their relations.

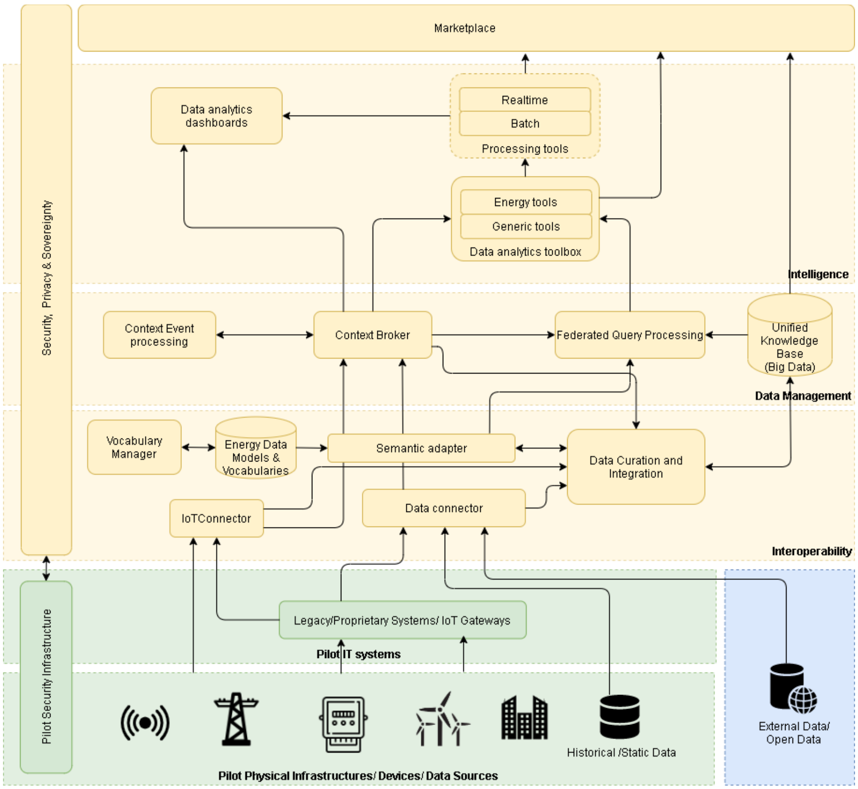


Figure 3: PLATOON reference architecture

Below, a short description of PLATOON's main components and layers:

- **Physical infrastructure and data sources:** This layer include all the data sources that are provided in the physical site of each pilot or in his organizational context.
- **Pilot IT Systems:** All the proprietary IT systems that manage the operational and historical databases within the organization.
- **External Data Sources /Open Data:** They represent all data sources external to the organizational context (out of the Platoon ecosystem) useful for integrating the knowledge base.
- **Interoperability layer:** This layer is responsible for transforming the data that is collected by data sources into structures that can be managed by systems to be exploited.

- **Data Management layer:** This layer oversees managing data (historical and real-time) providing it through standard API to the upper layers. The scope of the components of this layer is to provide a unified knowledge base in which the data collected and harmonised in the interoperability layer can be accessed through (semantic) federated queries. This layer will provide the specific big data technologies needed to manage the large amount of data produced by pilots.

- **Intelligence layer:** This layer is the one designated for processing information from the lower levels to provide value-added services. It includes all types of big data analysis and artificial intelligence, both real time and batch processing. The Intelligence toolbox will be formed of all the data analytics tools that will be developed in the project by the different partners for the different use cases defined in the deliverable D1.1.

- **Marketplace:** This component will be in charge of publishing and search different type of assets (including datasets, service and applications (e.g. analytic tools) providing also functionalities to describe them through metadata that includes the properties of the assets and the way to access them. The marketplace will be the way in which pilots can share, with the rest of the ecosystem, data and applications that will be accessible through standard metadata description and API.

- **Security and Privacy:** This is a transversal layer covering all the aspects related to security and privacy. Specifically, these include authentication and authorisation capabilities, functionalities to ensure confidentiality and integrity of the communications, data usage control and personal data management. This layer is also logically connected with the specific security frameworks of pilots' infrastructure providing functionalities to the rest of the architectural components that must run in a secure a reliable environment.

4. Pilots specific implementation plan

4.1. Pilot #1a Predictive maintenance of wind Farm

4.1.1 Pilot Characterization

4.1.1.1 General characterization of Pilot 1a

Scope

This pilot targets one aspect of the energy domain: predictive maintenance of wind turbines. In the last decade, there has been an extensive increase in the share of renewable energy sources in the overall electricity mix. As such it is important to have predictability about the availability of these renewable energy sources since there is increasing dependency in the grid on their availability. Gaining better insights in the chances of failure for the wind turbines in the fleet is a key aspect in this regard. At the same time can predictive maintenance reduce the cost of energy from wind to help the EU in its target to increase the contribution of renewable energy sources.

This pilot focuses on this societal challenge. It makes use of fleet data from many wind turbines to diagnose failures by pinpointing to the specific failure mode responsible for the failure. The main data streams that are used in this pilot are data streams that are typically standardly available for wind turbines (onshore and offshore): Supervisory Control and Data Acquisition (SCADA) data. This is timeseries data of sensors embedded in the turbine sampled by the SCADA system and aggregated to 10-minute averages. In addition, edge computing is used to locally aggregate and process high frequency measurements.

The use case at hand focusses on the predictive maintenance of wind turbine electrical drivetrain components: generator and power converter. The other subcomponents of the wind turbine are not in scope. A combination of data-driven and physics-based modelling is used.

Pilot objectives

This translates in the following objectives for the pilot:

O.1.Develop, implement, and validate accurate physical and data-driven models of the wind turbine electrical drivetrain components: generator and power converter.

O.2.Develop anomaly detection methods for identification of unhealthy behaviour of the components in scope.

O.3.Develop an approach to convert the identified anomalies towards health metrics to create a diagnostic tool.

O.4.Develop a methodology to reason on the anomalies detected by the different models to pinpoint the potential cause for the failure.

Pilot contributors
This pilot is coordinated by Vrije Universiteit Brussel (VUB) in participation with Tecnalia and ENGIE. University of Bonn is involved.

Related business cases
This pilot originates from clearly identified business cases for the different partners working in the pilot. The main business cases for this pilot are linked to the business cases of three partners:

- Tecnalia: The objective of Tecnalia is to further enhance its physics-based digital twin and develop new data analytics tools for predictive maintenance for electrical drivetrain components (generator and power converter) to reduce maintenance costs and increase availability of wind turbines.
- ENGIE: The objective of ENGIE is to increase availability and optimize maintenance of electrical drivetrain components of wind turbines in a fleet perspective. Physics-based models are expected to leverage the information that can be obtained from existing fleet data (e.g. SCADA tags, status logs) to enhance insight of the appearance and severity of failures or risks for failure initiation.
- VUB: The main business case linked to this pilot is the development of end-to-end diagnostics tools for the detection and follow-up of electrical component failures. The unique aspect of the VUB approach is in the hybrid data-driven-physics based approach.

4.1.1.2 General characterization of local environment

The **pilot focusses on wind turbines and will use datasets of different granularity. Two main data sources are used:**

- SCADA data coming from a part of the ENGIE fleet of turbines. **This consists of historic datasets that are used. The data itself is continuously connected and updated in batches.** This also includes status logs/ fault messages for the different systems.
- High frequency measurements coming from targeted measurement campaigns on the turbine electrical components.

The details about the test objects and the data properties will be discussed in detail in the following sectio**n.**

4.1.2 Overall Pilot's Architecture

4.1.2.1 ICT architecture and model flows

The overall ICT architecture of the pilot is shown in Figure 10. In general, it can be stated that ENGIE is the data provider and the technical expert party who interprets the outcome of the analytics models using domain knowledge. As such the data lake as well as the visualization and interpretation layer are at the ENGIE premises. VUB and Tecnalia provide data analytics modules. Each of these models can at a different physical location. The outcomes of the Tecnalia modelling approach will be provided to ENGIE directly and be used as inputs for the VUB modelling approach. The outcomes of the VUB modelling approach will be send to ENGIE. All data exchange will be facilitated using IDS connectors.

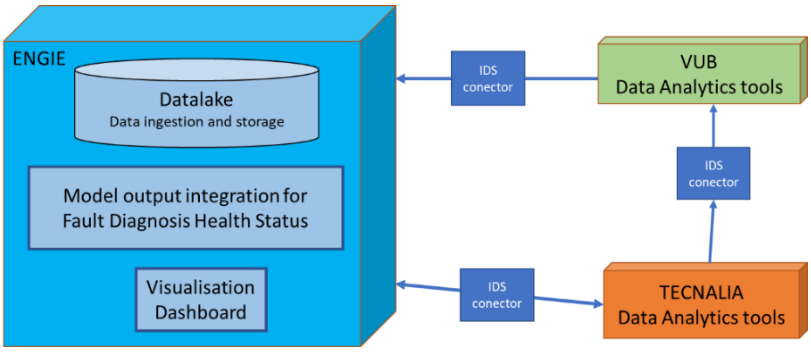


Figure 4: Pilot 1a Overview of the ICT architecture

For one data source (high frequency current data) edge computing will be used to aggregate the data closely to the sensors. This will be done using the architecture shown in Figure 11.

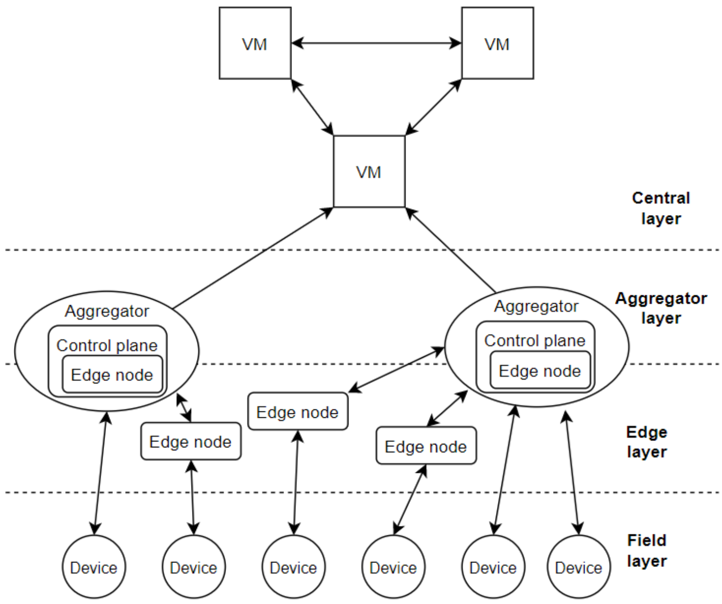


Figure 5: Pilot 1a Edge computing scenario for aggregations of the high frequency sensor data

Pilot data processing flow from an architecture point of view

This section provides a more detailed overview of the different components used in the overall data processing pipeline. First the data is integrated and different datasets for the pilot extracted, as shown in Figure 12. These data are stored at the ENGIE datalake.

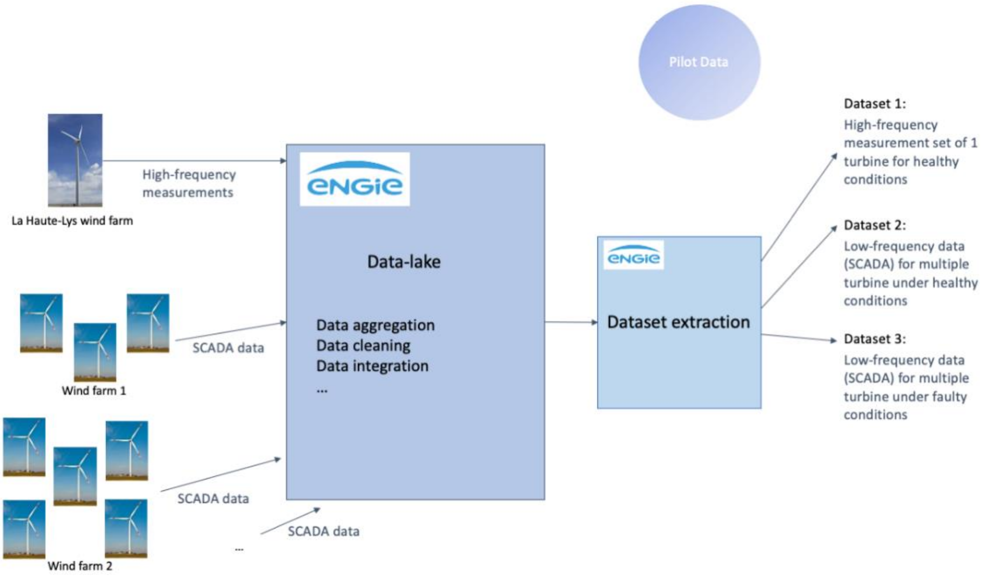


Figure 6: Pilot 1a Pilot dataset extraction

Different modelling approaches are integrated to detect abnormal behavior, as shown in Figure 12. As previously mentioned, different modelling methods are used (digital twin based on physical model, data-driven healthy behavior models). These are interacting towards fault isolation and diagnosis.

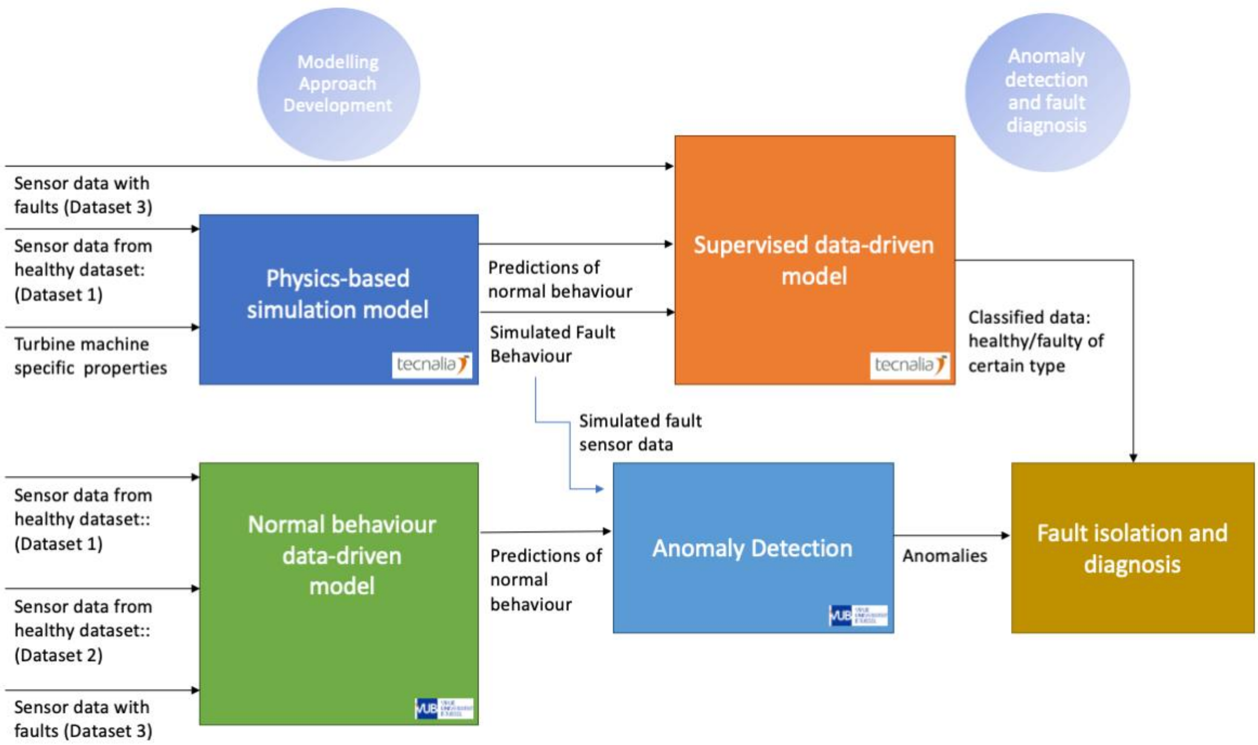


Figure 7: Pilot 1a overview of models and their interaction

As shown in Figure 14, once the data is classified in normal and abnormal, we aim to assign each of these labels to a subcomponent of the turbine. We aim to do this for all sensor signals on which analysis was done. Anomaly reasoning is used to reason on these labels and assess the health for each subcomponent. This should result in a health label for each subcomponent of the wind turbine. This health label is then sent back to ENGIE for visualization on a dashboard.

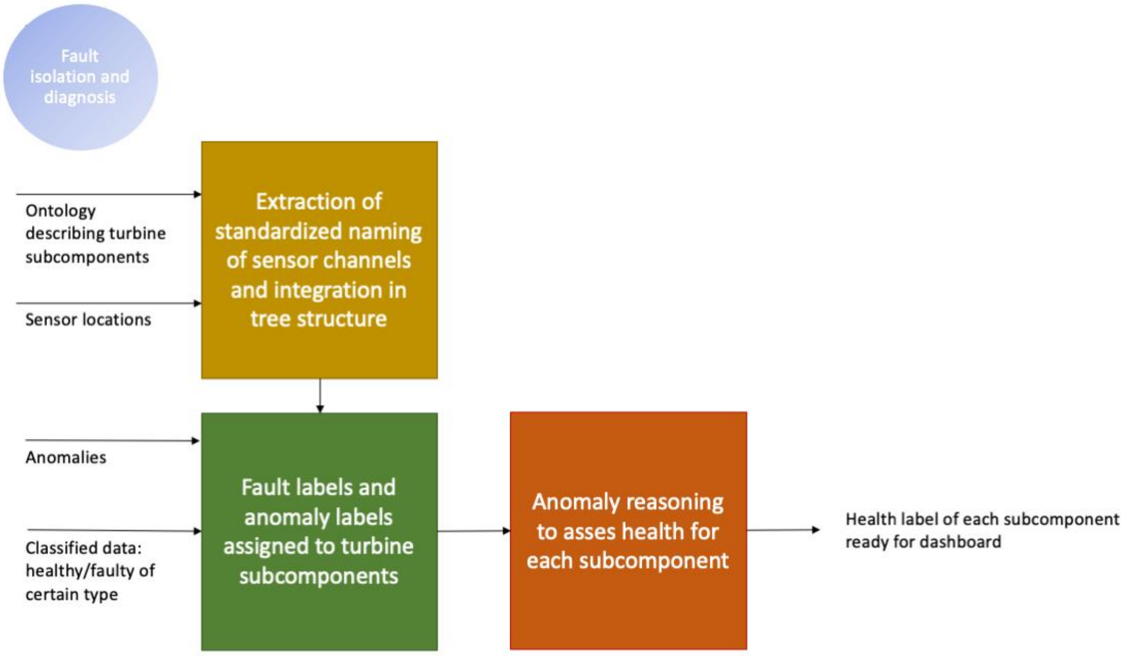


Figure 8: Pilot 1a Extraction of health information

4.1.2.2 Site assessment and existing infrastructures

All analytics in this pilot will be done using operational data of the current fleet of wind turbines of ENGIE. In addition, data of measurement campaigns that were done in the past is used. If needed additional measurements will be conducted during the pilot phase of the project. Feasibility is currently being investigated.

4.1.3 Pilot requirements

Interoperability layer

Component /service	Provider	Demonstration requirements	Readiness (if the requirements can be met on the pilot location)	
			Yes	No
Data Connector	ENGIE	Now there is a basic scenario for a connection with a	Already implemented for	Not implemented for the more complex scenario

		central repository for all wind data. It could be extended to a more complex scenario to connect directly to other databases. For VUB and TECN this will have no impact since the IDS connectors will be used. The basic scenario contains time series only which is non-semantic. In addition there will an attempt to complete a potentially more complex scenario to use semantic data. Two data connectors are identified: • Batch: SCADA datasets • Batch: High frequency measurement set of turbines.	the basic scenario.	with fully semantic data exchange.
IoT Connector	-	Not required.	-	-
Data Curation and Integration	ENGIE and TIB	Basic scenario time series is non-semantic. In addition we will try to put a potential more complex scenario exploiting semantic data.	Yes for Basic scenario time series non-semantic.	No for a complete a potential more complex scenario to use semantic data.

Semantic Adapter	ENGIE and TIB	Basic scenario: time series which is non-semantic. In addition, will try to put a potential more complex scenario to use with semantic data.	Yes for Basic scenario time series non-semantic.	No for a complete a potential more complex scenario to use semantic data.
Energy Data model (PLATOON Data models from T2.3)	ENGIE , VUB and TECN	Yes for the interoperability. Also it could be useful to use it for the data analytics.	Yes for the interoperability.	Pending failure modes for the data analytics.
Vocabulary manager	TECN and IAIS	Regarding interoperability define 3 levels: 1)Raw data with IDS 2)Semantic data with IDS 3)Semantic data with IDS and used for Data Analytics In this pilot we will target at least level 2.		No. Vocabulary manager is part of IDS vocabulary provider. This will be done in WP3. Not able to define now how this can be implemented with IDS vocab provider.

Table 1: Pilot 1a Interoperability layer requirements

Data Management Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Context Data Broker	ENGIE	Not needed		
Federated Query Processing	ENGIE and TIB	Not needed		

Unified Knowledge Base	ENGIE and TIB	Not consolidated on whether it is necessary		Not implemented yet.
Context Event Processing	ENGIE	Not required		

Table 2: Pilot 1a Data management layer requirements

Intelligence Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Analytics Toolbox and Processing Tools	TECN and VUB	For sure implemented as a service but might consider as well to do a test on the infrastructure using dummy code.	Yes. We will use the Data Analytics Tool container defined in T4.1.	
Data Analytics Dashboard – Visualization	ENGIE	Visualization Dashnobard to show outputs from data analytics tools from VUB and TECN.	Yes they already have the visualization dashboard.	Will need to be integrated with data analytics tools/storage.

Table 3: Pilot 1a Intelligence layer requirements

Marketplace

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Marketplace	IAIS	VUB and TECN will show metadata of proprietary tools in the marketplace. ENGIE – will show metadata for datasets and potentially also for apps/tools – Engie to confirm the last one with Koen.		No this will be developed as part of T3.4.

Table 4: Pilot 1a Marketplace requirements

4.1.4 Equipment and System Specification

All data that is used in the pilot is collected using equipment that is standardly available in the turbine, or the data was collected during historical measurement campaigns. We are currently investigating if it will be possible to install current probes in a test turbine. Whether this will be possible will become clear in the coming months.

4.1.5 Plan for implementation pilot services, and systems

This planning is currently under development and will be finalized early 2021.

4.1.6 KPIs measurements

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
1	Modeling quality	Modelling approach capable to fit healthy component data	O.1
2	Integration	Tool interaction/integration	O.1, O.2
3	Detection	Anomaly detection speed + accuracy (false vs true positives)	O.2
4	Load characterization	Important historical loading events can be captured using automated methods	O.4
5	Processing reach	Size of fleet dataset that can be analysed automatically: nbr of turbines, channels,…	O.1, O.2
6	Processing speed	Speed of the anomaly analysis	O.2
7	Maintenance costs	Maintenance cost reduction	O3, 04
8	Availability / Increase of RES usage	Increase availability of Wind Turbines (increase RES usage)	O3, 04

Table 5: Pilot 1a KPIs

4.2. Pilot# 2a Pilot electricity balance and predictive maintenance

4.2.1 Pilot Characterization

4.2.1.1 General characterization of Pilot 2a

Electricity balancing is a set of actions and processes performed by a TSO to ensure that total electricity withdrawals (including losses) equal total injections in a control area at any given moment. Electricity production from solar and wind plants is subject to considerable forecast errors that drive the demand for accurate forecasting of production of electricity. At each point in time, total production, combined with interchange, i.e., export or import of energy from/to control area, must be equal to total consumption in order to stabilize system frequency and to maintain exchange at scheduled levels; it is therefore also called load-frequency control. If the system runs out of balance, power stability and quality will deteriorate, which may trigger the disconnection of system components, and ultimately, power blackouts. Therefore, there is a need of operating reserves i.e., any type of capacity being used to support active power balance on country / regional level.
Independent producers (IPP) and producers from distributed and renewable sources (DER) will be actors in the balance reserve market in the future. Therefore, one of the goals of Pilot 2a is to develop and test PLATOON services for more accurate prediction of renewable energy generation as well as more accurate load forecast. Additionally, the increasing number of renewable energy resources such as photovoltaic and wind power plant has a significant impact on the stability and power quality of electricity transmission. Therefore, in pilot 2a we are also interested in adoption of PLATOON analytical services for analysis of unexpected variations (voltage profile of the power system) before and after RES integration to the power system. Finally, in pilot 2a we are interested in monitoring and analysing the output from the RES power plant for an asset management scenario.

4.2.1.2 General characterization of local environment

PLATOON Pilot #2a will take place in Serbia, while the overall goal of the pilot is to integrate and deploy different PLATOON analytical services with the Institute Mihajlo Pupin (IMP) proprietary VIEW4 Supervisory control and data acquisition (system). The VIEW4 SCADA is deployed at many parts in the energy value chain in Serbia, starting from control on the production side (in the large hydro and thermal power systems, as well as RES), via transmission management to distribution and electricity dispatching. In order to better understand the needs, several different scenarios have been defined in WP1 framework (please check LLUC-2a document). Scenarios refers to different Smart Grid domains:

- Market-related domain:
  LLUC P-2a-01 Balancing on regional level
  LLUC P-2a-02 Balancing on country level, reserve/energy exchange process

- Grid-related domains transmission, distribution, micro-grids:
  LLUC P-2a- 03 Load/Demand forecasting
- Resource-connected-to-the-Grid domains (Distributed Energy Resources,):

LLUC P-2a-04 RES forecasting
LLUC P-2a-05 RES effects on the Power System

- Support functions domains (Asset Management) :
LLUC P-2a-07 Predictive maintenance in RES power plants

- Scenarios were originally prioritized in Task 1.1 / Task 1.4 framework as follows:
  1. High priority (LLUC P-2a- 03, LLUC P-2a-04, LLUC P-2a-07)
  2. Medium (LLUC P-2a-05)
  3. Low (LLUC P-2a-01 and (LLUC P-2a-02)

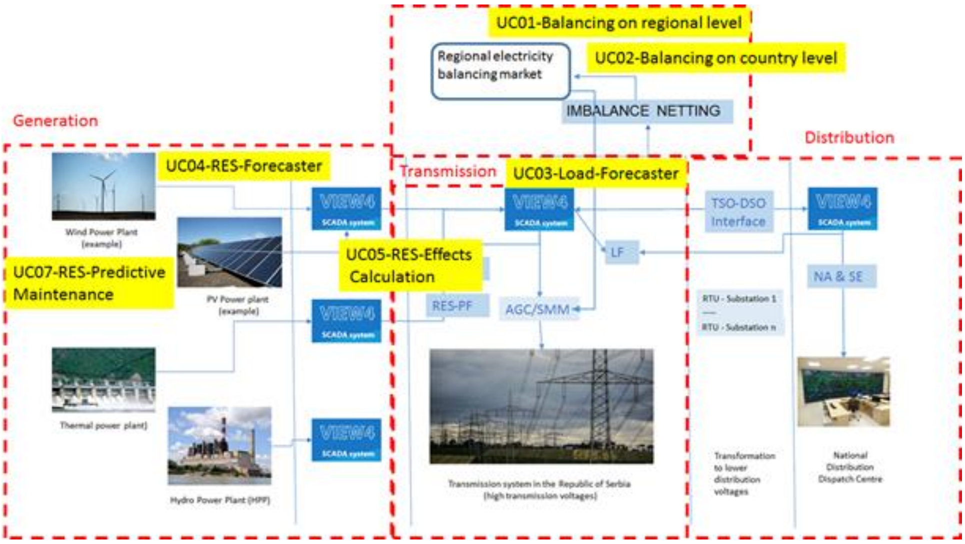


Figure 9: Pilot 2a overview

4.2.2 Overall Pilot's Architecture

4.2.2.1 Power grid architecture

As a part of pilot 2a two different renewable power plants have been included.

1. The first one is wind power plant located in Montenegro. It is connected to the grid monitored by the SCADA system. SCADA contains various telemetric data about production, generator state and current meteorological parameters. Therefore, to develop and integrated PLATOON platform in the pilot 2a, connection with the SCADA system will be crucial.
2. Another power plant is Photo-voltaic (PV) plant with the 50 kWp capacity located at the roof of the IMP. The electricity produced by this plant is directly fed into the grid, while the institute itself is fulfilling its demand from the grid. Namely, in accordance with the Serbian regulation, the electricity from some source can be either used locally (and never sold to grid) or vice versa. Since IMP is privileged producer, it is way more economically viable to sell that energy than to use it. This plant is, similarly to the previous one, controlled and monitored by the SCADA system, which contains extensive amount of data regarding PV plant parameters, such as production, currents,

voltages and measured meteorological parameters. Again, integration with the SCADA system will be crucial for PLATOON platform.

4.2.2.2 ICT architecture

The vision of deployment of PLATOON reference architecture in pilot 2a scenarios is presented in Figure 10. It was designed as structure of 6 layers which as a combination cover all the LLUC which will be demonstrated as a part of pilot 2a. The lowest layer is composed out of PMU and inverter units connected to the PV plant. It is followed by the Pilot Edge Node Layer, which is supposed to provide low level edge computing analytics such as RES Effect Calculator and Predictive Maintenance, which will be exploited as a part of LLUC 2a-05 and 2a-07. Furthermore, the following layers are interoperability and control ones, enabling collection and exchange of measurements and control action from various sources. Finally, cloud platform instantiated as a part of platform 2a at IMP is shown as the last layer and contains analytical tools for LLUC 2a-03 and 2a-04 together with MySQL data, semantic data and IDS connector.

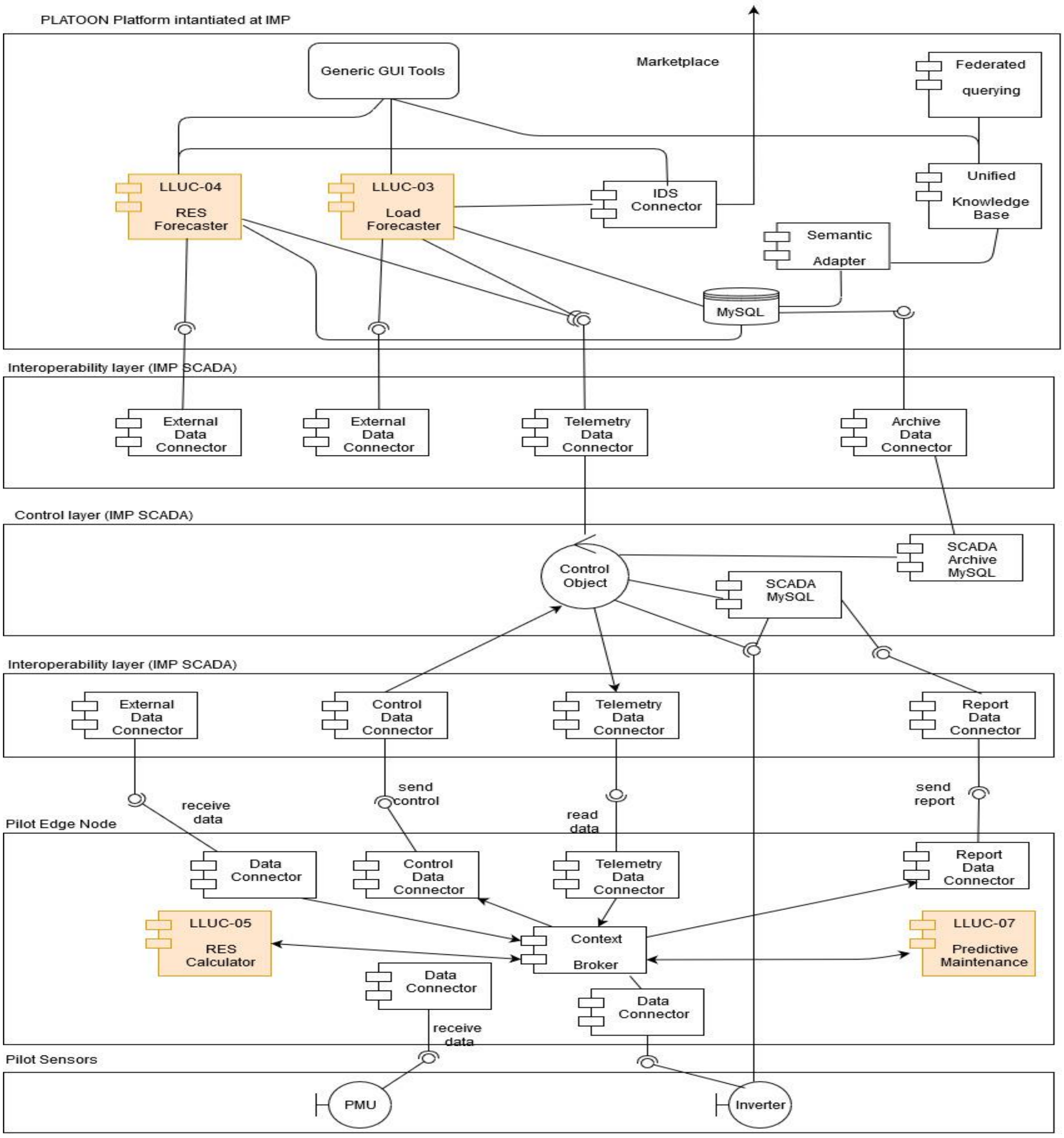


Figure 10: pilot2a ICT architecture

4.2.3 Pilot 2a requirements

Using the PLATOON methodology in the WP1 framework the general requirements were identified and reported in Deliverable 1.1 Business case definition, requirements and KPIs. Herein we discuss the requirements related to scenarios that will be tested in WP6 framework including:

- **LLUC P-2a-03 Demand forecast on transmission level**
- **LLUC P-2a-04 RES (Wind generation) forecasters**
- **LLUC P-2a-05 Effects of Renewable Energy Sources on the Power System (distribution level)**
- **LLUC P-2a- 07 Predictive maintenance in RES power plants**

In order to provide concise explanation of the requirements within pilot 2a, the elaboration will be divided into 4 categories: interoperability layer, Data Management Layer, Intelligence Layer and Marketplace as shown in Table I, Table II, Table III and Table IV. Details will be given in the following subsections.

Component /service	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
		Yes	No
Data Connector	**Study mode:** Non-semantic data. It will be time series extracted from SCADA Archive and stored in MySQL server. **Operational mode:** Telemetry data connector for reading data from SCADA system	**Operational mode:** SCADA – Platoon Platform connectors will be developed, which are relevant for LLUC-04. LLUC-05, LLUC-07.	
IoT Connector	Yes		**Operational mode:** IMP SCADA – Edge Computer interfaces should be implemented for LLUC-05 and LLUC-07.
Data Curation and Integration	**Study mode:** useful for LLUC-03	Virtuoso will be installed and the tools will be provided.	

Semantic Adapter	**Study mode:** Semantic Transformation for adapting pilot data to the semantic data model	Virtuoso will be installed and the tools will be provided.	
Energy Data model (PLATOON Data models from T2.3)	**Study mode:** Consolidated Data Model	**Study mode:** Consolidated data model will be used for advanced querying scenarios.	
Vocabulary manager	It is likely that this tool will be present on PLATOON level.		**Study mode:** to be used for developing new scenarios.

Table 6: pilot2a interoperability layer requirements

Component /service	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
		Yes	No
Context Data Broker	**Operational mode:** Needed in LLUC05 and LLUC07		It will be demonstrated when edge computer (CS) development is ready.
Federated Query Processing	**Study mode:** useful for LLUC-03		It will be demonstrate based on data in LLUC03 and LLUC-04.
Unified Knowledge Base	**Study mode:** Needed to host data from SCADA archives and open data collected from the Web. Could host the Consolidated Data Model and IMP specific vocabularies.	Virtuoso will be installed and the tools will be provided.	

Context Event Processing	Not required		

Table 7: Pilot 2a Data Management requirements

Component /service	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
		Yes	No
Data Analytics Toolbox and Processing Tools	4 scenarios elaborated. **Study mode:** LLUC-03, 04 **Operational mode:** LLUC-05, 07	Data Analytics Tool container approach defined in T4.1 will be used for LLUC 2a-03 and LLUC 2a-04.	
Data Analytics Dashboard – Visualization	UIs need to be integrated with data analytics tools/storage.		**Study/Operational mode:** This will be developed in Task 4.6

Table 8: Pilot 2a Intelligence Layer requirements

Component /service	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
		Yes	No
Marketplace	Forecasters (LLUC-03, LLUC-04) might be registered on the marketplace.	Metadata will be provided in WP3 framework.	

Table 9: Pilot 2a Marketplace requirements

LLUC 2a-03 and LLUC 2a-04

In Figure 11 simplified version of the pilot architecture is given, specifically for LLUC 2a-03 and 2a-4. The main idea of these LLUC is providing advanced analytics for renewable energy source (RES) production forecast, precisely for wind turbines, and load forecast on the country level. This models will be based on the historical data stored in SCADA which contains production, demand and meteorological conditions and semantic data stored as a part of the unified knowledge base.

Having in mind the LLUC definitions and previous tables, these two use cases will require following components Data Connector, Data Curation and Integration, Semantic Adapter, Federated Query Processing, Data Analytic Toolbox and Processing Tools and Marketplace.

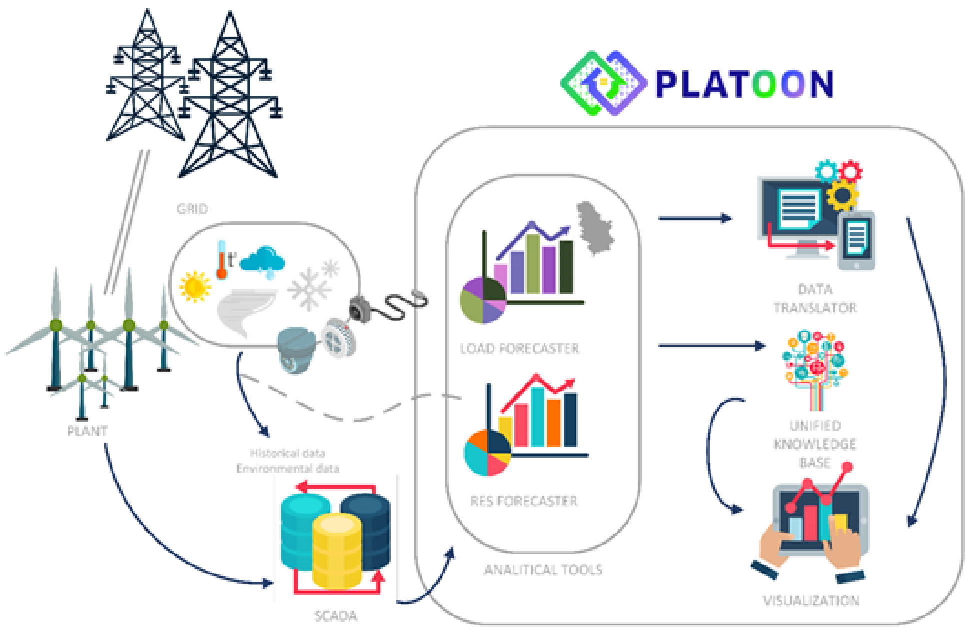


Figure 11: Pilot 2a LLUC 2a-03 and 2a-04 architecture

LLUC 2a-05 and LLUC 2a-07

In Figure 12 simplified version of the pilot architecture is given, specifically for LLUC 2a-05 and 2a-7. The main idea of these LLUC is providing low level analytics on the edge such RES Effects Calculator and Predictive Maintenance. These analytics will be provided using PMUs and by exploiting various measurements from the sensors collected by the SCADA system. Therefore, taking previous tables into consideration, following development will be needed: Data Connector, IoT connector and Context Data Broker.

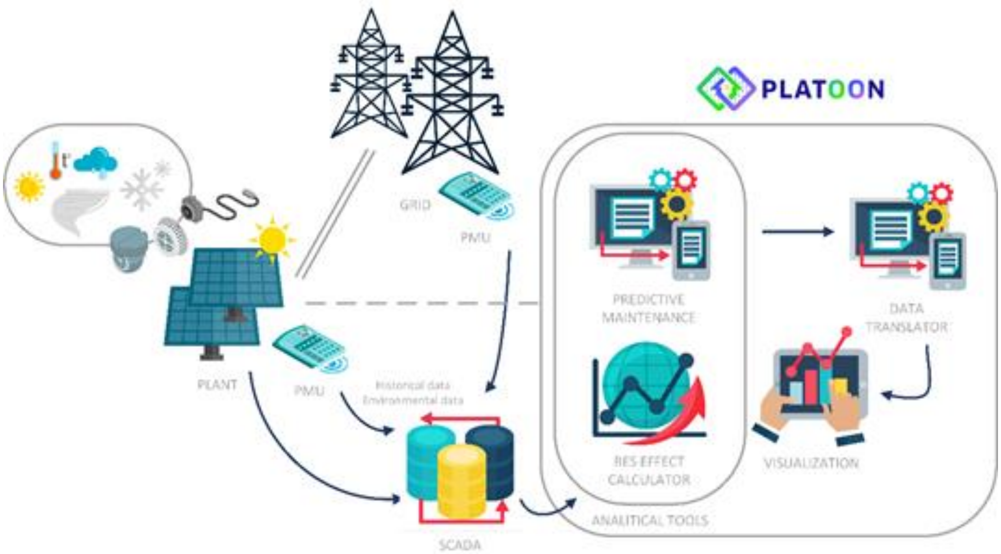


Figure 12: Pilot 2a: LLUC 2a-05 and 2a-07 architecture

4.2.4 Equipment and System Specification

4.2.4.1 Equipment – level

In order to fulfil the requirements given by the PLATOON project, within the pilot 2a PMU will be installed for LLUC 2a-05 and 2a-07. Namely, it will be necessary to provide hardware architecture for edge computing which will be able to perform analytical calculations regrading RES Effect and Predictive Maintenance. Apart from the PMUs and hardware which will be used for platform hosting, no additional will be required, since the pilot is already equipped with high number of sensors.

4.2.4.2 System - level

The main part of the work will be placed on the development of the various software components which would provide fully functional platform. As listed in the requirements section various adapters for communication purposes will be developed, both for the edge and cloud sides of the platform. Additionally, sematic storage will be included together with relational data base which is a part of SCADA system. Finally, analytical services will be developed, deployed and integrated – cloud based for LLUC 2a-03 and 2a-04 and edge ones for 2a-05 and 2a-07.

4.2.5 Plan for implementation pilot services, and systems (chronogram)

This planning is currently under development and will be finalized early 2021.

4.2.6 KPIS measurements

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
KPI-1	Inmproved forecasting accuracy	Deployment of new forecasting models (artificial intelligence methods and neural networks, hybrid models)	LLUC P-2a-03 LLUC P-2a-04
KPI-2	Savings from tertiary reserve trading	[i] G. Jakupović, N. Stojaković, Z. Vujasinović, N. Jović, D. Vlaisavljević, J. Trhulj (2020) Software Environment (Simulator) for Technical Support of Cross-border	LLUC P-2a-01

		Electric Energy Balancing In Wb6 Region, CIGRE South East European Regional Council Conference 2020 in Vienna, Austria.	
KPI-3	Better demand response	Responding better to changes in demand	LLUC P-2a-02 LLUC P-2a-05
KPI-4	Improved RES integration	Better evaluation of the effects from RES integration	LLUC P-2a-02 LLUC P-2a-04
KPI-5	Balanced energy mix	Reduction in peak use of fossil fuels	LLUC P-2a-04 LLUC P-2a- 05
KPI-6	Curtailment avoidance	Percentage of curtailment avoidance	LLUC P-2a-04
KPI-7	Portfolio optimization	Improved portfolio optimization of Balance Responsible Parties (Optimization/Management of Renewable Energy Systems)	LLUC P-2a-07
KPI-8	Saving costs	The installation of the machine learning algorithm for detection of abnormal behavior shall reduce the maintenance costs.	LLUC P-2a-05 LLUC P-2a-07
KPI-9	Increased stability	Increased degree of stability in the real power plant operation.	LLUC P-2a-06
KPI-10	Metadata models	Number of metadata specifications prepared and registered with CKAN related to the data that will be used in the analytical services	

Table 10: Pilot 2a KPIs

4.3.Pilot #2b Electricity grid stability, connectivity, and life cycle

4.3.1 Pilot Characterization

Pilot 2b is sector, 65,000 m2 of buildings, located in Palma de Mallorca, Spain.
Sampol is the DSO of the park and Platoon partners will develop tool for the grid stability, connectivity and life cycle.

- General characterization of Pilot 2b

In this pilot, two different Use Cases will be developed within the project:

- Predictive Maintenance for MV/LV Transformers: focus on transformer predictive maintenance, estimating transformer components health and its maintenance costs, planning maintenance actions, monitoring transformer alarms and studying different grid scenarios in case of replacing old transformers or adding complementary transformers.
- Non-technical loss detection in Smart Grids: quantification of losses in the distribution grid of a DSO and the detection of non-technical losses (NTL)

Pilot objectives
Considering the two UC defined, the following objectives are defined in the present pilot:
O.1 To develop, implement and validate a predictive maintenance tool for LV/MV transformers considering available data in this kind of installations. First estimating the health index of the transformer considering different failures modes of the transformer critical components. Define transformer maintenance plan considering the health index and maintenance and failure costs.
O.2. To develop, implement and validate a prescriptive analytics tool to evaluate the effect of different operational actions in the grid O&M cost sheet.
O.3. To develop, implement and validate a tool for the quantification of losses in the distribution grid of a DSO and the detection of non-technical losses (NTL)

Related business cases
The main business cases for this pilot are linked to the business cases of three partners:

- **Tecnalia:** The objective of Tecnalia in UC1 is to further enhance its physics-based digital twin and develop new data analytics tools for predictive maintenance for electrical drivetrain components (generator and power converter) to reduce maintenance costs and increase availability of transformers. In the UC2 is to develop data analytics tools to identify NTL and improve the losses track in its grid.
- **Sampol:** in UC1 the objective for Sampol is to increase availability and optimize maintenance of transformers in Smart grids. In the UC2 is to identify NTL and improve the losses track in its grid.
- **Indra:** To improve its tools in predictive maintenance and monitoring platform OneSait.

4.3.2 Overall Pilot's Architecture

4.3.2.1 Power grid architecture

Parc Bit's grid is formed by 5 km long mid voltage network and 5 km low voltage network, a main substation rated 80MVA, and 16 transformation centers in ring configuration, with 16 MVA in total. The grid comprises 166 clients with 10MW of power hired and 41GWh of energy consumed last year. Smart meters have been deployed in all the customers and data are transferred through PLC PRIME communication channel to the concentrators in transformer centers. From there, data are sent via TCP/IP connection to the SAMPOL's back office.

4.3.2.2 ICT architecture

The Spanish pilot comprises an electrical grid with data from transformers and distribution. All this data is collected in a MySQL data base and distributed among the project partners. In the next picture, it is shown a diagram of the ICT architecture for both LLUCs:

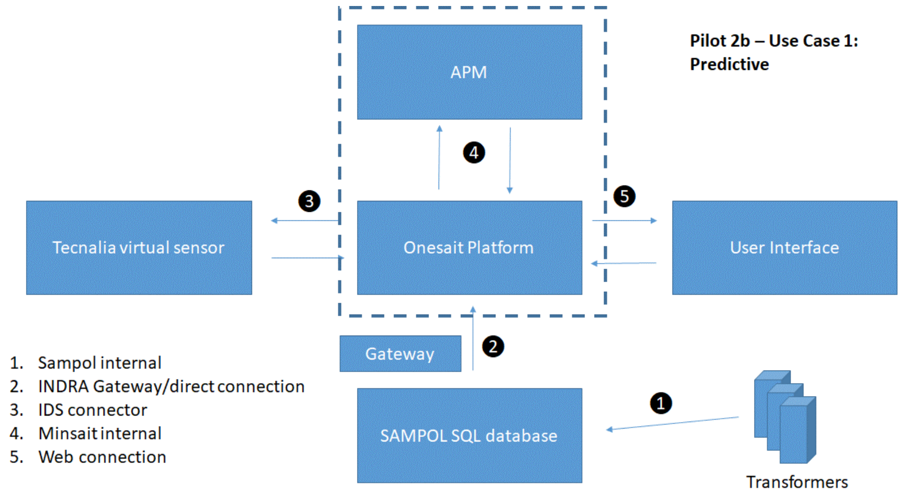


Figure 13: Pilot 2b - LLUC 01- ICT architecture

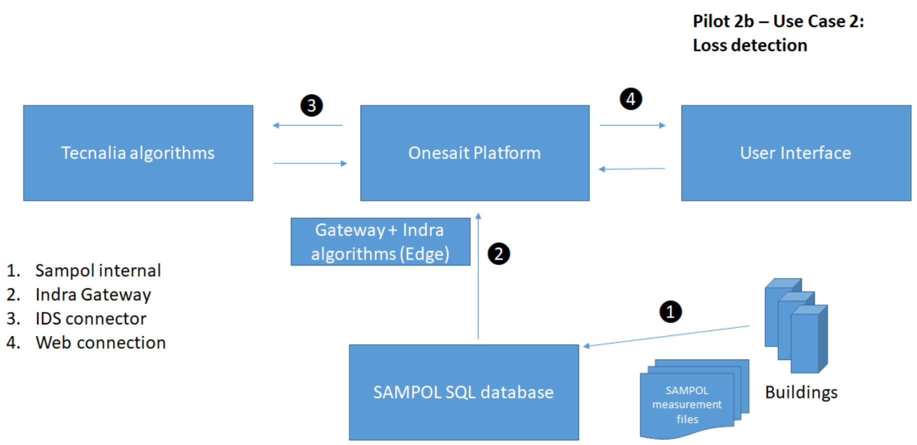


Figure 14: Pilot 2b - LLUC 02- ICT architecture

All data collected from the transformers (temperature, humidity, pressure, oil temperature, electrical measurements) and distribution (client's smart meters and data concentrators) is stored in a local MySQL database.
Tecnalia, in collaboration with Sampol, will develop the tools described before in this document, and afterwards data from the tools and the pilot will be used in Indra platform for visualization.

4.3.3 Pilot 2b requirements

Interoperability layer

Component /service	Provider	Demonstration requirements	Readiness (if the requirements can be met on the pilot location)	
			Yes	No
Data Connector	Indra/Tecnalia	On Onesait side an IDS compliant connector will have to be implemented to exchange data with Tecnalia. Data model translation from internal Onesait structure will also be a requirement	Will be implemented in the pilot for both use cases (starting point from Engineering Open Source)	
IoT Connector	Indra	Onesait gateway will most probably used to upload field data. There is a simpler scenario with direct connection to Sampol's database but will not be the ultimate solution	Onesait Gateway technology is intended to be used. Maybe a Indra-based instance of the gateway will be temporarily implemented due to COVID restrictions.	
Data Curation and Integration	Indra	Data will be consolidated in Onesait storage, mainly time series data	Covered in the pilot	

Semantic Adapter	Indra and Tecnalia	Semantic translations between Indra/Tecnalia and the Platoon model will be implemented. Several options are available (3 options). A decision will be made on this.	Covered in the pilot	
Energy Data model (PLATOON Data models from T2.3)	Indra and Tecnalia	Both for interoperability and data analytics.	Covered in the pilot	
Vocabulary manager	Indra and Tecnalia	Is it necessary to have a common VM? The role of Vocabulary Provider is being defined. Not applicable here.		

Table 11 Pilot 2b interoperability layer requirements

Data Management Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Context Data Broker	Sampol + Indra	Needed (Sampol data acquisition + gateway + Digital broker)).	*Yes*	
Federated Query Processing		Not applicable		
Unified Knowledge Base	Indra	Onesait Platform DB	*Yes*	
Context Event Processing		Not required		

Table 12 Pilot 2b data management requirements

Intelligence Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Analytics Toolbox and Processing Tools	Indra and Tecnalia	Will be implemented in the case of Tecnalia algorithms. Not so sure for Indra algorithms, both predictive/asset health in APM and loss detection on edge (similar case in Sisteplan)	Tecnalia algorithms	Indra algorithms
Data Analytics Dashboard – Visualization	Indra	Based on Onesait platform capabilities	Covered in the pilot	

Table 13 pilot 2 Intelligence layer requirements

Marketplace

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Marketplace	Franhofer, Tecnalia	Tecnalia algorithms (oil temp virtual sensor, RUL calc, Non-technical losses) in data analytics. Not decided yet for Indra algorithms. Sampol tools depending on results. Market place with catalogue of tools and datasets + IDS components	Covered in pilot for some algorithms	

Table 14 Pilot 2b Marketplace requirements

IDS

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Connector	Engineering	Tecnalia and Indra	Yes	
DAPS	Franhofer AISEC	Tecnalia and Indra	Yes	
Broker/App store (metadata registry)	Franhofer IAIS	Central component	Yes	
Clearing House	Franhofer IAIS	Central component	Yes	
Vocabulary provider	Tecnalia	Central component	Yes	

Table 15 pilot 2b IDS requirements

4.3.4 Equipment and System Specification

As mentioned before, the data required in this pilot comes from two sources depending on the Use Case: Parc Bit transformers for Transformer predictive Maintenance and DSO data for Non-Technical Losses detection.
In the following table, the equipment to be used in the pilot is described:

Equipment and System Specification		
Transformers	External temperature sensors	(8x3) Wireless sensors which measure the temperature of the outer surface of the transformer metallic casing, and the ambient temperature inside and outside the transformation center. Model IP68 WTS-O.
	External temperature receivers	(1x3) Wireless Mbus receivers that receive the measurements from the external temperature sensors and forwards the measurements to the Advantics data concentrator by Mbus protocol.

	External multiparametric sensors	(2x3) Wireless sensors which measure ambient temperature, humidity and pressure. Model WES-THP.
	Top oil temperature sensor	(1x3) Sensor which measures the oil temperature at the top layer, and additionally provides pressure and level measurements. Model BB211 (control unit) +TPL503 (sensor)
	Medium voltage electrical measurements	(1x3) Electrical network analyzer EM271-72DMV53 with (9) current transformers TCD1M-10080
	Modbus converters	(1x3 + 1) Modbus converters NBB-EN272501 that connect the data concentrators and the electrical network analyzers
	Advantics data concentrators	(1x3 + 1) data concentrators Model UCM-316.
Distribution feeder level	Smart meters	Existing ZIV smart meters
	PRIME data concentrators	Data concentrators that receive the measurement reports from the customers smart meters

Table 16: Pilot 2b Equipment and system specification

4.3.5 Plan for implementation pilot services, and systems

Regarding LLUC 01, during the first year of the project 2020, all equipment required is defined and installed in the pilot. In the same way, the SQL database is planned to the accessible by the end of 2020.At the beginning of 2021, when the database is running and accessible for all partners, pilot data will be analyzed, and tool development will start. During 2021 also the SAMPOL database will be integrated with Indra´s OneSait platform.

Regarding LLUC02, data is already available in the SQL database. During 2020 smart meter data has been analyzed and has started the development of data analytics tools for NTL detection.

By the end of 2021 tools are expected to be in a first version for running tests during 2022.
By the end of 2022, tools and test will be evaluated and reported.

4.3.6 KPIS measurements

In the following table are described the KPI defined in this pilot:

Pilot KPIs	
KPI-Name	**Requirement description**
UC1- Predictive Maintenance in transformers	
True positives (TP)	Number of anomalies detected with early warnings and confirmed with a corrective work order
False positives (FP)	Early warnings with no associated corrective work order
False negatives (FN)	Corrective work order without a previous early warning
True Negatives (TN)	No early warning and no work order
Specificity (%)	Proportion of true negatives relative to all negative cases (TN/(TN+FP))
Sensitivity (%)	Proportion of actual positives correctly identified (TP/(TP+FN))
Cohen's Kappa (%)	Measurement of matches in the predictive tool discounting the probability of randomly matching
Savings (€)	Cumulative measurement of savings associated to True Positives considering **a)** Avoided breakdown consequences + **b)** Downtime cost
Additional Costs (€)	Increased costs due to maintenance activities associated to False Positives. They should be subtracted from Savings to get the net value.
Anticipation time (days)	For each True Positive it represents the delta Time between the moment of detection and the time of failure
UC2 – NTL detection	
Global Losses Energy Percentage	Percentage of the energy that is provided from a MV substation or LV CT that is not settle to any consumer and is therefore lost. To be averaged in long periods (at least months). NTL-KPI-01 = NTL-KPI-02 + NTL-KPI-03
NTL Energy Percentage	Percentage of the energy that is provided from a MV substation or LV CT that is lost due to NTL

	NTL-KPI-02 = NTL-KPI-04 + NTL-KPI-05
NTL Energy Percentage	Percentage of the energy that is provided from a MV substation or LV CT that is lost due to NTL
Customer NTL Energy Percentage	Percentage of the energy that is provided from a MV substation or LV CT that is lost due to fraud executed by customers. This portion of NTL is more likely to be avoided after it is detected, as legal actions can be taken against the connection point contractors.
Customer NTL Energy Percentage	Percentage of the energy that is provided from a MV substation or LV CT that is lost due to fraud executed by non-customers. This energy is stolen by non-permitted connections to the grid, which are difficult to be located physically.
True positives (TP)	Number of customers identified as fraud authors in the NTL identification scenario which are verified to be committing fraud
False positives (FP)	Number of customers identified as fraud authors in the NTL identification scenario which are not committing fraud, as result of a verification action
False negatives (FN)	Number of customers which are not identified as fraud authors in the NTL identification scenario but are really committing fraud
True negatives (TN)	Number of customers which are not identified as fraud authors in the NTL identification scenario, and are not really committing fraud
Specificity (%)	Proportion of true negatives relative to all negative cases (TN/(TN+FP))
Sensitivity (%)	Proportion of actual positives correctly identified (TP/(TP+FN))
Cohen's Kappa (%)	Measurement of matches in the NTL identification scenario discounting the probability of randomly matching
Economic Savings	Economic savings due to detected non-technical losses.

Table 17: Pilot 2b KPIs

4.4. Pilot # 3a Office building: operation performance thanks to physical models and IA algorithms

4.4.1 Pilot Characterization

4.4.1.1 General characterization of Pilot 3a

Pilot 3a will consist in ENGIE Lab CRIGEN building office located in Paris region. The pilot targets optimizing the HVAC system performance and providing innovative services to help with the energy management. The use cases to be implemented within this pilot focuses on:

- **Optimizing heating and cooling of the different zones of the building regarding occupancy**

  Occupancy data are available via dedicated sensors, and the comfort and HVAC controls are available via the Building Management System (BMS) of the building. Using historical data, some learning algorithm are implemented to predict occupancy and anticipate heating and cooling period in the building and its different zones. A first optimization loop can be implemented to control the overall building occupancy planning and HVAC operation. A second optimization loop is used to adapt HVAC controls in the different zones of the building. The building manager can supervise and update some parameters in the system and access some regular assessment of the system controls. It also collects data from occupancy sensor to map the occupancy in the different zones of the building.

- **Controlling the HVAC load of an office building to provide demand response services while maintaining a reasonable level of comfort for the occupant thanks to the building thermal inertia.**

  Building parameters and weather forecast data will be used to provide predictions of the HVAC load and the potential flexibility available in the building, considering that a certain thermal comfort level must be maintained. These predictions are regularly transmitted to an aggregator that is then able to engage reliable flexibility services with the grid operator. The aggregator can then send or plan orders to stop the HVAC system of the building for a given time. If the orders are validated (within conditions of the contract and mini-mum comfort parameter are respected), they are implemented in the BMS. Feedback and KPI are shared with the aggregator concerning the load shifting operations.

4.4.1.2 General characterization of local environment

Pilot 3a demonstrator site is the ENGIE Lab CRIGEN building located in Paris region. It is a new office building constructed to the latest requirements of the French regulatory framework. Designed according to the E+C- French label by ENGIE researchers, the office building is more efficient than a called New Zero Energy Building (NZEB). The building is a part of a large project campaign within the "Inventons la Metropole du Grand Paris", a competition were the most innovative building projects in Paris region was selected. The heating needs of the building are 30% lower than those of a NZEB. The building occupation started in January 2020 and involve an office part (about 4650m²) and laboratory part (about 4120m²).

Figure 15: Pilot 3a ENGIE Lab CRIGEN building

The main characteristics of the NZEB office are: highly insulated building light wood structure, 15cm of insulation; double glazing; balanced ventilation with recovery heat exchanger; hybrid heat pump with hydronic and air distribution and fan coil units for heat and cold emission and control; active floors; PV plant on the roof for electricity self-consumption; hydrogen panels producing hydrogen from renewable; Building Energy Management System based on BACNET controlling the HVAC and comfort in the different zones of the building.

4.4.2 Overall Pilot's Architecture

4.4.2.1 Pilot architecture

The figure below presents a simplified architecture of the pilot 3a.

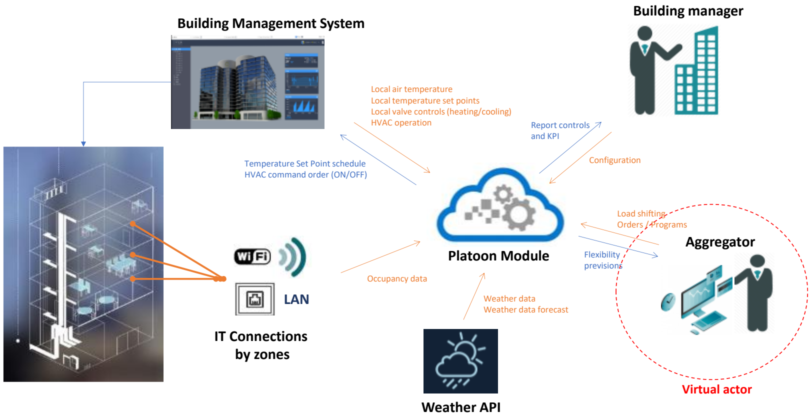


Figure 16: Pilot 3a architecture

ENGIE office building is equipped with a BMS (Building management system) that enables to monitor the air temperature and the level of comfort in the different zones of the building. This BMS provides an overview of the different valves in the different zones, so the overall HVAC operation in the building, and allows to manage the level of comfort of the building by controlling the different temperature set points.

Weather data source enables to collect weather data, to control the HVAC load and maintain a reasonable level of comfort for the occupant on the one hand, and on the other hand to be able to anticipate the preheating and the precooling of the building temperature required by the occupants upon their arrival to the building.
To monitor the occupancy of the building IT connection information are collected, precisely Wi-Fi connection and LAN connections to have an overview of the occupancy of the building.
The building manager oversees the building operation, he supervises the different KPIs and to ensure that the level of the comfort of the building is suitable for the occupants.
The aggregator is implicated to value the load flexibility on the French energy and capacity markets. A contract is signed between the Building manager and the Aggregator specifying the conditions and compensations related to the demand response services implementation.

4.4.2.2 Site assessment and existing infrastructures

Building Management System (BMS)

The BMS is based on BACNET IP and Modbus IP protocols to supervise HVAC operation and controls. The data will be available to the platoon project through a local server that will request data on the BMS using UPC-UA protocol.
The different equipment of the BMS are the following:

1 Bacnet IP Zones controller with temperature monitoring, heating, and cooling emission regulation (around hundred unit distributed in the building)

2 Bacnet IP controller for gas boiler, gas heat pump, cooling system and air handling unit (potential ON/OFF controls)

3 ModBUS IP Meter for gas and electricity consumption of the different heating and cooling equipment

4 Supervision PC

For the need of the pilot, real-time interaction with the building is required (with the possibility to send orders). Based on the protocol OPC-UA that is used on other ENGIE projects, a direct interaction will be implemented through a gateway or through the supervision and control unit (discussions on the architecture are being discussed).
Specific gateway accessible for local ENGIE server will be deployed to collect data and send orders to the building BMS.

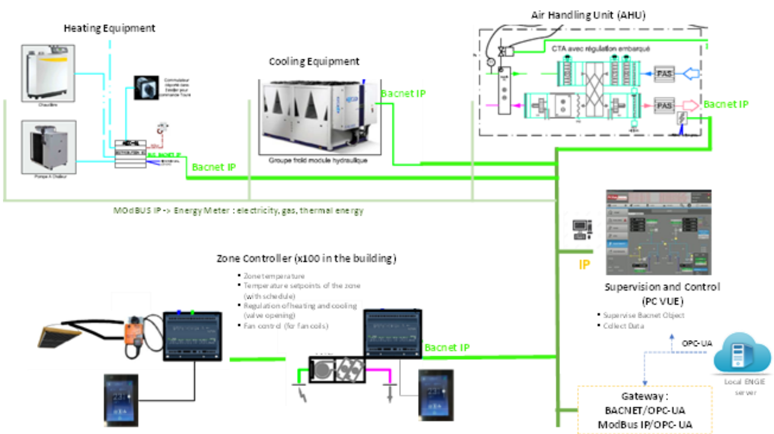


Figure 17: Pilot 3a Equipment and System Specification

IT data for occupancy:

Data from WIFI and LAN connection will be provided by IT department in the different zones of the building. The frequency constraints and zone definition is currently being discussed :

- Possible frequency: 15min data refreshment (10min and 5min studied as well).
- 15 independent zones defined for now.
- Data provided under csv format (detailed to be provided).

These data will enable to map the occupancy of the different zones of the building.

4.4.3 Pilot 3a specifications and requirements

Considering the two LLUC defined in WP1 by pilot 3a owner and their requirements, the following table are the results of the pilot's specific workshops. They present PLATOON pilot-compliant components to be implemented and tested within this demonstrator and define the requirements of each component enable an effective implementation.

The requirements have been classified according to the different layers of the PLATOON reference architecture.

Interoperability layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Connector	Engie	There are 2 data connectors. 1. Batch: data coming from BMS Realtime: Data coming from external service provider [to be considered]: IDS connector for weather data as data provider is external company	Yes - Currently handled by data ingestion framework, most of data integration requirements are met with several out of the box connection types	No - Data **sovereignty** (IDS) aspects interacting with the Security & Privacy module of PLATOON's reference architecture will be new
IoT Connector	Engie	There is 1 IoT connector 2. Edge computing service will	Same module as above	Same module as above

		be transmitting data every x interval related to number of people present in a zone		
Data Curation and Integration	TIB	Data ingested from BMS is from HVAC systems. Knowledge curation (de-duplication, knowledge graph enrichment etc) would be needed on new semantic data	Yes - Data curation part is currently covered through data pipelines by data ingestion/transformation component	No - Knowledge curation capability of DCI module in platoon is of special interest
Semantic Adapter	Engie	Semantic data model adaptation is needed for all data coming from data/IoT connectors	Yes - data ingestion/ transformation framework already takes care of semantic adaptation using sparql generate	
Energy Data model (PLATOON Data models from T2.3)	Engie	Pilot 3a data models	Yes	
Vocabulary manager	Tecnalia	Data semantic adaptation pipelines will have embedded sparqlGen statement according to vocabulary for each data stream pipeline. Needed if changes to	Yes – for scope mentioned	No - for keeping PLATOON vocabularies offline or any other use.

		ontologies, key thing is to look into IDS vocabulary provider (under consideration)		

Table 18: Pilot 3a Interoperability requirements

Data Management Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Context Data Broker	Engineering	Service specific context information retrieval, update of context information and realtime data transmission to Services from IoT connectors (raw + semantic) to services	Currently based on Kafka – publish/subscription model of real time data streams is supported	Context availability, Entity management are new functions
Federated Query Processing	TIB	Services querying data from semantic store + historical raw data from Unified KB		No
Unified Knowledge Base	Engie	Store raw data (non-semantic) as well as semantic data and results of services forecasting	Yes – as per understanding of current services, we will need to storer data by in raw and semantic form and at least would require two data stores (semantic and non-semantic) continuing UKB. No historical data query from pilot	-

			systems is identified yet.	
Context Event Processing	Engineering	Service failure estimation through event patterns for HVAC systems	Non	- pattern management - event processing management

Table 19: Pilot 3a Data management layer requirements

Intelligence Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Analytics Toolbox and Processing Tools	Tecnalia (tools design) / Engie (development of tools specific to pilot)	<refer: Pilot-3a services document>		5 identified services would require development based on tools specifications
Data Analytics Dashboard – Visualization	Engie			Analytics dashboard would be required to search each service/tool

Table 20: Pilot 3a Intelligence layer requirements

Marketplace

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Marketplace	Data to put in marketplace (to be discussed) - Tools + Metadata or Data	None		

Table 21: Pilot 3a Market place requirements

4.4.4 Plan for implementation pilot services, and systems (chronogram)

This section is not part of this deliverable and will be completed in the next iteration of this deliverable.

4.4.5 KPIS measurements

Pilot KPIs		
KPI-Name	**Requirement**	**Requirement description**
Lluc1-KPI-1	Comfort during occupancy time	Comfort evaluated thanks to air temperature in the building in function of occupancy time. Percentage of occupancy below a certain level of comfort will be evaluated.
Lluc1-KPI-2	Unnecessary HVAC heating or cooling indicator	Evaluate the percentage of energy emission that was unnecessary regarding the actual building occupancy. It is based on the controls of heating or cooling (percentage of valve) during unoccupied period
Lluc1-KPI-3	Gas and electricity Consumption by occupancy hour	Amount of gas and electricity consumption used for heating and cooling by occupancy hour of the building for a given period (a month, a year)
Lluc1-KPI-4	Climate adjusted Gas and electricity Consumption by occupancy hour	Amount of gas and electricity consumption used for heating and cooling, normalized for a given climate, by occupancy hour of the building for a given period (a month, a year)
Lluc2-KPI-1	Availability of demand response services provided over a certain period (month, year)	Percentage of days (%) where demand response services can be provided for a given offset capacity, in terms of power (kW) and/or energy (kWh). Specific time slots during the day can be targeted
Lluc2-KPI-2	Load offset capacity offered over a certain period (month, year)	Offset capacity, in terms of power (kW) or energy (kWh), available for a given percentage of days where the service is available. Specific time slots during the day can be targeted
Lluc2-KPI-3	Error on the HVAC load prediction over a certain period (no demand response event)	Error (%) on the HVAC load prediction calculated every 30min as the errors between the predicted and the realized energy consumption, divided by the predicted one (when HVAC is operating). The error can be characterized over the period: mean, standard deviations, daily distribution, seasonal distribution.

Lluc2-KPI-4	Error on the flexibility prediction	Error (%) on the "use" of the building thermal inertia in comparison with the prediction in case of the implementation of a flexibility event. It is related to the temperature drop in the building in comparison with the prediction.
Lluc2-KPI-5	Error on the HVAC load prediction for days with load shifting programs	Error (%) on the HVAC load prediction calculated every 30min as the errors between the predicted and the realized energy consumption, divided by the predicted one (when HVAC is operating). The error can be characterized over the period: mean, standard deviations, distribution during Demand response event.
Lluc2-KPI-6	**Capacity to answer load interruptions request or programs from the Aggregator**	Statistics concerning the implementation of the demand response request from the aggregator. The capacity to answer partially or totally the requests will be analyzed.

Table 22: Pilot 3a KPIs

4.5. Pilot #3b -01 (PI) Advanced energy management system and spatial (multi-scale) predictive models in the smart city

4.5.1 Pilot characterization

4.5.1.1 General characterization of Pilot 3b-01-PI

Poste Italiane manage buildings for around 5,0 million sqm (owned or rented) distributed in more than 13.500 building with three main destinations: Postal Offices open to public (retail business), logistics distribution and cross docking (mail & parcels) and directional offices covering all municipalities in Italy.
The distribution of the Poste Italiane network in all climate areas and its heterogeneity (dimension from 50 to more than 30.000 sqm) suggest than can be considered a perfect use case to cover a wide area of energy analysis and correlation with climate situation and type of buildings.
Poste Italiane already collect and manage big data related to energy use and consumption mainly from mid and big size buildings but is also going to increase the depth and detail of data collected through progressive integration of existing energy consumption devices (lighting, heating, cooling technical plants, …) in a centralized database to be supported with AI tools to determine benchmark, best practices and areas of opportunities for initiatives to increase energy efficiency and reduce CO2 production.
In this scenario Poste Italiane has selected a group of buildings to be considered in the Pilot that are all located in Rome Municipality Area. They span from 180 to 28.000 sqm and has four different destinations: Datacenter, Logistics, Retail and Offices (Directional), for a total of 16 buildings.

Figure 18: Pilot 3b general characterization

The pilot will address the following themes:

- Building Heating & Cooling consumption Analysis and Forecast.
- Predictive maintenance of cooling & heating plants.
- Lighting Consumption Estimation & Benchmarking.

- **LLUC 3b-01 Building Heating & Cooling consumption Analysis and Forecast**

The comfort of the working environments can positively affect the productivity of working human resources and quality of customer interactions in retail offices.
Creating favorable conditions in terms of temperature and humidity with the minimum usage of resources is the general scope of the use case. It will be done by applying a common methodology in 16 different buildings. Objectives concern the opportunity to test and benchmark results with a continuous improvement loop approach.
For these purposes will be identified metrics that allow to determine solutions that jointly guarantee comfort and energy savings.
The correlation with external weather conditions, building characteristics and past performances together with benchmark with similar building, represent an area of optimization for both cooling and heating systems. Sensors, meters and other hardware produce information that, through processing with forecasting algorithms and machine learning techniques, could be used to predict plants consumption and for the energy efficiency benchmarking.

Objectives:
O1.1: Energy efficiency plans (heating, cooling).
O1.2: Daily and hourly energy consumption forecast.
O1.3: Building energy usage benchmark.
O1.4: Reduction of emissions (CO_2 / TOE correlation).

- **LLUC 3b-02 Predictive maintenance of cooling & heating plants**

Today plants maintenance is carried out according to fixed schedules with planned actions with specific timing related to plants complexity and building dimension and through on demand tickets to solve plants failures or fixing issues (change temperature for better comfort).
The number of interventions, and the number of plant failures could be optimized through condition monitoring techniques to track the performance of the equipment during normal operation and to identify any anomalies and resolve them, before they give rise to failures without increasing planned maintenance.

Predictive maintenance allows equipment users and manufacturers to assess the working condition of machinery, diagnose faults, or estimate when the next equipment failure is likely to occur. If we can diagnose or predict failures, we can plan maintenance in advance, reduce downtime, and increase operational efficiency. Using plants energy consumption data and historical information about fault and maintenance it will be possible to identify anomalies and predict failures in the plants.

Output expected:

O2.1: Improve plants efficiency.
O2.2: Technical plants fine tuning.

O2.3: Increase the availability of heating/cooling plants.

- **LLUC 3b-03 Lighting Consumption Estimation & Benchmarking**

The weight of consumption due to lighting is estimated to be greater than 20% of the overall electrical consumption of buildings. A deeper understanding of the lighting optimization levers and correlation (hours of artificial lighting use, number of users, sqm, …) can be useful to reduce lighting consumption.
Understanding lighting consumptions as accurately as possible it is crucial; on the other hand, they are often aggregated with other energy usage, so the specific consumption is often estimated using algorithms and benchmark tools. Knowing other consumption usage data (such as heating and cooling...), total consumption of the building, lighting installations number and type and other building characteristics (such as category, square meters, generic occupancy profiles...) we want to estimate the specific building lighting consumption, in order to benchmark, plan optimization actions and detect anomalies and outliers. Estimating the lighting consumption will also be possible to better compare the new performance with the previous lighting technology where new installations are made.

Output expected:

O3.1: Estimation and benchmarking between different lighting solutions.
O3.2: Correlation between the number of building user and the lighting consumption.

4.5.1.2 General characterization of local environment

Four different destinations for the building spaces are considered: Datacenter, Logistics, Retail and Offices (Directional), for a total of 16 buildings. The buildings were constructed at different time and have different structures and materials.

4.5.2 Overall Pilot's ICT architecture

The figure below presents a simplified architecture of the pilot 3b for Poste Italiane.

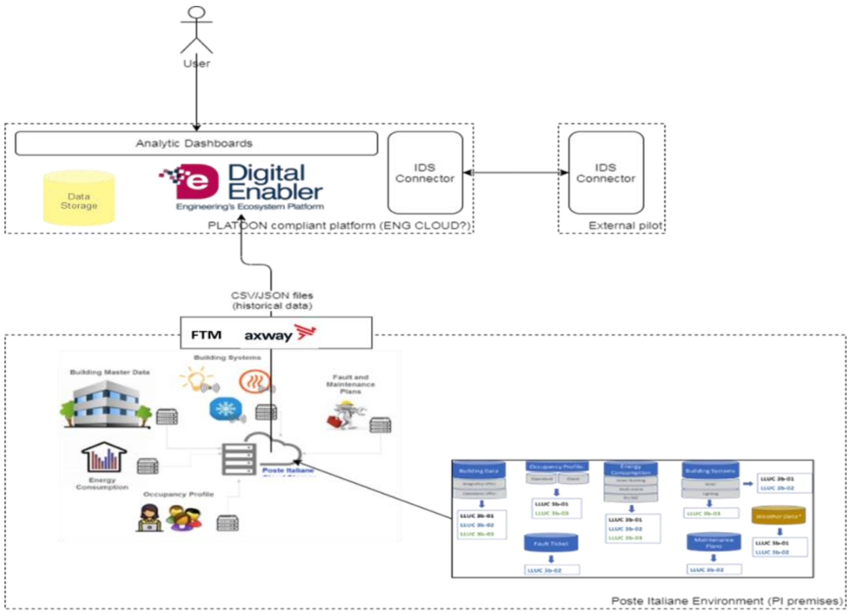


Figure 19: Pilot 3b ICT Architecture

Poste Italiane Pilot is focused on gathering energetic (and related) data / concept for two main purpose:

- Constitute the PLATOON database, modules, and application.
- Develop and acquire application and algorithms from PLATOON for data analysis and for defining energetic optimization actions.

For this is very important for the Pilot clearly define Poste Italiane dataset and the ways these data will be gathered and transferred to Platoon.

IT data

Poste Italiane Pilot #3b dataset is comprised by the following data (recovered by different Poste Italiane Systems and aggregated) that will be sent to the Digital Enabler Platform (an Engineering data analitycs platform). The Digital Enabler Platform will manage Data Storage and interactions with Platoon Platoon.

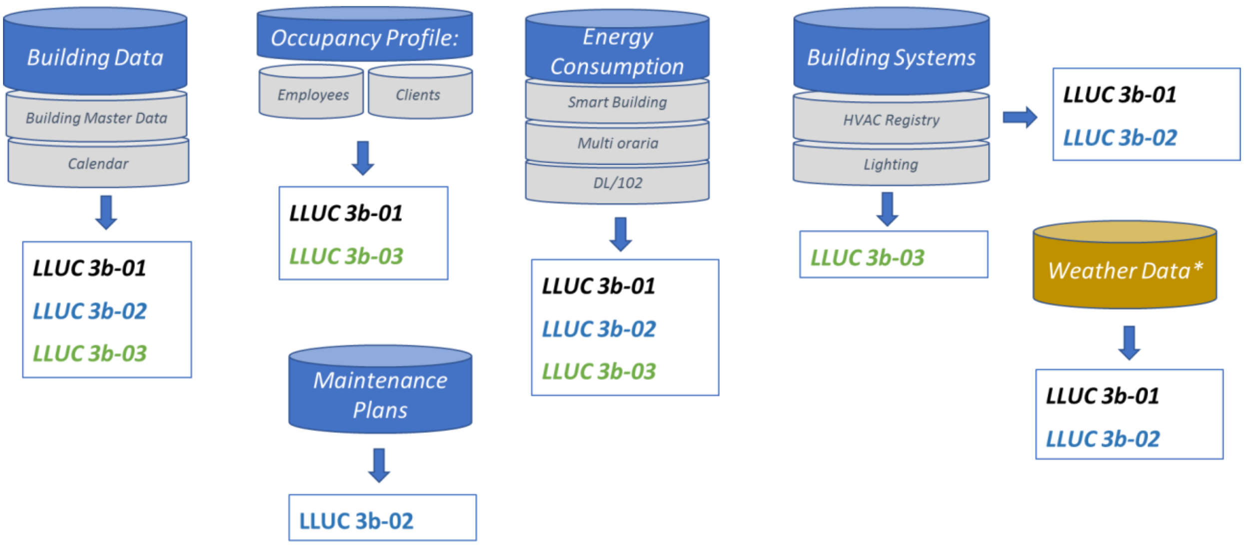


Figure 20: Pilot 3b Data Source Overview

- **Building Data:** detailed static data for each building. These data give information about building characteristics (destination, climate zone, square meter, etc.).
  There will also be in its info regarding offices calendar (opening time, closing time…).
- **Occupancy Profile:** daily number of employees and clients for each building.
- **Energy Consumption**: data are aggregated at building level, for energy line: cooling, heating, lighting (where available) and for plant (where available). They include data regarding internal temperature and humidity of the buildings.
  For Smart Buildings there will also be info about systems faults.
- **Building Systems**: information about plants (cooling, heating or lighting), technical characteristics, and numbers.
- **Maintenance Plans**: Information about maintenance events and frequency in the pilot's buildings.
- **Weather Data**: data on external temperature and humidity (will be recovered by Platoon Platform) - Open*External Data.*

For some data will be necessary to maintain trace of changes. This requirement is applicable on data whose change are very slow (e.g. Building Master Data, System registry).
The different data containers provide information and data useful for specific use cases, as pointed in Figure.
PI have different management system that produce information useful to the pilot.
These data are not aggregated and not necessarily coherent in terms of time frame and detail.
The data, before to be sent to the Digital Enabler Platform data will be:

- Pre-Filtered.
- Aggregated.
- Made Coherent.
- Transformed in the CSV format.

The goal is to aggregate data creating a new organized dataset and send it to PLATOON platform with monthly or daily frequency (static data, such as building master data, i.e. building characteristics, will be re-sent too).

Data Exchange Summary Process
PI will collect data from its internal systems through batch processes and will transfer it periodically (daily or monthly, depending from the typology of data), to an external Data Storage in a secure way, through SFTP managed by Axway Gateway product. The Data format will be CSV.
Axway will provide a centralized and secure way to transfer data externally with total end-to end visibility. Once received by the Digital Enabler Platform, they will be stored in a cloud repository external to PI.
Axway will ensure the following requirements:

- End-to-end visibility across all transfers.
- Monitoring and alerts for real-time issue resolution.
- Audit and archive file transfer activity to meet reporting and auditing needs.

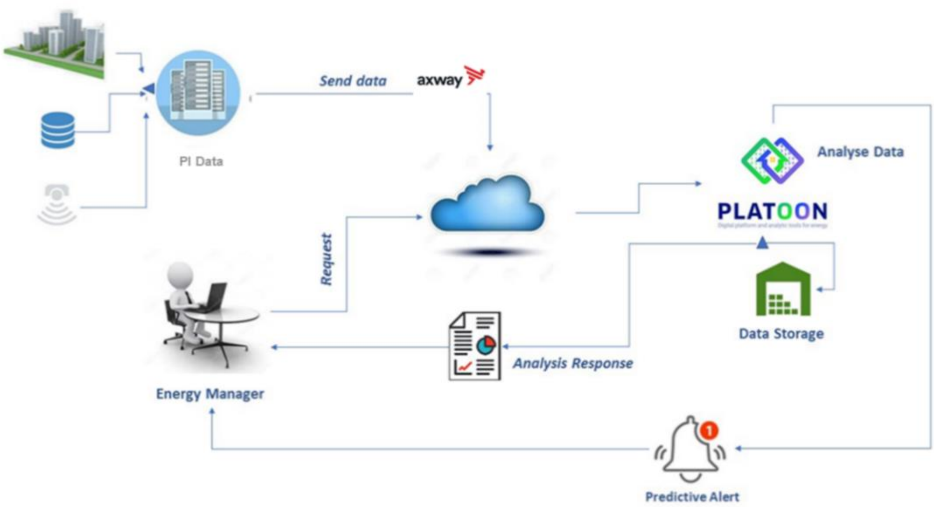


Figure 21: Pilot 3b Data Exchange Summary Process

4.5.2.1 Site assessment and existing infrastructures

All analytics in this pilot will be done using consumption and operational data of 16 building of Poste Italiane. In addition, some data of measurement campaigns that were done in the past is used. If needed additional measurements will be conducted during the pilot phase of the project. Feasibility is currently being investigated.

4.5.3 Pilot 3b requirements

LLUC #3b (01-PI; 02-PI ; 03-PI)
Interoperability layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Connector	ENG	Data will be exchange with the pilot through a file exchange protocol (e.g. SFTP) provided by AXWAY gateway	Existing connector will be customized to be compliant with the final chosen protocol	
IoT Connector		Not required. Only historical data will be managed		

Data Curation and Integration	ENG/TIB	Could be necessary for the data integration of the pilot	DE already has components that can be used for these functionalities, anyway we want also to reuse and integrate with the solution developed in platoon	
Semantic Adapter	ENG/TIB/ENGIE	Yes, to adapt pilot data to the data model	DE already has data model adapted/mapper, anyway we want also to reuse and integrate with the solution developed in platoon	
Energy Data model (PLATOON Data models from T2.3)		Yes	We will reuse the ones developed in T2.3	
Vocabulary manager		Probably not necessary		

Table 23 pilot 3b-PI interoperability layer requirements

Data Management Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Context Data Broker	ENG	Probably not strictly need due to the fact that we will not deal with real-time data	DE already integrates FIWARE Orion context broker	
Federated Query Processing	TIB	Probably needed		To be reused the one provided in PLATOON
Unified Knowledge Base	ENG/TIB	Yes, Required for the pilot data	DE already provided solution for unified repository (e.g. Hadoop based), but we want also to reuse and integrate with the solution	-

			developed in platoon	
Context Event Processing		TBD	Already integrated in DE	-

Table 24: Pilot 3b-PI Data management layer

Intelligence Layer :

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Analytics Toolbox and Processing Tools	ENG	Yes, needed to analyze data based on pilot requirements	DE already has data analytics capabilities and machine learning algorithms, that will be customized and configured for the project needs.	
Data Analytics Dashboard Visualization	ENG	Yes, needed to analyze data based on pilot requirements	DE already has data visualization capabilities provided by the suite KNOWAGE already integrated in the platform	

Table 25: Pilot 3b-PI Intelligence layer

IDS

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Connector	ENG	To be used for possible use cases that involve data transfer with external parties	ENG is the developer of an open source IDS connector (TRUE) that we will integrate in the DE	

DAPS	IAIS	Identity provider	Already developed will use the version from Fraunhofer AISEC.	Need to define the tokes.
Broker/App store (metadata registry)	IAIS	Look for data and tools metadata.		No, this will be developed as part of T3.4.
Clearing House	IAIS	Track data exchange		No, this will be developed as part of T3.4.
Vocabulary provider	TECN	In principle yes but need to define with IAIS more about vocabulary provider.		No, this will be developed as part of WP3.

Table 26: Pilot 3b-PI IDS

Marketplace

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Marketplace	IAIS	To be identified which data / tools can be / should be eventually published in the marketplace Anycase PI is available to show metadata of proprietary tool in the marketplace		DE has its own marketplace but for PLATOON we are going to use what is provided in T3.4.

Table 27: Pilot 3b-PI Market place

4.5.4 Equipment and system specification

Building-level

Equipment and System Specifications					
Level	Equipment	System Specification	status	data source site typology	notes
Building level	Sensors	Indoor enviromental Temperature and humidity sensors	Ready for Platoon test	Smart building	9 sites, comprehensive environmental monitoring
		Outdoor enviromental Temperature and humidity sensors	Ready for Platoon test	Smart building	2 sites (1 medium and 1 large smart building)
	Meters	Energy meters (electricity consumption for heating, cooling, lighting)	Ready for Platoon test	Smart building; Dlgs 102/14	accuracy>99% . 9+2 sites
	Lighting	All the installation with led lamps	Installed	All sites	16 sites
Headquarter	Smart Building SW	Building & Energy Management system (SIELTE). Reporting and storaging data from sensors and energy meters and from weather web site.	Ready for Platoon test	Smart building	9 sites
	102/14 meters Platform	Energy Management system (SEICA Z_Energy). Reporting and storaging data from energy meters.	Ready for Platoon test	Dlgs 102/14	2 sites

	Energy quarterly data	Billing platform (Elyx) and Database of data consumption.	Avalaibl e	Local energy distributor	5 sites

Table 28: Pilot 3b-PI Building-level

4.5.5 Plan for implementation pilot services, and systems

All the technical equipment required is defined and installed in the pilot. In the first 3 month of 2021 will be implemented the data collection and transfer flow for the alimentation of the database. By the end of 2021 tools are expected to be in a first version for running tests during 2022. By the end of 2022, tools and test will be evaluated and reported.

Basic Digital Enabler deployment (ready for PLATOON development activities)

Component /service Service 01:	Supply	Validation	Installation/ Configuration	commissioning
Time expected in weeks [1]	0	0	By February 2021	By February 2021

Table 29: Pilot 3b-PI basic digital enabler

Data connector for PI pilot

Component /service Data Connector	Supply	Validation	Installation/ Configuration	commissioning
Time expected in weeks [3]	By January 2021	By January 2021	By February 2021	By February 2021

Table 30: Pilot 3b-PI data connector

semantic Adapter/Data integration

Component /service Semantic Adapter/Data integration	Supply	Validation	Installation/ Configuration	commissioning
Time expected in weeks [5]	Include provisioning of the specific components in relation with the PLATOON developments By March 2021	Includes Data mapping activities By March 2021	By May 2021	By May 2021

Table 31: Pilot 3b-PI Semantic adapter/data integration

IDS/Security integration

Component /service IDS/Security integration	Supply	Validation	Installation/ Configuration	commissioning
Time expected in weeks [7]	By June 2021	By June 2021	By June 2021	By July 2021

Table 32: Pilot 3b-PI IDS/Security integration

Data Analytics Tools

Component /service	Supply	Validation	Installation/ Configuration	commissioning
Service 01: Energy Consumption Forecast Service 02: Predictive maintenance Service 03: Energy consumption Benchmarking Service 04: Lighting Consumption Evaluation Service 05: Consumption vs Occupancy correlation				
Time expected in weeks [9]	By July 2021	By September 2021	By the end of 2021	By the end of 2021

Table 33: Pilot 3b-PI Data analytics tools

4.6. Pilot #3b – 02 (ROM) Advanced energy management system and spatial (multi-scale) predictive models in the smart city

4.6.1. Pilot characterization

4.6.1.1. General characterization of Pilot 3b-02-ROM - Monitoring and Analysis of energy meters data of ROM municipality asset.

The Public Works and Infrastructures Department of Roma Capitale (SIMU Department) includes Plants Division with at least 3 offices managing energy issues: the Energy Manager Office of Roma Capitale (EMO), the Utilities Meters Office (UMO) and the Thermal Plants Office (TPO). This Unit manages around 8950 energy meters (6500 electric meters and 2450 gas meters) related to almost 2000 buildings owned by the municipality. To help the offices in this activity, considering the huge amount of data coming from the meters each month, an integrated monitor and analysis system shall be implemented. The data should be analyzed automatically in order to highlight anomalies, to generate reports for different purposes, to produce forecasts in terms of energy consumptions, to help building energy efficiency scenarios, in brief to support the offices personnel thus freeing up time and resources to tackle energy efficiency activities more effectively.

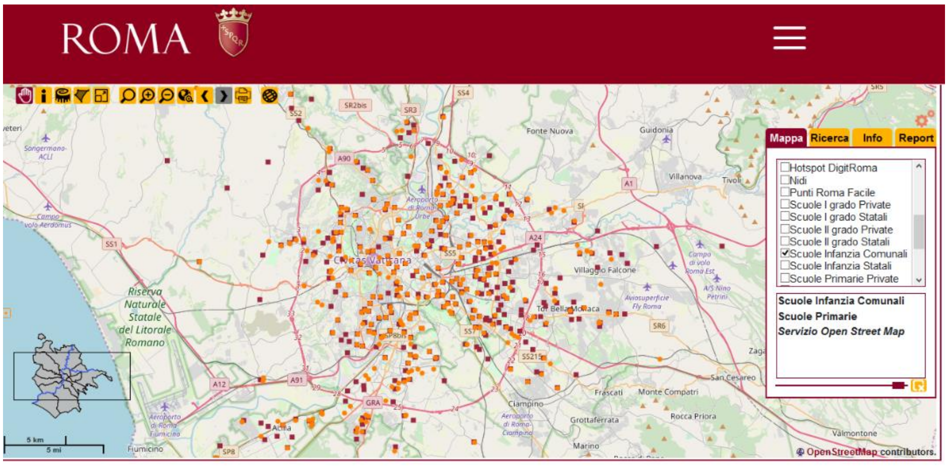


Figure 22: Pilot 3b-02-ROM - Rome Municipality Buildings

The pilot will address the following themes:

- Spatial Reporting
- Benchmarking Analysis
- Forecast on energy consumptions
- RES potentialities

- **LL_UC ROM_04a -Spatial Reporting:**

  GIS visualization for the Building Energy Consumptions (EC) and general energy performances (EP).

  Output Expected:
  Spatial visualization (GIS or WebGIS) of the Buildings EC & EP data;
  Spatial and attributes queries produce Flash Reports and aggregated results;
  Summary structured Reports are available, with graphs and maps.

- **LL_UC ROM_04b Benchmarking Analysis**
  Benchmarking serves to measure EC & EP relative to other similar buildings, or to modelled simulations of a reference buildings set, or to the same building past data
  SUB-SERVICES: Anomalies Detection, Alerting, Support to general asset maintenance planning.

  Output Expected:
  All data are available to elaborate and report the values of EC & EP in terms of
  Ranking,

Anomalies,
Averages for typologies,
Deviations
Normalization …
(Ref: BS EN 16231);
Sub-Services:
Automatic Alert delivered to Actors

- **LL_UC ROM_04c Forecast on energy consumptions**

  Predicting energy usage of the buildings by analyzing multiple factors.
  Simulating future consumptions scenarios for different time/functional use profiles of buildings or changes in performances (control factors).

  Output Expected:
  Reports are released for :
  Future energy consumptions
  (1 month ahead + next year forecast)
  Simulated Scenarios
  CO2/TOE impact
  Economical (estimated) impact

- **LL_UC ROM_04d RES potentialities**

  Identifying potentiality in terms of :
  - RES (PV, Solar, Geothermal, HeatPump, …) productions
  - Storage to maximize self-consumptions

  Sub-services:
  - updating AUDITS
  - existing RES Plant efficiency.

  Output Expected:
  RES potentialities plan is delivered as output after selecting a sub-set of buildings, in terms of potential:
  - PV plants power
  - PV energy
  - Plants dimensions
  - storage capacity
  - max. self-consumptions
  - max exceeding energy

  Sub-services:
  - to update AUDITS (export function)
  - to assess the existing RES plants efficiency

4.6.1.2. General characterization of local environment

ROM municipal buildings asset is composed by almost 2000 buildings or complex of buildings equipped with 8950 energy meters (6500 electric meters and 2450 gas meters, owned respectively by ARETI and ITALGAS).

4.6.2. Overall Pilot's ICT architecture

- Data exchange:

ROM buildings asset Energy consumptions data flow is now enclosed inside the contractual relationships between ROM offices and the engaged vendors. The policies and procedures to exchange and exploit this data outside this relationship have to be defined within the WP3 works, on the basis of PLATOON needs and objectives, and then authorized by the competent office of ROM.

- Edge computing:

No edge computing solution are foreseen.

- Storage and processing solutions:

Local Data storage and processing solutions are provided by Digital Transformation Department (DTD) of Roma Capitale within the CITY DATA PLATFORM, a fiware based data storage and processing initiative that is under development.
It is already defined among the specific objectives of this initiative the intention of the municipality to grant the access to the ROM buildings energy data for the PLATOON purposes, but the procedure (push, pull, automated, semiautomated, web services, ...) has to be identified and agreed.
Within CITY DATA PLATFORM a section (called DTD energy data Hub) will be dedicated to the Energy Data coming from:
1- from Vendor & DSO actors that are managing the power and gas meters for the ROM buildings asset
2- from other ROM offices that will pre-process some of these data (for example, Master Data for the buildings related to the general energy performances and uses)
3- from SIMU Technological Plants Unit offices that will collect and transmit data to DTD energy Data hub whenever the modality n.1 would not be possible

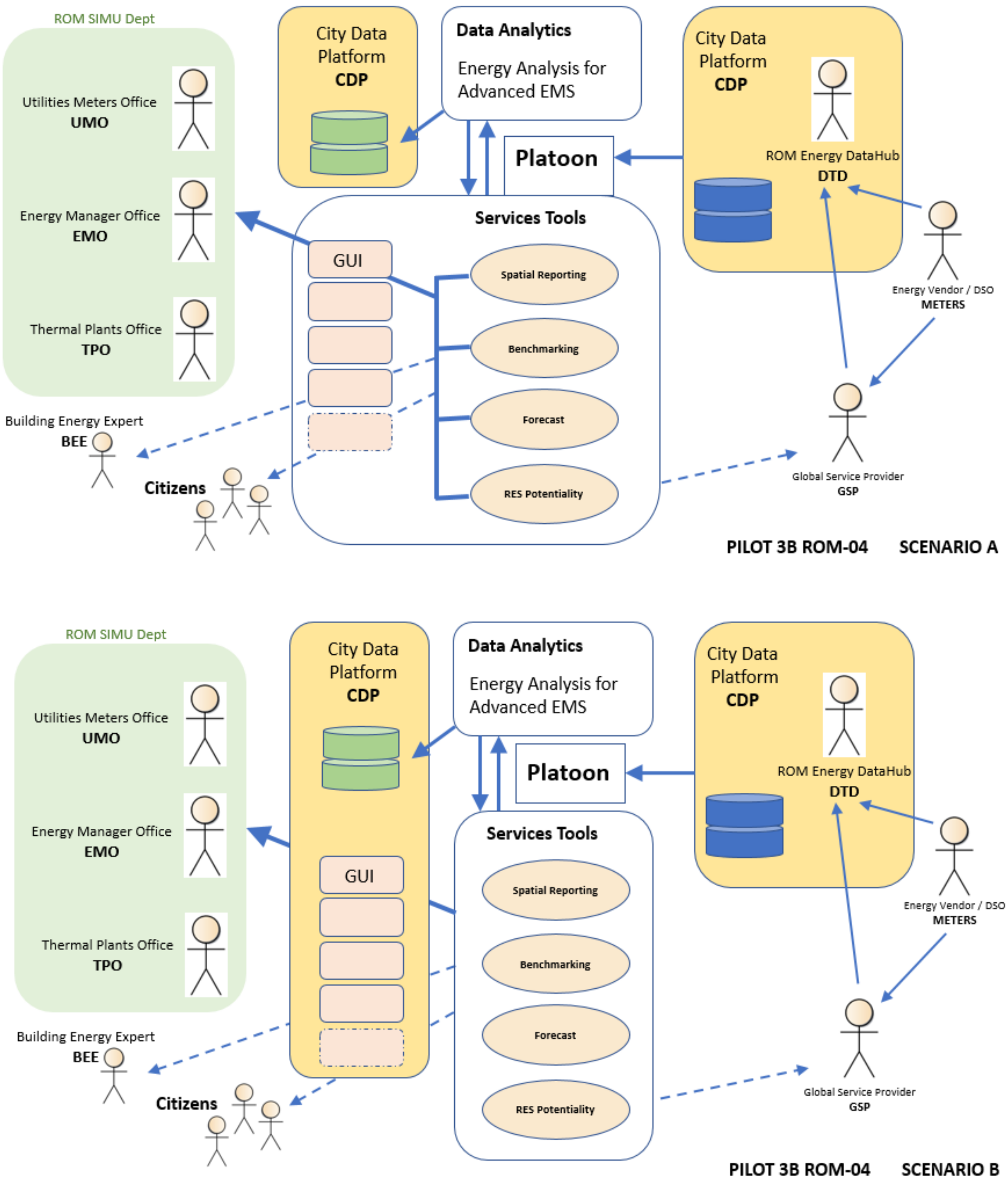


Figure 23: Architecture UC 3b-ROM with 2 scenarios concerning City Data Platform role

Site assessment and existing infrastructures

- The electric meters are managed by a different energy Vendor that stipulated energy contract with ROM (ENEL – Consip Contract), but are owned and monitored by DSO ARETI.
- The gas meters are managed by 2 actors depending on the buildings typologies: one gas vendor (ESTRA) for residential housing buildings and one concessionary for Integrated Energy Service (CPL Concordia) who pays the bills and sells energy comfort services for the rest of the buildings (GSP in fig.1). All gas meter are owned and monitored by gas DSO ITALGAS.

The proposed PLATOON use cases in ROM pilot are mainly addressed to exploit the big data coming from these meters to offer analytical services for energy efficiency purposes. These use cases are not focused on the power grid side of the general infrastructure although the main objective of the pilot aiming the reduction of consumptions and peaks will likely impact on the power grid, for both electricity and gas.
Note: ARETI the electric power DSO signed a LOS to Platoon project and is working within a parallel H2020 project (PlatONE) to set up and implement solutions to increase energy flexibility.

4.6.3. Pilot 3b-02-ROM requirements

Interoperability layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Connector	ENG	At the moment there is scenario under development for a connection with a central repository for all data ROM side : CITY DATA PLATFORM (see scenario A e scenario B in fig.2).	Existing connector will be customised to be compliant with the final chosen protocol / otherwise a dedicated Connector with DE will be implemented in ROM data platform	ENG
IoT Connector	-	Not required.	-	-
Data Curation and Integration	ENG/TIB	Could be necessary for the data integration of the pilot	DE already has components that can be used for these functionalities, anyway we want also to reuse and integrate with the solution developed in platoon	ENG/TIB

Semantic Adapter	ENG/TIB/ENGIE	Yes, to adapt pilot data to the data model	DE already has data model adapted/mapper, anyway we want also to reuse and integrate with the solution developed in platoon	ENG/TIB/ENGIE
Energy Data model (PLATOON Data models from T2.3)		Yes for the interoperability. Also it could be useful to use it for the data analytics.	Yes for the interoperability.	
Vocabulary manager		Probably not necessary		

Table 34 pilot 3b-ROM interoperability layer requirements

Data Management Layer

Component /service	Provider	Demonstration requirements	Readiness (*if the requirements can be met on the pilot location)*	
			Yes	No
Context Data Broker	ENG	Probably not strictly need due to the fact that we will not deal with real-time data	DE already integrates FIWARE Orion context broker	
Federated Query Processing	TIB	Probably needed		To be reused the one provided in PLATOON
Unified Knowledge Base	ENG-TIB	yes, Required for the pilot data	DE already provided solution for unified repository (e.g. Hadoop based), but we want also to reuse and integrate with the solution developed in platoon	
Context Event Processing		TBD	Already integrated in DE	

Table 35: Pilot 3b-ROM Data management layer

Intelligence Layer :

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Analytics Toolbox and Processing Tools	ENG / ENGIE		Yes. We will use the Data Analytics Tool container defined in T4.1.	ENG / ENGIE
Data Analytics Dashboard Visualization	ENG	Yes, needed to analyze data based on pilot requirements	DE already has data visualization capabilities provided by the suite KNOWAGE already integrated in the platform	

Table 36: Pilot 3b-ROM Intelligence layer

IDS

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Connector	ENG	To be used for possible use cases that involve data transfer with external parties	ENG is the developer of an open source IDS connector (TRUE) that we will integrate in the DE	
DAPS	IAIS	Identity provider	Already developed will use the version from Fraunhofer AISEC.	Need to define the tokes.
Broker/App store (metadata registry)	IAIS	Look for data and tools metadata.		No, this will be developed as part of T3.4.
Clearing House	IAIS	Track data exchange		No, this will be developed as part of T3.4.

Vocabulary provider	TECN	In principle yes but need to define with IAIS more about vocabulary provider.		No, this will be developed as part of WP3.

Table 37: Pilot 3b-ROM IDS

Marketplace

Component /service	**Provider**	**Demonstration requirements**	**Readiness** *(if the requirements can be met on the pilot location)*	
			Yes	**No**
Marketplace	IAIS	To be identified which data / tools can be / should be eventually published in the marketplace		IAIS

Table 38: Pilot 3b-ROM Market place

4.6.4. Equipment and system specification

Table 39: Pilot 3b-02-ROM - Equipment and system specification

Equipment and System Specification		
E.g. Building level	sensor	ROM pilot's use cases do not foresee, at this stage, the use of other devices other than the power meters. So we can consider the meter itself the main sensor in the use case. Note: It would be possible later that one large office building equipped with BMS and sensors could participate to the PLATOON test-beds phase, if both parts (platoon consortium and ROM) would consider this eventuality useful and interesting.
	Building PV system	165 buildings are equipped with PV plants, all connected to the grid through the power meters in order to exchange (exceeding energy) with the DSO grid and configured for self-consumption of the RES production
	BMS	BMS are not involved in the project at this state. Note: It would be possible later that one large office building equipped with BMS and sensors could participate to the PLATOON test-beds phase, if both parts (platoon consortium and ROM) would consider this eventuality useful and interesting.
E.g. Community level	Community storage	no
	Municipal Level	QUESTIONS: The under-development ROME CITY DATA PLATFORM (fiware based) could host the PLATOON services and tools and not only the energy data to be exchanged between ROM and PLATOON.

4.6.5. KPIs

Table 40: Pilot 3b-02-ROM- KPIs

Key performance indicators			
ID	**KPI-Name**	**Requirement description**	Reference to UC Objectives
ROM_04_Kpi_R01	Total Energy Savings [kWh / Y] TES Electricity TES Gas	The analysis of the meters data (historical and current) will produce a series of measures and interventions that should reduce the yearly total energy consumptions, such as dismission of un-useful meters, maintenance and intervention on buildings following anomalies detection, contractual re-definition resulting from Platoon analysis. Component indicators are the Total Energy Savings in terms of Gas and in terms of Electricity, that gives a better picture of the impact of Platoon services.	Energy Savings Target to be defined
ROM_04_Kpi_R02	Saving Personnel costs [Euros saved/Y]	The installation of a monitoring system shall reduce the costs for the personnel. It is calculated from the difference of the saved personnel costs (per year) and the depreciation amount of the data monitoring system.	Costs Savings Target to be defined
Rom_04_Kpi_R03	Nb of Energy Savings Results [Nb / Y]	this indicator counts the number of energy meters for which Platoon services produce some action resulting in energy saving during the year. A Derived Kpi is the Average (or Specific) Energy Saving calculated as: ROM_04_Kpi_01 / ROM_04_Kpi_03	Energy Savings Target to be defined
Rom_04_Kpi_R04	Nb of Anomalies detected [Nb / Y Or monthly]	Not all alerts sent by Platoon tools produce Energy Savings therefore it is interesting to track separately the Number of Anomalies occurred during a period (Year or month of observation). The definition of Anomaly (à to be better defined:checklist of conditions; setting thresholds and Benchmarking; excluding False Positive Alerts à manually obliterated) for a specific energy meter is based on the	ROM EM office support Target to be defined

		occurrence of the consumption divergence from the expected value, in a certain period. Typically when the building itself or the usage of the building is highly inefficient Platoon will send a series of alerts. This must be consider a good result of the project even if the beneficiary (ROME EM Office) is unable to intervene producing energy savings.	
Rom_04_Kpi_R05	CO2 [%]	% of CO2 emission reduction (using CO2/TOE correlation)	Emission reduction Target to be defined
Rom_04_Kpi_R06	RES suggested self-consumptions [KWh/Y]	The calculation of the RES potentiality or more precisely of the self-consumption energy that could be covered by RES/Storage solutions is based on the load curves, on the availability of irradiated surfaces to install RES plants, their tilt/orientation, … (à PV-GIS JRC model or other) Platoon output in terms of Total RES kWh/Y calculation represents a positive impact to be measured. Rom_04_Kpi_R06 is an additional component to ROM_04_Kpi_01 as it represents the potential further Energy saving	RES Potentialities Estimations Target to be defined
Rom_04_Kpi_R07	Nb of Tools Outputs [Nb / Y Or monthly]	Platoon results in terms of Queries with Output processed by the offered (tested) tools represents a positive impact to be measured. Measuring the usage, this KPI is referring about the effective engagement of the ROM personnel. Counting outputs for each distinct services and tools will help to address further development and exploitation strategies.	Engagement of the users Target to be defined

4.7. Pilot #3C Energy efficiency and predictive maintenance in the smart tertiary building hubgrade.

4.7.1. Pilot Characterization

4.7.1.1. General characterization of Pilot 3C

Nanogune building is a public research centre located in San Sebastian (SPAIN). The building has 7319 m2 distributed over six floors. Nanogune was inaugurated in January 2009, and it houses offices, 15 ultra-sensitive laboratories and a cleanroom of nearly 300 m2 where the air purity is under strict supervision.

The pilot deploys and Advanced EMS - HVAC Control and RES usage optimization regarding energy bill and Predictive Maintenance in Smart Tertiary Building Assets. The use cases to be implemented within this pilot focuses on:

The current use case applies to tertiary buildings that have already in place a BMS system that allows the monitoring and control of HVAC loads and local RES

The implementation of the EMS as described before, targets to minimize the energy bill maximizing the RES usage by shifting the HVAC loads anticipating the energy cooling or heating demands.

Building cooling or heating demands can be anticipated by pre-cooling or pre-heating strategies implementation. The availability of RES increases the HVAC loads shifting profitable not only in dynamic energy prices scenarios but in scenarios in which the energy prices are constant.

The use case applies to tertiary buildings in which there is already a BMS implemented that enables a seamless access to building usage data (HVAC, lighting, occupancy schedules). On top of the BMS, the PLATOON project will implement analytical models that based on machine learning techniques will predict the building thermal demands as well as the local energy production. Based on that predictions, optimization algorithms will be implemented.

Improve the maintenance policies in the tertiary buildings implementing the predictive maintenance in some specific assets trying to increase the availability and useful life of these assets reducing the general maintenance costs

Achieving good maintenance on the assets of a tertiary building requires determining which of those assets must be maintained through a corrective policy (cheap and easily replaceable assets), a preventive policy (assets that for legal aspects must be reviewed and controlled every 15 minutes) or a predictive policy (based on knowledge of your health condition).

In the latter case, it is important to know if the cost of controlling future failures of an asset (knowing when the next failure will occur) is less than the solution to the problem. Thus, if we know when the asset is going to fail, we can anticipate and act in coordination with all the resources we have.

Since predictive maintenance and its methodology are used in expensive assets whose breakdowns cause high costs or significant availability losses, it is necessary to know in almost real time the situation of the corresponding asset and be able to act accordingly.

4.7.1.2. General characterization of local environment

Building's primary energy sources are gas and grid electricity. There are two gas boilers that provide heat to the facilities and an air/water chiller with heat recovery for cooling. The BMS of the building controls the lighting and HVAC system.

In Nanogune, three different types of users are involved: energy managers, facility managers and occupants. GIROA-VEOLIA is the energy manager who is in charge of analysing historical energy data (energy consumption and production) and improving energy efficiency of the building. The facility manager is in charge of the building infrastructure and its correct functioning. The facility manager and GIROA-VEOLIA, as energy manager, are the end-user of the modules developed in PLATOON. Finally, building occupants refer to researchers and workers that make use of the facilities.

In Nanogune, taking into account the electrical and thermal energy meters, there are 79 sensors connected to the BMS and database. Apart of that, 200 more variables of temperature, humidity and pressure will be connected to the project database.

In order to establish the reference consumption of the nanoGUNE building, monthly energy bills were collected and used for gas and electricity. The natural gas is used to produce energy for space heating, laboratory equipment and hot water for sanitary use as shown in the figure below.

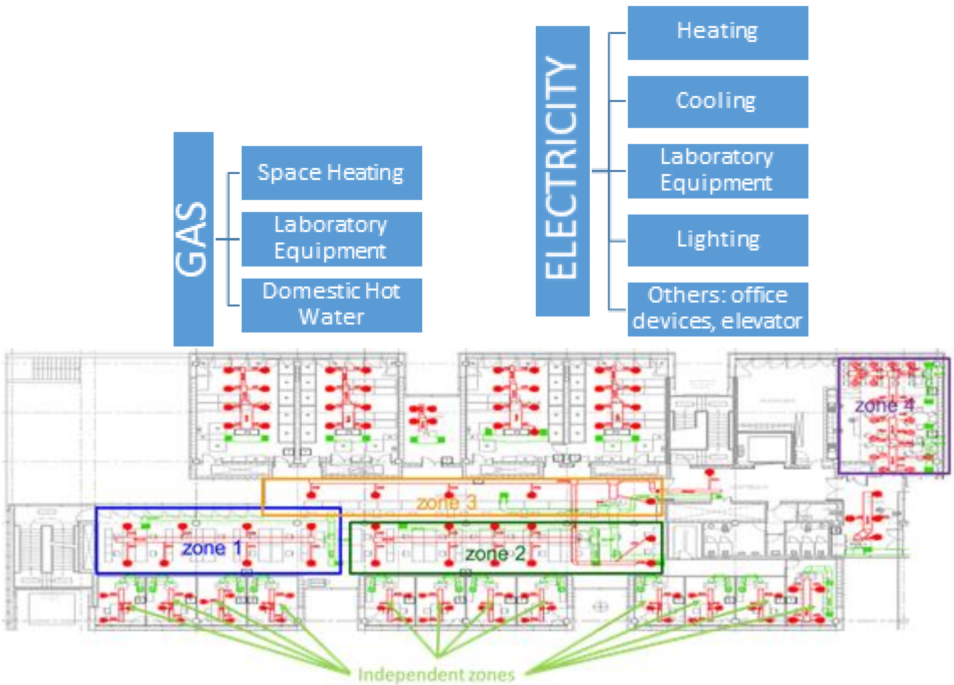


Figure 24 Pilot 3C comfort areas

4.7.2. Overall Pilot's Architecture

4.7.2.1. Pilot's ICT architecture

The figure below presents a simplified architecture of the pilot 3c .

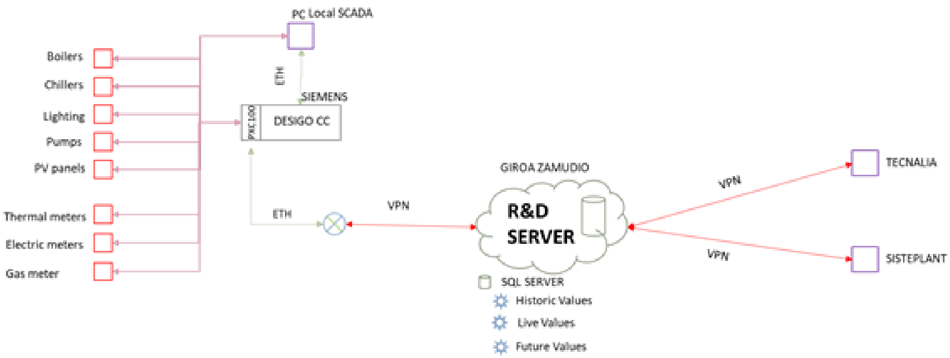


Figure 25 Pilot 3C ICT architecture

All the signals are collected via Modbus IP or Bacnet IP and are centralized in two PLCs, one for local scada and the other for communication with Project PLATOON.
All Project data, together with the weather forecasting services, are centralized in an SQL database on GIROA-VEOLIA's servers, and a space is reserved on this server for the installation of developments made by SISTEPLANT and TECNALIA if necessary. This is where they have two Linux virtual machines and another Windows virtual machine where the partners connect to them via client VPN connections.
In the database the values are recorded with a periodicity of 15 minutes but if necessary, the sampling time can be reduced to every minute.

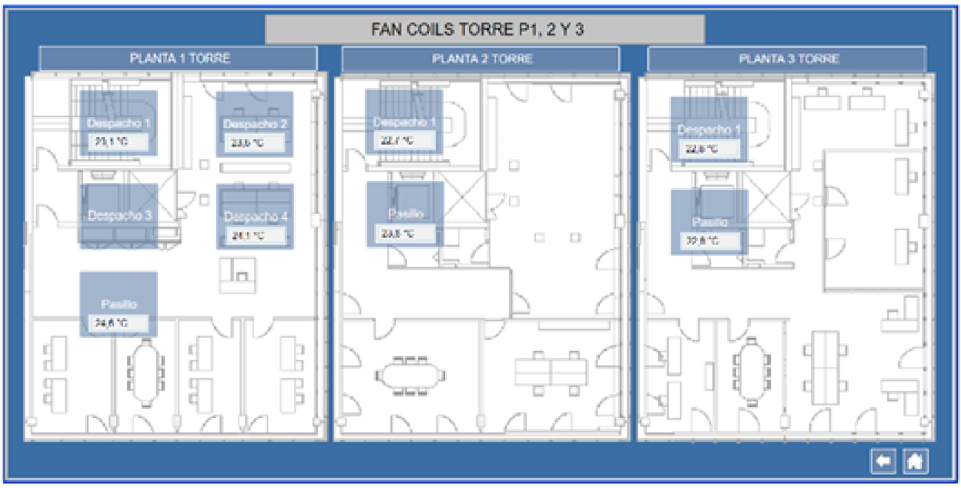
4.7.2.2. Site assessment and existing infrastructures

Building Management System (BMS)

A SIEMENS DESIGO DC BMS has been installed in nanoGune. A second PLC has also been installed to allow communication with the outside world and to be able to store all the data in the SQL database. The data will be available to the platoon project through a local PLC that will request data on the BMS using OPC-UA protocol.
The different equipment of the BMS are the following:

1. Bacnet IP Zones controller with temperature monitoring, heating, and cooling emission regulation (around hundred unit distributed in the building)
2. Bacnet IP controller for gas boiler, gas heat pump, cooling system and air handling unit (potential ON/OFF controls)
3. ModBUS IP Meter for gas and electricity consumption of the different heating and cooling equipment

In principle, direct action on equipment is not foreseen, although it could be done. In this case, a series of operating recommendations will be sent to the building's facilities manager.


FAN COILS TORRE P1, 2 Y 3
PLANTA 1 TORRE
PLANTA 2 TORRE
PLANTA 3 TORRE
Despacho 1
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Despacho 3
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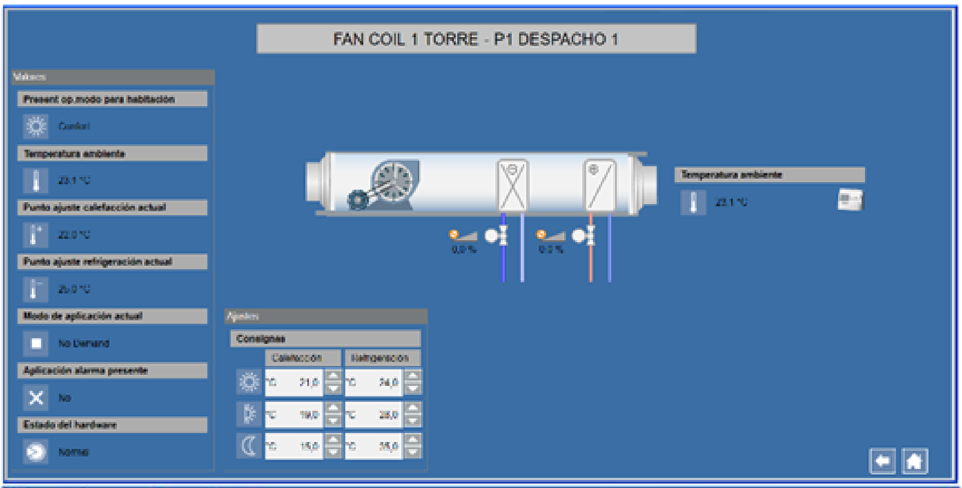
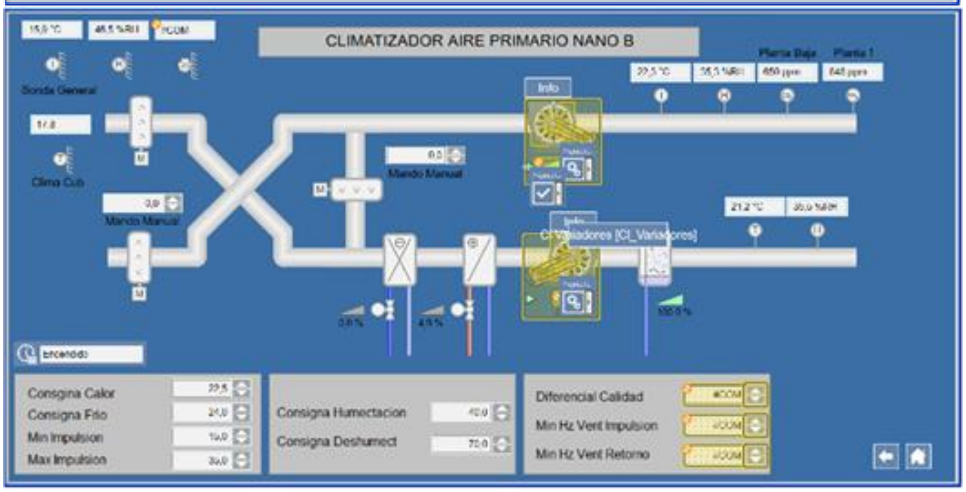

FAN COIL 1 TORRE - P1 DESPACHO 1
Temperatura ambiente
Punto ajuste calefacción actual
Punto ajuste refrigeración actual
Modo de aplicación actual
Aplicación alarma presente
Estado del hardware
Consignas
Calefacción
Refrigeración


CLIMATIZADOR AIRE PRIMARIO NANO B
Sonda General
Clima Cub
Mando Manual
Planta Baja
Planta 1
Info
Encendido
Consigna Calor
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Max Impulsion
Consigna Humectacion
Consigna Deshumect
Diferencial Calidad
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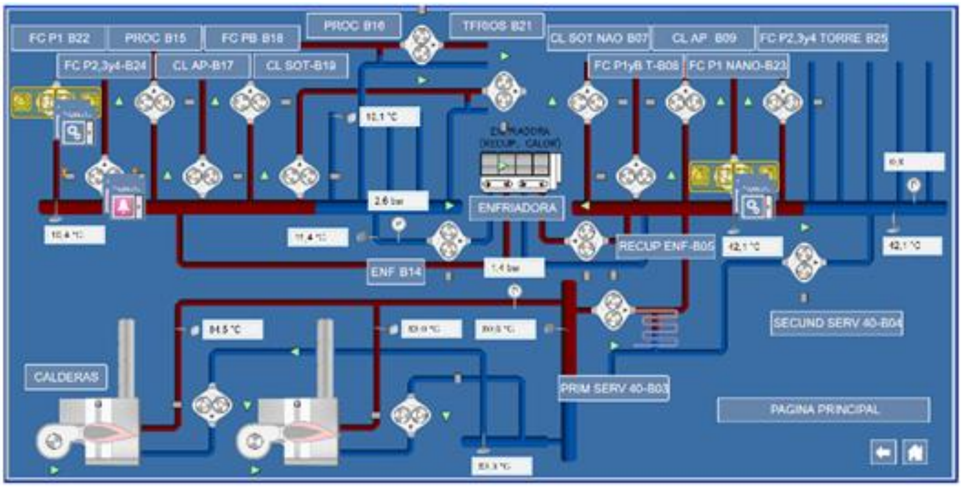

Figure 26 Pilot 3c BMS zones

4.7.3. Pilot 3c requirements

Considering the two LLUC defined in WP1 by pilot 3c owner and their requirements, the following table are the results of the pilot's specific workshops. They present PLATOON pilot-compliant components to be implemented and tested within this demonstrator and define the requirements of each component enable an effective implementation.

The requirements have been classified according to the different layers of the PLATOON reference architecture.

Interoperability layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	**No**
Data Connector	GIR	Non-semantic data. It will be just simple time series data stored in SQL server of Giroa.		No, but it is ongoing. Planned to have it finished by the end of 2020.
IoT Connector	GIR	Non-semantic data. It will be just simple time series data stored in SQL server of Giroa.		No, but it is ongoing. Planned to have it finished by the end of 2020.
Data Curation and Integration	GIR	Non-semantic data. It will be just simple time series data stored in SQL server of Giroa.	Curation (data quality check) already implemented.	Integration no, but it is ongoing. Planned to have it finished by the end of 2020.
Semantic Adapter		Not required. Non-semantic data.		
Energy Data model (PLATOON Data models from T2.3)	GIR, SIS and TECN	Yes for the interoperability.	Yes it is already in T2.3 for the interoperability.	
Vocabulary manager	TECN and IAIS	Regarding interoperability define 3 levels: 1)Raw data with IDS 2)Semantic data with IDS 3)Semantic data with IDS and used for Data Analytics		No. Vocabulary manager is part of IDS vocabulary provider. This will be done in WP3. Not able to define now how this can be implemented with IDS vocab provider. Where are we going to store the vocabularies? Which vocabulary manager are we going to use? Vocol…?

		In this pilot we will target at level 1.		

Table 41: Pilot 3c Interoperability layer requirements

Data Management Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Context Data Broker	GIR	Something similar but we do an API call every 6 hours for getting meteo data from Merasoda and store in the database. We do it ever 6 hours because they update solar radiation data every 6 hours. Similar for electric prices but only one call everyday at 12 to one service and then at 1pm connect to OMIE (official source).	Already implemented.	
Federated Query Processing	-	Not required. Non-semantic data.	-	-
Unified Knowledge Base	-	Not required. Non-semantic data.	-	-
Context Event Processing	SIS	Yes required for alarms. Very similar to what they have in Promind called RabbitMQ	Already implemented RabbitMQ.	-

Table 42: Pilot 3c data management layer requirements

Intelligence Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	**No**
Data Analytics Toolbox and Processing Tools	TECN and SIS	For sure implemented as a service but might consider as well to do a test on the infrastructure using dummy code.		No. We will use the Data Analytics Tool container defined in T4.1.
Data Analytics Dashboard – Visualization	SIS	Use Promind of some capabilities of Prisma - Visualization Dashnobard to show outputs from data analytics tools from SIS and TECN. Also GIR want to show some results in another dashboard that they use internally in Giroa.	Yes they already have the visualization dashboard in Promind /Prisma.	Will need to be integrated with data analytics tools/storage. GIR dashboard not ready yet.

Table 43: Pilot 3c intelligence layer requirements

Marketplace

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	**No**
Marketplace	IAIS	TECN will show metadata of proprietary tools in the marketplace. GIR will not publish in the marketplace. The data acutally belongs to the building owner (CIC Nanogune) so they cannot comercialise the data. Only offer		No this will be developed as part of T3.4.

		additional services using the data. SIS will show metadata of proprietary tools in the marketplace and offer additional engineering services using the data (e.g. similar to what they do for optimizing plant layout in industry)		

Table 44: Pilot 3c Marketplace

IDS

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Connector	ENG	Data usage. Between GIR and TECN. Potentially between TECN and SIS (still tbd).		No this will be developed as part of T3.2-T3.3.
DAPS	IAIS	Identity provider	Already developed will use the version from Fraunhofer AISEC.	Need to define the tokes.
Broker/App store (metadata registry)	IAIS	Look for data and tools metadata.		No, this will be developed as part of T3.4.
Clearing House	IAIS	Track data exchange		No, this will be developed as part of T3.4.
Vocabulary provider	TECN	In principle yes but need to define with IAIS more about vocabulary provider.		No, this will be developed as part of WP3.

Table 45: Pilot 3c IDS requirements

4.7.4. Plan for implementation pilot services, and systems

The following tables detail the current implementation timeline for the main components of this pilot:

Data Connector, IoT Connector, Data Curation, and Integration

Component /service Service 01: from previous table	Supply	Validation	Installation/ Configuration	commissioning
Time expected in weeks [1]	Planned to have it finished by the end of 2020.	Planned to have it finished by the end of 2020.	Planned to have it finished by the end of 2020.	Planned to have it finished by the end of 2020.
Risks	No			
Remarks [2]	Any impacts on timeline or any alarms to be evaluated.			

Table 46: Pilot 3c Timeline for data connectors, data curation and data integration

Data Analytics Tools

Component /service Service 01: from previous table	Supply	Validation	Installation/ Configuration	commissioning
Time expected in weeks [3]	Planned to the design of the Data Analytics Tools container design and procedures to generate and implement containers by M12.	Planned to the design of the Data Analytics Tools container design and procedures to generate and implement containers by M12.	Planned to have it finished by the end of 2021.	Planned to have it finished by the end of 2022.
Risks	None so far			
Remarks [4]	Any impacts on timeline or any alarms to be evaluated.			

Table 47: Pilot 3c Timeline for data analytics tools

4.7.5. KPIS measurements

Pilot KPIs		
KPI-Name	**Requirement**	**Requirement description**
LLUC P-3c- 01	Energy demands forecast	Prediction of the future (24h) energy demands in building as a function of bulding characteristics, outside temperature and thermal comfort constraints.

LLUC P-3c- 02	Forecast local energy production	Prediction of the future (24h) local RES production as a function of RES system characteristics and sun irradiance forecast.
LLUC P-3c- 03	Optimize energy usage	Considering the outcomes of the two scenarios above, the weather forecast and energy prices optimizes the HVAC control and RES usage to minimize the energy bill. Optimization for RES (24hr plan including times for buying/selling and consuming produced energy) and HVAC Systems (scheduling for HVAC on/off command).
LLUC P-3c- 04	Predictive maintenance	Predictive maintenance tools for the following assets of smart tertiary building: Boilers, Chillers, Air Handling Units (AHU), Split Systems, Fan coils, Extractors and Pumps.

Table 48 Pilot 3C KPIs

4.8. Pilot #4a Energy management of microgrids

4.8.1. Pilot Characterization

The MG2lab in the Department of Energy, Politecnico di Milano, is a cutting edge microgrid integrating different Distributed Energy Resources (DERs) like solar, combined heat and power, battery and hydrogen storage and serving both electric and thermal load to power lighting, heating, desalination, electrical vehicles and electrical bikes.

4.8.1.1. General characterization of Pilot 4a

The implemented microgrid is multi-good and multi-fluid and it features the ability to be operated both on-grid and off-grid modes; additionally, it is flexible with multiple configurations (single/multi node), including an Artificial Intelligence (AI) implementation for optimal management.

It provides an analysis facility for real-life scale research, simulation and test purposes, thus allowing to study new data-driven paradigms for energy management able to deal with increased complexity of the energy systems and to assess the advantages of innovative strategies.

This project further aims at the following goals:

- Grid-connected Distributed Energy: optimally manage Behind the Meter (BtM) grid connected storages and renewables in combination with onsite load and distributed generators.
- Off-Grid Microgrids: furtherly increase the fuel savings and add robustness in off-grid microgrids, through a novel optimization layer making use of load and photovoltaic forecasters to achieve 100% load coverage.
- Prosumer Aggregation: test and improve a commercial Virtual Power Plant platform for enabling the access of storages and other prosumers to the electricity market, leveraging on the new regulatory framework.
- EVs as a Distributed Energy Resource: analyse the viability of EV battery usage for supporting the grid frequency, through so called Vehicle to Grid (V2G) service.
- Storage as EV Fast Charge enabler: design an EV fast charging solution infrastructure, enabling a real deployment of fast charge infrastructures in urban areas.

In particular, the microgrid interconnects:

- Dispatchable generators, which operation can be scheduled, as the Combined Heat and Power (CHP) generator;
- Non-dispatchable generators, associated with the exploitation of renewable energy sources, such as Photovoltaic (PV) fields;
- Three different kinds of storage systems: thermal storage system, lithium ion Battery Energy Storage System (BESS) and hydrogen Hybrid Energy Storage System (HyESS);
- Three Power Centers (PCs), acting as electric hub;
- A back-to-back (B2B) inverter, acting either as load or grid simulator. Its main purpose is to simulate electricity user as well as, if needed, connection point with the electric grid;

- Some controllable units, that are electric loads but employed in several goods production such as heat pumps and water purification system;
- Three charging stations for Electric Vehicles (EV), two of which for electric cars and the other for electric bikes (E-Bike).

4.8.1.2. General characterization of local environment

The microgrid is placed at the Department of Energy of Politecnico di Milano. In particular, the non-dispatchable units (PV modules) are located on the building's roofs, in particular the BL25 and BL25A aka Laboratory of Micro-Cogeneration (LMC). The thermal loads and generator, the grid simulator and the HyESS are placed in the LMC – the gas storage system is placed nearby, outside LMC. All the remaining units are in a container located outside the LMC in a parking area known as B37.

Figure 27: Pilot 4a demonstration site

4.8.2. Overall Pilot's Architecture

The architecture of the pilot is provided in the followings, with brief details on the physical on-site devices, including the pilot's power grid schema presenting the set of devices and systems that will enable the functionalities to be demonstrated.

4.8.2.1. Power grid architecture of Pilot 4a

The experimental microgrid interconnects the following systems and sub-systems:

a) **Power Centers (PC)**, acting as electric hub;
b) **Generators:** dispatchable and non-dispatchable units for Heat, Power and Combined Heat and Power (CHP) generation:
   - three photovoltaic fields:
     - PV1: 25 kW
     - PV2: 24 kW
     - PV3: 26 kW
   - a natural gas Micro-CHP system (TOTEM)
     - Electric power 25 kW, Thermal power 25 kW
c) **Storage**: three different systems:

- a thermal storage system (50 kWh)
- two lithium ion Battery Energy Storage Systems (BESS):
    - BESS1: 70 kWh Lithium batteries
    - BESS2: 70 kWh Lithium batteries
- a hydrogen Hybrid Energy Storage System (HyESS):
    - 30 kWh storage coupled with power-to-power system- Alkaline Electrolyzer (25 kW) PEM Fuel Cell (25kW)

d) **Loads**:

- an electric grid simulator, that acts as virtual electricity user as well as (if needed) connection point with the electric grid: 100kW;
- some programmable electric loads:
    - Two heat pumps Smart-grid ready: 2 x 6 kW
    - Potable water production (Sireg Hydros): 6 kW
    - Lights: 5 kW
- three charging stations:
    - two fast charging stations for 2 Electric Vehicles (EV): 2 x 50kW
    - one for 10 Electric bikes (BMW): 10 x 250 W

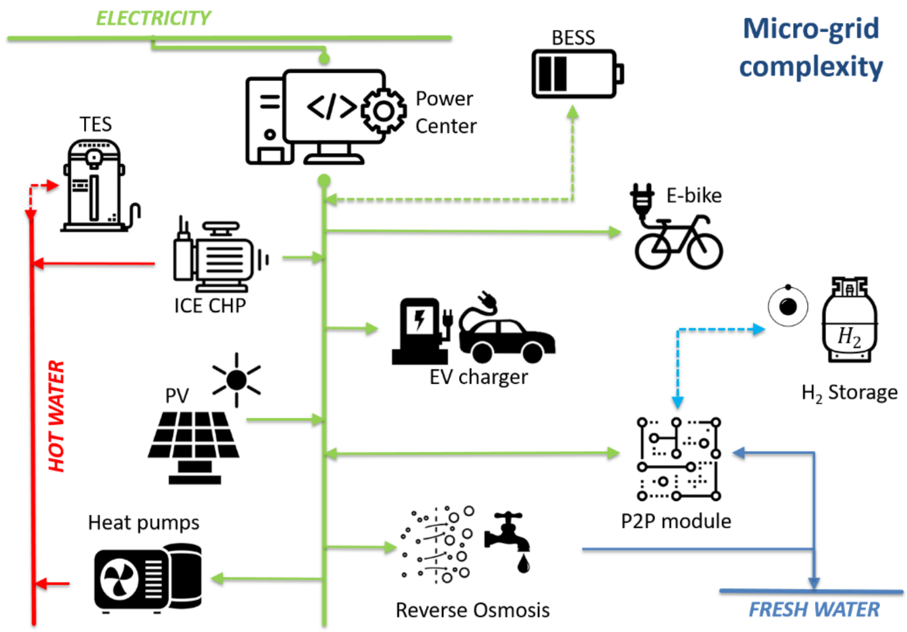

Figure 28: Pilot 4a MG2lab micro-grid interconnections

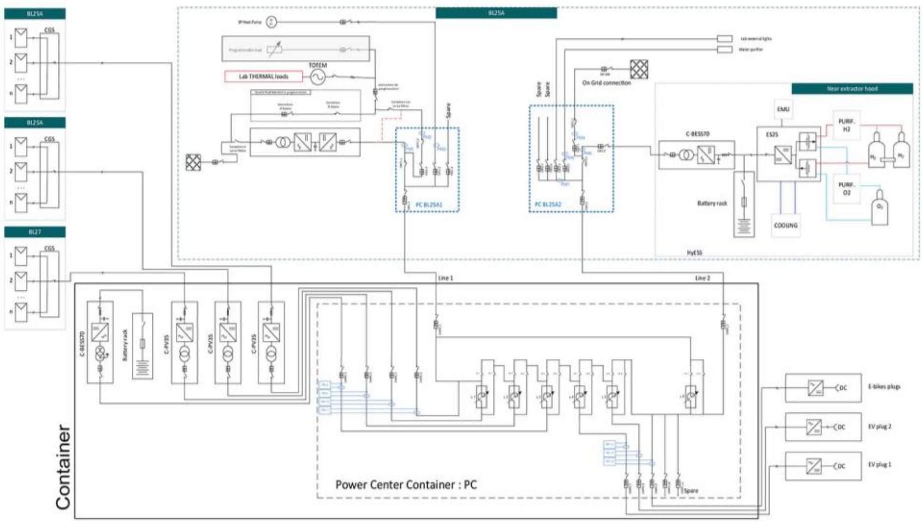

Figure 29: Pilot 4a MG2lab detailed layout

4.8.2.2. ICT architecture

The microgrid is organized in three different **Power Centers** (PC), each connected to the others, which work together, as shown in the following figures describing the microgrid communication diagram and power centers, components, and controllers.

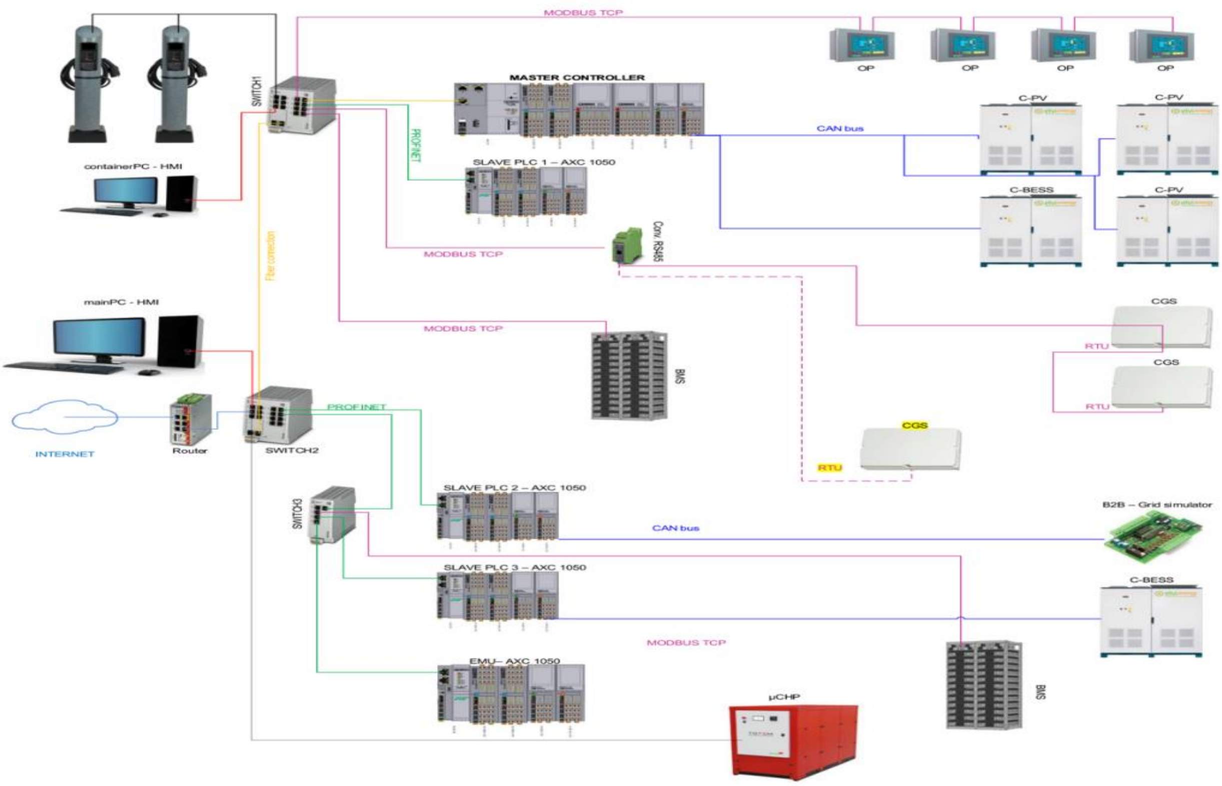

Figure 30: Pilot 4a Microgrid communication diagram

Power Center	Components	Controller
PC1	Photovoltaic fields, PV1 and PV2	Master
	Battery Energy Storage System, BESS	Slave 1
	Electrical Vehicle plugs, EVs	Slave 1
	Spare connections	Slave 1
PC2	Heat pumps	Slave 2
	Back-To-Back simulator, B2B	Slave 2
	Combined Heat and Power generator, TOTEM	Slave 2
	Water Purifier, WP	Master
	Spare connection	Slave 2
PC3	Hybrid Energy Storage System, HyESS	Slave 3
	Grid connection	Slave 3
	External lights	Slave 3
	Spare connections	Slave 3

Figure 31: Pilot 4a Power Centers, Components and Controllers

4.8.2.3. Site assessment and existing infrastructures

PC1: is the main Power Center and it is composed by two photovoltaic system, plus a third one which has to be installed, a storage system, a master controller and three electro-vehicle plugs. It also comprehends two free spares for further development - most of its components are placed inside the container in the parking space named B37. Elements in PC1 are:

- two operative photovoltaic fields are placed on the roof of the BL25A building; the first field, called PV1, is composed by 6 strings of 13 modules each, for a total of 78 modules, the second one, called PV2, is composed by 6 strings of 12 modules each, for a total of 72 modules; three C-PV35 photovoltaic inverters are used for DC to AC conversion. A junction box (CGS) can monitor:
    - ➢ The current of each string;
    - ➢ The environmental temperature;
    - ➢ The PV modules temperatures.
- the BESS system constituted by: 70kWh Lithium-ion Samsung battery string: it needs to cope with sudden changes in electrical load and thus to ensure operation of the microgrid in the first 5 minutes of transient, during which the P2P settle down to steady state – a converter (C-BESS70) manages the bidirectional energy flow between the microgrid and the first ESS; it is fundamental to provide inertia to the system and stabilize the microgrid operation.
- The Electric Vehicle charging stations are placed just outside the container. There are three different recharge stations: two of them are for electric cars and the last one is for electric bikes. The recharge stations were installed to simulate real-life-load.
- The Master Controller represents the control and supervision system. This determines and imposes the set-points of each subsystem with which it communicates – a Human Machine Interface (HMI), which is basically an industrial PC allows the operator to interact with the system and modify the parameters and commands of the network
- The last component inside the container is the auxiliary's cabinet; it is powered directly from the microgrid and guarantees the supply of the container auxiliary systems and the Master Controller (MC). The auxiliary system comprehends:
    - ➢ Container lights and plugs;

- HVAC system: Heating, Ventilation and Air Conditioning system to control the temperature which is fundamental for the correct operation of the inverters and the battery strings;
- A fire detection system, constituted by a fire alarm control panel, a fire detection sensor, a fire extinguisher and a manual device.

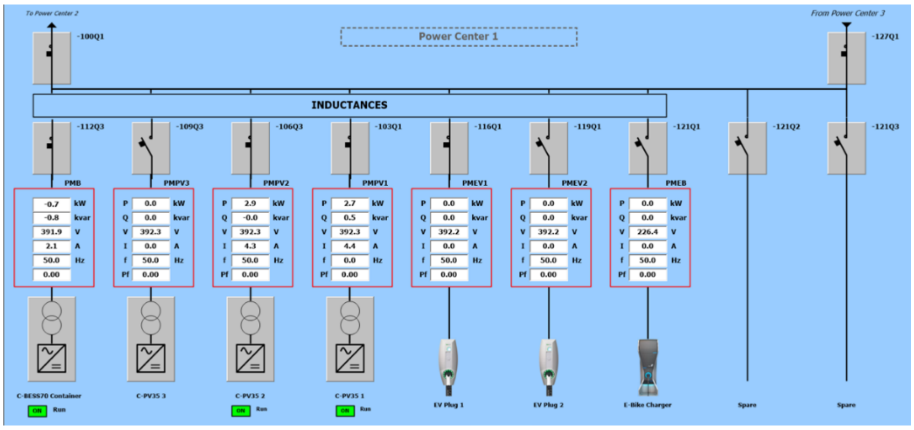

Figure 32: Pilot 4a PC1 detailed view

The **PC2** is composed by two heat pumps, one back-to-back, one TOTEM, one water purifier, two spares for further development.

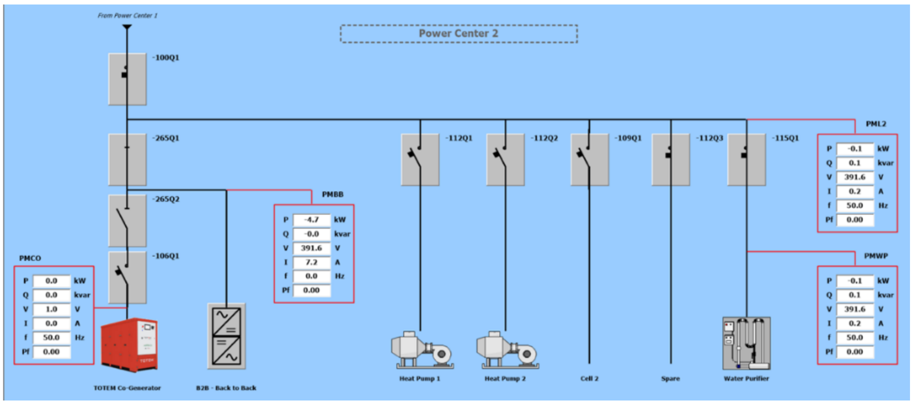

Figure 33: Pilot 4a PC2 detailed view

The **PC3** is composed by the links to the PC1, the external lights, a hybrid-storage system BESS and two spares for further development of the microgrid.

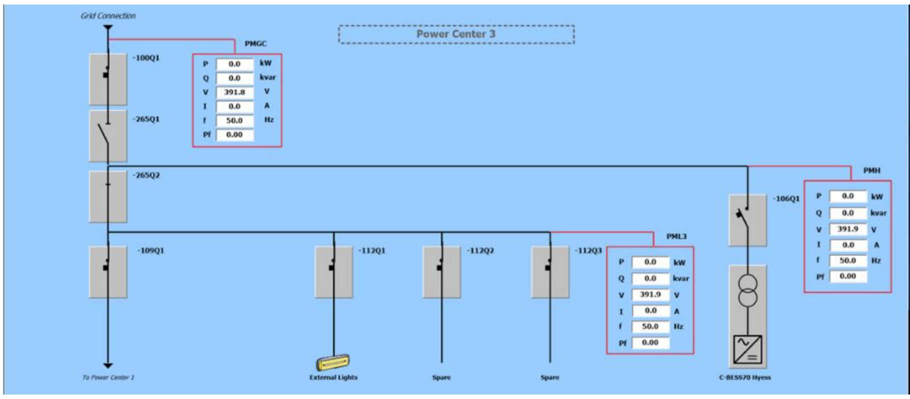

Figure 34: Pilot 4a PC3 detailed view

4.8.3. Pilot 4a requirements

Interoperability layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Connector	ENGIE (Transfer Data from Legacy system to Platoon System)	Now there is basic scenario a connection with a central rep for all wind data. They could extend it to a more complex scenario to connect directly to other DBs. Engie to confirm. For VUB and TECN will have no impact. Engie Identify 3Vs of data (volume, velocity and variety – format) – this should be provided to T2.4. Basic scenario time series non-semantic. Also, will try to put a complete a potential more	Probably some interfaces to query the SQL DB (TBC by POLIMI)	Will depend on the configuration of the Pilot. Data Policies, Data Access, Cyber restrictions. The deployment of the data connector will be highly depending on the constraints of POLIMI (cloud, on premise, …). MaM (POLIMI) consider that the internal implementation should be the one considered for stability concerns.

		complex scenario to use semantic data. [POLIMI] In case of Polimi it will be the "Server" of MG that is already deployed on site. DC is responsible to collect Data from any Data Source (legacy system, DB, Rest API …). It is a software component. Data Connector should be able to access Interfaces to collect it.		
IoT Connector	-	Not required. They have a block on Azure for this. [POLIMI] Already have IT setup to collect data from Assets.	-Yes – Already working	N/A
Data Curation and Integration	ENGIE and TIB	Basic scenario time series non-semantic. Also, will try to put a complete a potential more complex scenario to use semantic data. [POLIMI] Times Series / Non Semantic. RAW data directly in the DB.	Yes for Basic scenario time series non-semantic. POLIMI Same	No for a complete a potential more complex scenario to use semantic data. POLIMI Same
Semantic Adapter	ENGIE and TIB	Basic scenario time series non-semantic. Also, will try to put a complete a potential more	Yes for Basic scenario time series non-semantic. POLIMI Not ready	No for a complete a potential more complex scenario to use semantic data. POLIMI Should be used in the Pilot for basic scenario.

		complex scenario to use semantic data. POLIMI Aims to convert data (non-semantic one) to semantized Data to expose them to Data Curation and Integration part. In the case of POLIMI : some data can be in real time, but mostly it is now in Batch approach. Some Algorithms (forecasting) are almost real time (30’). Batch – Almost real time – Real time capabilities of POLIMI MG		
Energy Data model (PLATOON Data models from T2.3)	ENGIE , VUB and TECN	Yes for the interoperability. Also it could be useful to use it for the data analytics. POLIMI Yes for the interoperability (ongoing definition in 2.3)	for the interoperability. POLIMI Not ready, will be implemented for the pilot	Pending failure modes for the data analytics. POLIMI TBD on which“Analytic”/Model part it will be considered
Vocabulary manager	TECN and IAIS	Regarding interoperability define 3 levels: 1)Raw data with IDS 2)Semantic data with IDS 3)Semantic data with IDS and used for Data Analytics In this pilot we will target at least level 2. POLIMI	POLIMI No Should be useful for POLIMI. TBC	No. Vocabulary manager is part of IDS vocabulary provider. This will be done in WP3. Not able to define now how this can be implemented with IDS vocab provider.

		Should be useful for POLIMI. TBC. 1)Raw data with IDS 2)Semantic data with IDS 3)Semantic data with IDS and used for Data Analytics In this pilot we will target at least level 2.		

Table 49 Pilot 4a Interoperability layer requirements

Data Management Layer

Component /service	Provider	Demonstration requirements	Readiness (*if the requirements can be met on the pilot location)*	
			Yes	No
Context Data Broker	ENGIE	Not Sure if it is required- Engie to confirm POLIMI Definition: Data Broker that provides access to context information. Information about entities in Real env. (e.g. Real time information from sensor, ...). We are focusing on information that change with a certain frequency. Weather information is a good example that can be considered when it comes to use Context Data Broker.	POLIMI to confirm	POLIMI to confirm

		If it is only historical data, CDB is not needed. POLIMI to confirm		
Federated Query Processing	ENGIE and TIB	4 scenarios – 1)Without 2)Inside Engie 3)Outside Engie 4)Inside and outside Engie Engie to confirm which one is needed POLIMI to confirm	Engie need to confirm POLIMI to confirm No Ready	Engie need to confirm POLIMI to confirm Could be implemented in some function/tools
Unified Knowledge Base	ENGIE and TIB	They will try to implement but need to specify with TIB exactly what it is POLIMI Need to assess if it makes sense for POLIMI.	POLIMI Need to assess if it makes sense for POLIMI.	Not implemented ye POLIMI Need to assess if it makes sense for POLIMI.
Context Event Processing	ENGIE	Not required Software Component (inside/outside POLIMI) to analyze context information (that change very quickly) focusing on specific events , situation (e.g. Streams) – using Triggers / Rules applied to these information/events. Ex: Critical Situation identification,… Can be applied to historical information too. This component is linked to the	POLIMI Depending on capacity to extend a semantic view of events in the POLIMI MG	POLIMI Depending on capacity to extend a semantic view of events in the POLIMI MG

		Context Data Broker. POLIMI Already existing in POLIMI. But Can be useful if extended to a semantic description of event		

Table 50 Pilot 4a Data management requirements

Intelligence Layer

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Data Analytics Toolbox and Processing Tools	TECN (Procedure > Container) POLIMI (Code > Container) ENGIE (Implementation with Semantic)	For sure implemented as a service but might consider as well to do a test on the infrastructure using dummy code. POLIMI Owns Algo/Models for POLIMI MG.	Yes. We will use the Data Analytics Tool container defined in T4.1. POLIMI Not ready can be tested (EPS)	POLIMI
Data Analytics Dashboard – Visualization	POLIMI	Visualization Dashboard to show outputs from data analytics tools from VUB and TECN. POLIMI Already Dashboard.	Yes they already have the visualization dashboard. POLIMI Yes they already have the visualization dashboard.	Will need to be integrated with data analytics tools/storage. POLIMI Will need to be integrated / Linked if needed in PLATOON Ecosystem

Table 51 pilot 4a intelligence layer requirements

Marketplace

Component /service	Provider	Demonstration requirements	Readiness *(if the requirements can be met on the pilot location)*	
			Yes	No
Marketplace	IAIS	VUB and TECN will show metadata of proprietary tools in the marketplace. ENGIE – will show metadata for datasets and potentially also for apps/tools – Engie to confirm the last one with Koen. POLIMI Could description / Metadata – To be confirmed		No this will be developed as part of T3.4.

Table 52 Pilot 4a Market place requirements

4.8.4. Equipment and System Specification

The equipment to be integrated and developed in the scope of Pilot 4a is reported in the following table:

Power Center 1 (PC1)	PC1	The first Power Center (PC1) is composed by: • Three photovoltaic systems. • A Battery Energy Storage System (BESS); • An electro-vehicle plug, plus other two to be installed; • Two spares connections for further development. Sometimes it is referred as “Container”, since most of its components, with the exception of the PVs, are placed inside the container in the parking space named B37
	PV system	The first field, identified as PV1, is composed by 6 strings of 13 modules each, for a total of 78 modules. The second one, identified as PV2, is composed by 6 strings of 12 modules each, for a total of 72 modules.

		The third one, identified as PV3, is composed by 4 arrays of 22 modules each, for a total of 88 modules. All fields have the same configuration: every module in the string is connected in series, while the strings are connected among themselves in parallel through a string box, in turn connected to the PC1. Moreover, each field has a dedicated inverter, referred as C-PV35, which with all the remaining components of the system, is on the inside of the container. The version of the modules adopted is the SPR-X20-327-COM, which has a nominal power of 327W. The junction box can monitor: • The current of each string. • The environmental temperature. • The PV modules temperatures.
	BESS	Inside the container is also placed the Battery Energy Storage System, constituted by: • 70kWh Lithium-Ion Samsung battery string. • C-BESS70, for DC to AC conversion. The C-BESS70 converter manages the bidirectional energy flow between the MG and the first ESS; it is fundamental to provide inertia to the system and stabilize the micro-grid operation.
	AUX	The last component inside the container is the auxiliary's cabinet; it guarantees the supply of the container auxiliary systems and the Master Controller (MC). The auxiliary system comprehends: • Container lights and plugs. • HVAC system: Heating, Ventilation and Air Conditioning system to control the temperature which is fundamental for the correct operation of the inverters and the battery strings. • A fire detection system, constituted by a fire alarm control panel, a fire detection sensor, a fire extinguisher, and a manual device. The Master Controller represents the control and supervision system. This one is obtained from three hardware components: • Master Controller, which determines and imposes the setpoints of each subsystem with which it communicates. • Human Machine Interface (HMI), which is basically an industrial PC that allows the operator to interact with the system and modify the parameters and commands of the network.

		• Router, which enables the internet connection for controlling and monitoring the network remotely. The real HMI is placed in LMG while in the container there is the possibility to connect an addition monitor remotely controlled.
	EV charging station	The Electric Vehicle charging stations represent the last component of the PC1 and they are placed just outside the container. There are three different recharge stations: two of them are for electric cars and the last one is for electric bikes. The EV charging stations have a nominal power of 50kW and they are capable of fast charging; they were installed to simulate real-life-load, and, for the moment, they represent an opportunity for further development of the micro-grid.
Power Center 2 (PC2)	PC2	The PC2 is placed in the Laboratory of Micro-Cogeneration (LMC), in the same building of LMG, and it is composed by: • two heat pumps. • one back-to-back. • one CHP generator from TOTEM. • one water purifier. • two spares connections for further development. This Power Centre is focused on a cogeneration system and it is organized in two different cells in the laboratory.
	Heat pump	The two heat pumps are a 6kW Daikin pumps (EHBX08DA6V)
	Water purifier	The water purifier installed in the micro-grid is a four-stage reverse osmosis system that works in a closed cycle. Each stage consists of a single pressure vessel, which contains a single membrane element. The brine solution at the end of a membrane becomes the feed solution of the next membrane. The permeate streams are collected from each membrane and they are mixed, in parallel, in the permeate pipe. The desalination system has a nominal power of 1,2kW and a nominal flow rate of 10 m^3/h
	Totem	The engine is one of the main components of this Power Center and it is a modified motor of the FIAT 500, called TOTEM; it is a 25kw natural gas micro-cogenerator that can produce contemporarily electrical power and heat. Designed to be fueled with natural gas and propane, it is coupled with a water-cooled alternator for electrical power production. Thanks to an efficient heat exchanger system, heat is recovered from the internal combustion engine as well as the alternator and provided as a by-pass product. In addition, it is equipped with the Engine Controlled Unit developed by Magneti Marelli for a real time and precise control of the engine. The TOTEM generator is connected

		through a circulating water circuit to the tank serving as thermal storage. From the tank, an additional circuit leads the hot water to the virtual thermal user, where heat is dissipated. The cooled water is in turn be rerouted back to the component.
	B2B converter	The grid simulator, or back-to-back inverter represents a conversion control center that can work as a grid or charge simulator. The B2B can both inject and withdraw electric energy from the grid and modulate the electric parameters on the micro-grid side to meet specific criteria. It will thus allow to reproduce the effect of grid connected operation mode when MG frequency and voltage are imposed by the main grid. Reversely, the grid simulator can also behave just like a virtual electric load, injecting the equivalent of the desired electric load power profile on the electric grid without interfering with the evolution of frequency and voltage on the micro-grid side.
Power Center 3 (PC3)	PC3	The PC3 is in the LMG and it is composed by: • Hybrid Energy Storage System (HyESS); • point of connection to the network. • external lights. • two spares connections for further development.
	HESS	Basically, it is the main component of PC3 and in turn is composed of subsystems, such as: • Hydrogen Power-to-Power (P2P) system. • battery pack, a 70 kWh Lithium-ion Samsung battery string. • two conversion modules: DC-DC conversion module and DC-AC conversion module, which is another C-BESS70 converter. • Hydrogen and Oxygen storage tanks. • Hydrogen and Oxygen treatment system. • cooling system for P2P.
	P2P	The Hydrogen Power-To-Power (P2P) system is the vertical integration of two modules in a unique composed cabinet: respectively a 25kW Gas-To-Power (G2P) module coupled with a 25kW Power-To-Gas (P2G) module, with hydrogen and oxygen treatment systems and storage capacity in between. The P2G module is based on a high pressure alkaline electrolyser that converts electrical energy into chemical energy. Through electrical energy electrolysis of water is performed, producing hydrogen and oxygen. After the drying from the residual electrolytic solution, which is performed by the gas treatment system, the gases can be

		directly storable in suitable tanks. The G2P module is based on a H2/O2-fed Proton Exchange Membrane (PEM) fuel cell, which re-converts chemical energy into electrical energy, recombining the stored gases and giving water as the only by-product. The whole P2P system can then be a battery with a charging phase with gas production by P2G and a discharge phase with electricity production by G2P. The BESS, which is identical as the one for PV, and the Hydrogen P2P system are connected by means of a DC-DC converter, in parallel on a common DC bus.
External	**Weather station**	Installed next to the photovoltaic field, the meteorological station allows to collect environmental parameters of interest. It is equipped with two secondary standard pyranometers to detect the total solar irradiance on horizontal and tilted plane (30°). The latter measurement is directly implemented to define the solar irradiation on the modules, since they have the same tilt angle. Additionally, a thermohydrometer for temperature and humidity measurements is installed. Remaining sensors are a combined speed-direction anemometer for wind detection, a rain collector and two additional pyranometers, one for diffuse radiation and the other one for global radiation measurement. The meteorological station performs ambient conditions measurements every ten seconds.

Table 53: Pilot 4a Equipment and system specification

4.8.5. Plan for implementation pilot services, and systems (chronogram)

This planning is currently under development and will be finalized early 2021.

4.8.6. KPIS measurements

Pilot 4a KPIs	
KPI-Name	**Requirement description**
Energy availability	Optimal energy consumption (increase in energy availability)
Cost	Reduction of maintenance effort and costs
Forecast	Reduced forecasting errors
Realtime	Ability to monitoring/analyze/optimize data and the system at real time rate

Table 54: Pilot 4a Plan for implementation of pilot services and systems

5. PLATOON's Global Implementation Plan

The objective of this section is to provide a global schedule for PLATOON implementation; it summarizes the individual pilot's implementation plan above described.

However, as it was explained in the previous sections, most of the pilots are still finalizing the implementation plan for their pilots. A plan is already in place and a fully defined implementation plan should be ready by M18, so the pilots have time to implement it before pilot validation on M24.

Thus, this section is not part of the current version of the deliverable. It is a placeholder that will be completed in the second version of this deliverable to be submitted at M24.

6. Conclusions

Part II : Validation Plan

This section is place holder for the aims to present a validation plan for all the services that are developed within PLATOON. Currently this part has not started yet. Details will be provided by month 24 in the second version of this deliverable. For the moment only the placeholder is included.

1. Introduction

2. PLATOON components test and validation

2.1. Data Market Place

Specification

- Description
- Main functions:
  Ex: Data collection, data aggregation, APIs, Forecast calculation and processing
- Interfaces
  EX: Inputs (historical data set), output (results data)

Validation method

- Test assessment: data quality, unit tests, functional tests
- Test approach

Test protocol

- Test setup: The requirements to be considered for the test
- Pass/fail criteria
- Test program

2.2. Edge computing

Specification

1. Description
2. Main functions
3. Interfaces

Validation method

Test assessment: data quality, unit tests, functional tests
Test approach

Test protocol

- Test setup: The requirements to be considered for the test
- Pass/fail criteria
- Test program